Predictors of successful ageing: findings from the longitudinal follow-up of the Lothian Birth Cohort 1921

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Doctor of Philosophy – The University of Edinburgh – 2006

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Declaration

This thesis has been composed by myself, and has not been submitted for any other degree, diploma or professional qualification. The work is my own except where acknowledgement is made by reference. The data presented were collected, collated and checked as part of the Lothian Birth Cohort 1921 (LBC1921) Study over waves of cognitive testing conducted at ages 11, 79 and 83, and self-reports completed at ages 80 and 83. My involvement began with the age-83 data collection wave. I contributed to the cognitive testing of the cohort at that time and was solely responsible for all aspects of the self-report (to be detailed throughout). All analyses presented in this thesis are original and were conducted by me.

Acknowledgements

I would like to thank my supervisors, Professor Ian Deary and Dr Martha Whiteman, for their continued support and encouragement during the completion of this thesis. I am indebted to Ian for the opportunity to work on the LBC1921 Study, to Martha for her work on the initial wave of the project, and to both for their guidance throughout.

My gratitude also to Alison Pattie – Research Associate on the LBC1921 Study – who collected and organised much of the data and who has been a vital source of information and support.

To all occupants of S6, past, present and honorary – Alison Pattie, Michelle Taylor, Paula Davies, Janie (Cuthbert) Corley, Caroline Brett, Caroline (Goodlet) Cameron, Beverly Shipley, Sarah Harris, Susan Shenkin and Brian McGurn – thank you for your patience, encouragement, and, of course, those countless tea and cake breaks!

Of course, this thesis would not have been possible had it not been for the enthusiasm and cooperation of those taking part in the study. My thanks to the members of the Lothian Birth Cohort 1921 who have so wholeheartedly given their time to us.

Finally, my thanks to my family and friends who have always been so supportive and positive, and who have provided endless opportunities for distraction!

I was funded by a Royal Society of Edinburgh/Lloyds TSB Foundation for Scotland Studentship (2002-05). The 1932 Scottish Mental Survey was conducted by the Scottish Council for Research in Education. The Lothian Birth Cohort 1921 Study has been funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the Chief Scientist Office of the Scottish Executive.

Abstract

The progressive ageing of the world's population implies that any age-associated deterioration will become ever more prevalent. Some individuals can be identified as ageing more 'successfully' than their peers; the maintenance of mental abilities in old age is one marker of this. Isolating modifiable determinants of cognitive ageing is therefore a research priority. Factors from the domains of work, social support networks and activity participation were examined in an ageing group retrospectively and contemporaneously. Aged 11, these individuals had taken a test of mental ability (the Moray House Test: MHT) as part of the 1932 Scottish Mental Survey. Some 550 survivors were recruited ~79 years old into a longitudinal study of cognitive ageing-the Lothian Birth Cohort 1921-when they again took the MHT, plus a battery of tests (Raven's Progressive Matrices, Verbal Fluency and Logical Memory). A 2nd wave of testing was completed at ~83 years old. Over the 4 years of follow-up, significant decline was observed in cognitive ability (composite of the 3 tests) and separately for Raven's and Verbal Fluency, but not for Logical Memory. In regression analyses, higher cognitive ability at age 79 assessed by the MHT (expressed as age-79 IQ) was predicted by less hazardous working conditions, a quieter working environment and receiving more supervisor support; living with a spouse/partner for a fewer number of years in young adulthood and having fewer close friends/relatives in old age; and increased activity in midlife and old age. Each factor explained about 1% to 3% of the variance, independent of age-11 IQ and sex. Less cognitive decline from 79 to 83 years old (on the general ability composite) was associated with increased support from coworkers and walking (versus not) at age 80, each accounting for about 2% of the variance (independent of age-11 IQ and sex). When the analyses were pooled across lifestyle domains and further potential confounders (including education, social class, depression and disease history) were controlled, measures of the hazards encountered at work and lifetime activity participation each accounted for 1% to 3% of the variance in age-79 IQ, whilst walking accounted for about 2% of the variance in later life cognitive change. Inactivity in midlife and a lack of exercise in old age are plausible risk factors for cognitive decline. They are, fortunately, potentially malleable; promoting activity may offer pathways to improved cognitive ageing.

Part I – Cognitive ageing

Ageing is an integral, natural part of life. The way in which we grow old and experience this process, our health and functional ability all depend not only on our genetic makeup, but also (and importantly) on what we have done during our lives; on what sort of things we have encountered in the course of our lifetime; on how and where we have lived our lives (World Health Organization, 1998, p. 1).

Chapter 1: An ageing world; an ageing mind

1.1. The ageing population

You are getting older. Fact.

To soften the hammer-blow, consider these facts also:

1. everyone else is getting older, indeed, the whole of the human population is ageing;

2. you can expect to live longer than has ever been the case in the whole of human history (Butler, 1997).

The world's population is growing older. The global trend towards an older population, "whereby the share of older persons in a population increases relative to younger persons" (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005, p. 8), is primarily the result of a decrease in fertility coupled with increased life expectancy. Mortality decreased more rapidly during the last century than ever before. In the developed world – consisting of Australia/New Zealand, Europe, Northern America and Japan – mortality is low, and declining still further, whilst fertility is below replacement levels (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005).

In terms of global life expectancy, the average human currently lives for 65 years; this is projected to rise to 75 years by 2045-50 (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005). Longevity is greater still in the most developed nations. Current average life expectancy in these regions is predicted to increase from 75 years to 82 years over the next half century. The number of older individuals worldwide (defined as those aged 60 and over) will subsequently swell from 672 million in 2005, to an estimated

1.9 billion by 2050 – an almost three-fold growth. Older people, currently accounting for about 20% of the developed world's population, will constitute almost a third of this (32%) in 50 years time; indeed "by 2050 there will be 2 elderly persons for every child" (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005, p. 9). The increase in those aged 80 years and over (described as the very old, or oldest-old) will be more apparent still, with the number of individuals in this age-group growing faster than any other: from 86 million to 394 million over the next 50 years. "Population ageing, which is becoming a pervasive reality in developed countries, is also inevitable in the developing world and will occur faster in developing countries" (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005, p. 9).

1.1.1. Ageing trends in the UK

The ubiquitous phenomenon of population ageing is observable not only at the broad international level but at a national level of description also. For the United Kingdom, an echo of the trends envisioned in the global data is expected: over the next 50 years, average life expectancy is predicted to increase from 78.3 years to 83.5 years; 21.2% of the UK population are currently aged over 60, rising to 29.4% by 2050; the proportion of the oldest old is expected to double from 4.4% to 8.8% within half a century (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005).

1.1.2. Scottish projections

And even closer to home (home being Scotland in this instance)?

> We can see unprecedented change here too... The trends paint a complex and sophisticated picture of what sort of Scotland we could be facing by 2025... We can also assume considerable changes in demographic patterns – persistently low birth rates, a population living longer, but not necessarily a population living healthier...one of the few certainties that we have about our future is that, over the next 20 years, Scotland's demographics will have shifted. Scots will be living longer, and our age profile will have become more elderly. By 2025, 30% of the Scottish population are expected to be

> over 60 – and 1 in 6 will be over 70. Scotland is not alone in facing those challenges – and opportunities – of an older population (McConnell, 2006).

From the most recent population projections, between 2004 and 2031 the number of individuals in Scotland aged 75 and over is expected to rise by 75%, from about 370,000 to 650,000 (Registrar General for Scotland, 2005). Moreover, the 60-74 year old age group is also predicted to increase in size whilst all other age groups are expected to see a drop of between 11 and 18%. It is therefore clear that the progressive ageing of the human population is a worldwide phenomenon, but it is one which will unavoidably and acutely affect national, and indeed local, governments (World Health Organization, 2002).

1.1.3. The 'dependent' population

Policy makers worldwide are necessarily considering how the needs of an increasingly elderly population can be provided for (World Health Organization, 2002). Importantly, the world's shifting demography intimates that over the next 50 years the number of individuals of working age (15-59 years old) will decline in the most developed countries (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2005). This has led to fears that a smaller potential workforce may be unable to meet the social and economic needs of a proportionally larger 'dependent' group (Larson, 2003). In Scotland, for example, the number of dependants per 100 individuals of working age will increase from 60 in 2004 to 75 in 2044; the number of individuals of working age is predicted to drop by 7% between 2004 and 2031 whilst the number of pensionable individuals will increase by 35% over the same period (Registrar General for Scotland, 2005).

> Currently there are about two working adults to every child and pensioner. By 2041 this could fall to 1.3 (Scottish Executive, 2006, p. 4).

This disturbance of the world's balanced demographic is likely to have a major impact on many aspects of society, across social, familial, economic and healthcare domains (Butler, 1997; Greengross, Murphy, Quam, Rochon, & Smith, 1997).

As a species, we are now living longer, but are we living healthier? A paraphrasing of a question posed by the World Health Organisation stated: "years have been added to life but will life be added to years?" (Dean, 2003, p. 1). Ageing has been defined as "the progressive loss of function accompanied by decreasing fertility and increasing mortality with advancing age" (Kirkwood & Austad, 2000, p. 233). It is often said that ageing is inevitable; it happens to all organisms. Whilst this is not strictly true (as many organisms are spared the reduction in fertility and heightened mortality associated with increasing age: Kirkwood et al., 2000), it is indubitably an axiom applicable to humans. With time, senescence affects our functional abilities although the actual course of change is variable across individuals (World Health Organization, 1998). Increasing age is often coupled with a greater burden of disease and cognitive problems (World Health Organization, 2002). Indeed in the over 80s, the fastest growing age group, problems associated with disability and dementia increase considerably (Butler, 1997), in addition to functional limitations and a resultant loss of independence (Khaw, 1997). Older adults are more likely to suffer from the leading diseases compared with younger adults; "the total death rate in developed countries such as Britain is 500 times greater at age 80 than at age 20" (Peto & Doll, 1997, p. 1030). Population ageing is therefore amongst the greatest concerns for nations, and "the progressive 'greying' of our populations makes it necessary to unravel the mechanisms of diseases that typically strike at the highest ages" (Westendorp & Wimmer, 2005, p. 419). It is, however, important to state that old age *per se* is not costly in terms of healthcare, but rather it is the poor health often associated with age which can bring increased economic burdens (World Health Organization, 2002). Peto and Doll (1997) note that simply because older people are more likely to experience a greater burden of disease does not imply there is some shared latent mechanism or process of ageing. Furthermore, older people are not necessarily reliant on others, as many maintain their independence into their advanced years. Older individuals can often still be in employment, or may make valuable contributions to family or society through unpaid positions or home work (World Health Organization, 2002). However, those thriving in old age are rarely the subject of ageing research.

1.2. Active, healthy, successful ageing

Almost 20 years ago, Rowe and Kahn (1987) lamented that research into ageing more often highlighted increased age as the principal determinant of decrements seen across physical and mental domains at the exclusion of potential psychosocial and lifestyle causes. Even recently, it is still the norm for studies to focus on disease or pathological endpoints in ageing (Hendrie et al., 2006). It was, and is, common to investigate normal ageing versus a pathological group which subsequently ignores the great variation that exists within the 'normal' group (Rowe & Kahn, 1987). By investigating the normal group more closely, it is possible to further subdivide by those ageing usually in comparison to those ageing successfully. This being the case,

> one can find older persons with minimal physiologic loss, or none at all, when compared to the average of their younger counterparts. Those people might be viewed as having aged successfully with regard to the particular variable under study (Rowe et al., 1987, p. 143-144).

1.2.1. Maintaining function in later years

Due to the marked transformation currently underway in the demographic makeup of the world's population, it is becoming critically important to investigate how individuals can age successfully, maintaining their functional abilities in old age to allow continued independent living and increased, or at least sustained, quality of life. This quality of life may be directly associated with their functional status; that is, "a person's ability to perform the activities necessary to ensure well-being" (World Health Organization, 1998, p. 2). Functional status may well determine how able an individual is to continue leading a full and independent life. The foremost test for the ageing population is therefore how to preserve aspects of their health into later years, and thus continue to experience an acceptable quality of life (Khaw, 1997).

"Death is inevitable but disease is not" (Greengross et al., 1997, p. 1029). This apothegm encompasses the notion that old age can be a time of maintained functional status, and implies that individuals could and should be able to enter their later years without experiencing a greater encumbrance of disease. Simply measuring increases in longevity, however, is insufficient to assess this as

> life expectancy counts all years of expected life the same regardless of whether they are enjoyed in good health or with significant disability. A variety of measures have therefore been derived for incorporating a "healthy" element into life expectancy. One such measure is *Healthy Life Expectancy* (Clark, McKeon, Sutton, & Wood, 2004, p. 1).

Healthy life expectancy has been defined as "the number of years people can expect to live in good health. The discrepancy between healthy and total life expectancy…therefore indicates the length of time people can expect to spend in poor health" (Information and Statistics Division NHS Scotland, 2004, p. 1). For example, the first data available for Scotland suggest that although life expectancy is 78.7 and 73.3 years for women and men respectively, the corresponding healthy life expectancies (from self-assessed general health status) are 67.2 and 64.6 years. Although healthy life expectancy has risen in previous years, it is concerning that the rate of change has lagged behind increases in life expectancy (Clark et al., 2004). Consequently, factors which might decrease the number of years towards the end of life that are blighted by disability or disease are being sought (Greengross et al., 1997). Such an undertaking is becoming more pressing with increased longevity being experienced by an ever-greater number of individuals; it is vital that the extra years constitute a time of continued health (including physical, mental and social well-being) and activity.

One of the methods for encouraging such healthy ageing is by the promotion of physical or mental activity to avoid disuse of body and mind (Khaw, 1997). The World Health Organisation (WHO) has termed this *active ageing*, such that quality of life is maintained into old age (World Health Organization, 2002). Maintaining independence, "the ability to perform functions related to daily living", and autonomy "the ability to control, cope with and make personal decisions about how one lives on a day-to-day basis" (p. 13), are a major part of this.

1.2.2. Defining successful ageing

Promoting healthy or active ageing is crucial because individuals are now more likely to experience a longer lifespan. It is also valuable as it emphasises the need to be proactive (as individuals and as an ageing society) to secure later health, "rather than merely [reacting] to disease" (Larson, 2003, p. 874). Doing so, however, is predicated on the knowledge of the factors that lead to the aforementioned healthy, active ageing. A number of studies are therefore directed toward uncovering such factors, including, for example, the MacArthur Studies based in the USA (Berkman et al., 1993). This study of older individuals defined the participants within the sample as ageing 'successfully' if their physical functioning was superior to that of their peers. Moreover, to be defined as ageing successfully participants necessarily maintained relatively higher levels of cognitive functioning, that is, a preservation of their thinking and memory skills. By comparing those ageing successfully to those faring less well, it is assumed the factors predicting successful ageing will be identified and consequently promoted in future generations (Berkman et al., 1993). However, studies focussing on successful ageing – as opposed to decline – are rare (Hendrie et al., 2006) and Phelan and Larson (2002) found no single operationalisation of the successful ageing concept after searching for studies conducted over the past 40 years. Researchers highlighted different definitions which included aspects of life satisfaction, longevity, freedom from disability, mastery/growth, active engagement with life, high/independent functioning (including physical, cognitive or social function) and positive adaptation. The major predictors of successful ageing revealed by these studies included high educational level, regular physical activity, high self-efficacy, social contacts/supports and freedom from chronic illness (Phelan & Larson, 2002). A number of studies adopting definitions of successful ageing have included the elements identified above, in particular emphasising the ability to live independently, and to have excellent physical health and superior performance on tests of mental ability (Andrews, Clark, & Luszcz, 2002; Jorm et al., 1998a). Mental ability is a salient and consistently cited aspect in many definitions of successful ageing (Andrews et al., 2002; Berkman et al., 1993; Jorm et al., 1998a). Rowe and Kahn (1987) suggested that cognitive function may be a potential marker for successful ageing: changes seen in later life may reflect not only the ageing process *per se*, but the expression of a range of factors acting in numerous domains. Mental ability is also a potential predictor of other aspects of active ageing (World Health Organization, 2002).

1.2.3. Finding the determinants of successful ageing

Thus, with a progressively ageing population, the problems often associated with old age will become more prevalent. Even if the proportions suffering from age-related conditions remain constant, the absolute numbers will nonetheless rise due to the growing size of the 'at risk' age group (Khaw, 1997). It has therefore become increasingly necessary to investigate the ageing process and how this affects different aspects of people's lives. By discovering potential protective factors, promotion of a longer and healthier life, whereby disability and disease are delayed (Hadley & Rossi, 2005), and the discrepancy between total and healthy life expectancy is diminished, may be possible. Indeed, the National Institutes of Health in the United States formed a committee to evaluate critically the extant literature pertaining to the promotion of cognitive and emotional health in the elderly. The report stated "identifying the demographic, biological, and psychosocial factors that can help people maintain or enhance their cognitive…health as they grow older becomes a major public health goal" (Hendrie et al., 2006, p. 13). Successful cognitive ageing is a fundamental marker of successful ageing, therefore, cognitive outcomes should be studied on the basis of identifying factors which preserve function rather than an over-simplified disease versus no disease dichotomy (Hendrie et al., 2006). The determinants of cognitive disease, cognitive decline or good cognitive health may not be shared, or equally important to the differently defined outcomes; maintained cognitive function "might thus be related to other factors than what is found for deteriorating…cognitive function and, even more so, for defined disorders" (Skoog, 2006, p. 89). Researchers should be cognisant of the potential for this. It would be advantageous to investigate cognitive ageing as a continuum, one which covers a full spectrum of potential ageing trajectories from observable decline to preserved or improved function. 'Successful' cognitive ageing would be the positive end of this continuum to be promoted in future interventions whilst the decline at the negative end should be protected against.

There are numerous potential determinants of healthy, active and successful ageing from across the lifespan, with a major aspect of successful ageing being the maintenance of cognitive function. With increasing age, however, the general trend is towards poorer performance on cognitive tests (which will be discussed presently: Schaie, Willis, & Caskie, 2004). Cognitive decline will therefore have important ramifications for successful ageing. However, before considering the nature of cognitive change in later life, and the predictors of this, it is necessary to demarcate what, for current purposes, is intended by the terms cognitive function, intelligence, or mental ability (which will be used interchangeably).

1.3. The nature of intelligence

Such is the nature of intelligence, that there remains a great deal of debate about what the construct actually is. Indeed, in order to clarify misunderstandings and potentially misleading claims about the 'knowns and unknowns' of intelligence, the American Psychological Association assembled a task force to report on the fundamental issues, whose aim was to clearly articulate what was understood scientifically by the term intelligence (Neisser et al., 1996). The report stated:

> individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought (Neisser et al., 1996, p. 77).

This general characterisation covers both what a lay and expert conception of intelligence might amount to; beyond this, however, it is important to understand the way in which these observed differences in mental functioning might be structured and determined. "Because there are many ways to be intelligent, there are also many conceptualizations of intelligence" (Neisser et al., 1996, p. 95). Nevertheless, for the present thesis, the psychometric approach, being the prevailing form of research in the area of intelligence, will be taken, bringing with it 100 years of research and development (Neisser et al., 1996). This approach to intelligence attempts to rank individuals according to their performance on a number of psychometric tests (Deary, 2000). These can assess a specific ability using one form of item (such as verbal or numerical), or may be structured in a larger battery of many tests to form a composite measure of overall test performance. These general scores are traditionally reported as IQ (intelligence quotient) scores using a standardised scale with a mean of 100 and a standard deviation of 15. People can differ on their scores for both the numerous specific tests, and on their overall level of performance. Throughout, when the terms intelligence, cognitive function or mental ability (or combinations thereof) are used, they refer only to psychometric intelligence as assessed by psychometric measures. This methodology necessarily involves interpreting these scores on standardised tests as reflecting underlying differences in some actual intellectual capacity.

1.3.1. General intelligence

One of the most important initial findings across research with these varied tests was the discovery of a 'positive manifold' (Spearman, 1904): individuals' scores on one test are positively associated with their performance on a range of other, often disparate measures. This ever-present positive interrelatedness has led many, most notably Spearman (1904; Spearman, 1927), to propose the existence of a general factor of intelligence (conventionally annotated *g*); performance on each measure of mental ability can be accounted for in part (although to a varying degree) by *g* (Neisser et al., 1996). Thus, one way to view cognitive function is as *g*: the shared variance across a number of abilities. This paradigm was not, however, universally accepted (nor is it still, although, as will be discussed, it now sits within the most widely accepted models of cognitive ability) and initiated research leading to conceptions of intelligence which highlighted varying numbers of specific factors or abilities, often to the exclusion of a superordinate *g* factor. The models of intelligence vying for supremacy often favoured different levels of description, consequently making them appear seemingly incongruent or contradictory. Such competing models are, in fact, in far greater agreement than was often manifestly apparent (Deary, 2000). J. B. Carroll is most often cited as the consensus-maker in this fracas, as his laborious work has since effectively located this general factor at the apex of a hierarchy of ability: *g* forms the peak, below which are found more specific abilities (Carroll, 1993).

1.3.2. Reaching a consensus

Carroll's efforts were based on reanalysing the corpus of data that had amassed concerning the structure of intellectual abilities as a necessary "review and critique of the extant literature on the identification, characteristics, and interpretation of cognitive abilities" (Carroll, 1993, p. 73). This included surveying the available factor analytic and correlational studies of mental ability over the previous half century. From his initial list of around 1500 references – containing all or virtually all the important and classic factor analytic studies – 477 datasets were selected for reanalysis. Just over 460 led to satisfactory solutions. The complex procedure utilised exploratory factor analysis in order to determine the number of common factors present within each dataset, resulting in the production of simple-structure first-order factors, which were subsequently analysed for the presence of higher-order factors, at the second, and sometimes, the third order. The 2850 factors produced across the different datasets reanalysed by this process were inspected and given appropriate names. This allowed an examination across the datasets to "determine how many different factors are represented among them, preparatory to interpreting them as basic dimensions of individual differences in cognitive abilities" (Carroll, 1993, p. 135).

The outcome of this laborious endeavour suggested that mental abilities could be described by a hierarchical model, consisting of 3 strata (Carroll's model is reproduced in Figure 1.1). It was an essentially syncretic model, fusing the 'opposing' blocs of previous intelligence theory and research. At the highest level, stratum III, was situated a general intelligence factor (much like Spearman's *g*, although labelled G in Carroll's analysis). Below this (stratum II) lie a number of distinct broad ability factors, including fluid intelligence, crystallised intelligence, general memory ability, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness and processing speed. Finally, stratum I consists of the narrower, more specific lower-order factors most likely to be subjugate to the appropriate stratum II factor. For example, induction and quantitative reasoning factors would lie below fluid intelligence; memory span and free recall memory factors would fall under general memory (Figure 1.1). Whilst a factor of general intelligence is firmly placed at the peak of the mental ability hierarchy, it is *de rigueur* to reiterate that the "possible importance of more specialized abilities cannot and should not be ignored" (Carroll, 1993, p. 27).

Due in no small part to the comprehensive efforts of Carroll, a *g*-centric, hierarchical concept of intelligence "is the most widely accepted current view of the structure of abilities" (Neisser et al., 1996, p. 81). A broad consensus has emerged around this hierarchical structure; however, it is imperative to distinguish between this as a description of the structure of psychometric test performance and an explanation of why people differ in their mental abilities (Deary, 2000). Nevertheless, as the "job of mapping the structure of psychometric intelligence differences is done to a sufficient degree" (Deary, 2000, p. 32), it is possible to begin examining the determinants of individual differences in mental ability, and importantly for current purposes, how these factors affect the level and change of cognitive function in later life.

1.4. Intelligence and ageing

On the whole older people do less well on some tests of mental ability compared with younger adults (Schaie et al., 2004; Hedden & Gabrieli, 2004; Salthouse, 2006). The ageing process enervates certain aspects of intelligence; that is, with increased age, cognitive decline is apparent. This general trend towards poorer psychometric test performance with increasing age has been reported by a number of international research teams cross-sectionally, or by following a diverse range of cohorts longitudinally. Longitudinal studies are, however, comparatively rare due to the logistics involved in following a large enough sample over time, and the length of follow-up required to observe actual changes in mental ability (Hedden et al., 2004). These studies also vary greatly in their design, in the nature of the tests employed or in the characteristics of the actual individuals tested. Yet, to illustrate the nature of the changes in cognitive ability that can be expected with increased age, results from one major study are discussed presently.

1.4.1. The Seattle Longitudinal Study

In 1956, the Seattle Longitudinal Study (SLS) was initiated by K. W. Schaie (constituting his doctoral dissertation), a study which has since become a key reference in the domain of cognitive ageing research. This influential project (which is still ongoing) has consisted of 7 waves of testing to date, and is a significant source of information regarding the changes in mental ability across almost the full human adult life course (Schaie et al., 2004; Schaie, 2005a). The continuing purpose of the study is to explain not only differences in the actual level of ability at a given age, but also the differences observed in the rates of change with increasing age. The latter aim could potentially suggest interventions whereby it may be possible to reduce or reverse the ageing of mental functions (Schaie et al., 2004; Schaie, 2005a).

The design of the study is unique. At the first wave in 1956, 500 participants were recruited for baseline cognitive examination from the Seattle area. These were randomly selected from a potential pool of 18,000 individuals registered at a Health Maintenance Organisation (HMO), stratified by sex and age such that there were 25 men and 25 women born in each year from 1889-1939 (aged 21 to 70 at baseline). Seven years later, these participants were recalled for repeat cognitive testing. At this time, a new sample numbering 996 individuals was also recruited. This process of retesting the survivors of previous waves and recruiting a new sample has been repeated every 7 years, so that there currently exist 9476 complete records for 4857 participants. Thus, the cross-sequential design of the SLS allows a simultaneous investigation of cohort and cross-sectional differences in cognitive ageing, and importantly, a comparison between individual paths of change in cognitive function longitudinally (Schaie et al., 2004). Over the waves of the SLS, participants have been asked to complete measures (based on Thurstone's Primary Mental Abilities) of verbal meaning, space, reasoning, number and word fluency, and in the fifth cycle (1984), multiple markers for different abilities were added (Schaie et al., 2004). Analysing these data has allowed Schaie and colleagues to investigate some of the most fundamental questions in cognitive ageing research.

The unique cross-sequential nature of the SLS allows the comparison of both longitudinal and cross-sectional data. The differences noted across cohorts vary with the particular ability under investigation; for instance, word fluency appears to be poorer in the more recent, and hence younger, samples, although these participants generally posses better inductive reasoning ability. Schaie and colleagues therefore offer the following caution to fellow researchers: if abilities in which performance is generally improving in younger cohorts are only considered cross-sectionally, these abilities may be described as being more susceptible to age-related decline than is actually the case. That is, at a single time point, older people would be observed performing poorly relative to younger individuals on the particular measures. This difference, however, is partly attributable to the improved performance in the younger group rather than wholly being the result of any cognitive decline in the older individuals. Likewise, those abilities exhibiting a performance bias for older cohorts would be characterised as showing less change with age than is the case. Longitudinal studies allow the analysis of *actual* changes with age, and remove the potential for misinterpretation of results as a consequence of possible generational changes in ability (Schaie et al., 2004).

To illustrate this, consider Figure 1.2. In the first graph (*A*), cross-sectional data are shown from the SLS and would appear to show steady, linear declines in inductive reasoning, spatial orientation, perceptual speed and verbal memory across the lifespan (numeric and verbal abilities show relative stability). Contrast this with longitudinal data gathered over a 7-year period (*B*). This would suggest that abilities are relatively stable in young and mid-adulthood, with declines becoming apparent from around 60 years of age (Schaie, 2005a). Examining cognitive abilities either cross-sectionally or longitudinally can therefore produce quite different models of change. Cross-sectional studies may overestimate changes associated with increasing age due to cohort effects. Longitudinal studies, however, are not immune from bias either, and may underestimate cognitive changes due to non-random attrition, or practice effects over numerous testing sessions (Hedden et al., 2004). Bearing in mind such methodological caveats, it is nevertheless evident that, in general, cognitive abilities may be relatively preserved to old age before declining from that point onward.

Furthermore, "there is no uniform pattern of age-related changes across all intellectual abilities" (Schaie et al., 2004, p. 309). Essentially, different abilities begin to show marked decline at different ages, and this decline occurs at different rates. As a result, any study with only a general measure of ability may be insufficient for cognitive ageing research. Fluid abilities [("concerned with basic processes of reasoning and other mental activities that depend only minimally on learning and acculturation" (Carroll, 1993, p. 624)] are seen to decline at an earlier age than crystallised abilities ["concerned with mental processes that reflect not only the operation of fluid intelligence but also the effects of experience, learning, and acculturation" (Carroll, 1993, p. 624)], although the latter show more rapid decline after about 70 years of age. Noticeable declines are generally apparent across the range of diverse abilities tested in the SLS when individuals reach 50-60 years old, and by the mid 70s, declines in all abilities are evident. Perceptual speed exhibits almost linear decline from young adulthood onwards. However, it is important to note that at age 81 "less than half of all observed individuals experienced reliable decremental change on a particular ability over the preceding seven years" (Schaie et al., 2004, p. 310). That is, whilst in general cognitive abilities decline with age, there is considerable individual variation in the extent to which this is experienced (Salthouse, 2006).

1.4.2. The course of decline

The SLS is but one study of cognitive ageing; there are a number of others each with unique design features (though most are specifically cross-sectional or longitudinal, not both as with the SLS). The individuals studied are from a range of backgrounds, have been followed for differing lengths of time, and have been tested using diverse test batteries. However, a common feature in all these studies is the general decline noted in cognitive abilities with age.

For example, the Religious Orders Study, conducted by Wilson and co-workers, has been following older Catholic nuns, priests and brothers, with the aim of examining the ageing process (and specifically Alzheimer's disease) in a group believed to be relatively homogenous with respect to lifestyle and living conditions from adulthood and beyond (Wilson, Bienias, Evans, & Bennett, 2004). The participating individuals undergo a clinical examination on a yearly basis (and have all agreed to a brain autopsy after death), allowing the level and change in mental ability to be studied. The study began in 1994, and by the end of 2002, there were 958 participants (with a target sample size of 1000). The mean age at baseline was 75.3 years. As part of the annual evaluation, each participant completes 21 cognitive tests, the scores from which are summed to give a global score. Furthermore, the tests are scored according to the domain they assess (episodic memory, semantic memory, working memory, perceptual speed and visuospatial ability) which has shown that with increasing age, the rate of decline in performance recorded across each of these domains is greater. The results of this research project have also suggested that "part of the age-related cognitive decline is global in nature but another specific proportion appears to be domain specific" (Wilson et al., 2004, p. 287); about 30% of the variance in the rate of change was shared across cognitive domains. As the participants are assessed annually, the follow-up period may be far shorter in the Religious Orders Study compared to other longitudinal projects. Moreover, there may be a large effect of terminal decline, that is, precipitous decline observed in the years immediately preceding death. Wilson and colleagues' (2004) analysis suggests that the rate of cognitive deterioration accelerates by a factor greater than 6 around three and a half years prior to death.

Whilst the Religious Orders Study aimed to investigate a group who showed potentially limited variation in their lifestyles, it may be that this cohort is highly unrepresentative of older people in general. Yet similar results have been reported in community dwelling samples of elderly persons. The Canberra Longitudinal Study was initiated in 1990 with follow-ups occurring every 4 years since (Christensen et al., 2004). The main aim of the study was to investigate the prevalence and determinants of dementia, although a secondary aim was to establish the course of what has been termed 'normal' cognitive decline. The participants were aged 70 years or over at baseline and recruited through the electoral roll. Individuals were additionally recruited from nursing homes, plus an oversampling of those older than 90. In total, 945 individuals participated in the first wave, 638 at wave 2 and 379 at wave 3. Attrition was mostly attributable to death, as refusal rates were reported as being under 10% (Christensen et al., 2004). On all the measures employed, greater decline was recorded for older individuals, with the exception of the National Adult Reading Test [NART (Nelson & Willison, 1991): this is a test of the pronunciation of irregular words, and performance at the task is often used as a measure of pre-morbid ability]. Furthermore, "decline was almost universal in at least one cognitive area among those over 85 years" (Christensen et al., 2004, p. 171).

The Kungsholmen Project (KP) is another population based study with individuals aged 75 years and over, which began in Sweden in 1987 (Backman et al., 2004). The longitudinal study has comprised assessment on 5 occasions over 13 years, with participants completing a battery of measures, including tests of attention and executive skills, episodic memory, short-term memory, verbal fluency and visuospatial skills. Although again a primary focus of the study was to investigate the determinants of dementia, valuable insights have also been gained into aspects of normal cognitive ageing. Increasing age (both cross-sectionally and longitudinally) was associated with poorer performance on tests of episodic memory, and other mental ability domains.

> The KP data...indicate a clear age-related deterioration from the mid 70s through the mid 90s for tasks in which performance [is] contingent on new learning, speed, and flexible adjustment to new situational demands...small or non-existent age-related differences were observed in tasks that draw on pre-experimental experience, have limited speed demands, and are highly automated (Backman et al., 2004, p. 217).

The KP data, as with the other longitudinal studies described, highlight the notion that age-related changes in cognitive function do not necessarily affect all domains in a wholesale fashion; whilst decrements are seen in memory and mental speed from mid adulthood, certain abilities are maintained and may not show decline until advanced years.

From the selected studies summarised, a number of key findings in cognitive ageing research have been illustrated. Cognitive changes observed cross-sectionally and longitudinally may differ, with longitudinal studies suggesting mental abilities may be sustained into old age. When marked decrements become apparent in later life, the rate of change is greater with increasing age. In addition, "ageing...influences certain cognitive functions disproportionately" (Hedden et al., 2004, p. 88); distinct domains of mental function (for example, memory, reasoning or verbal ability) exhibit unique patterns of change, with deterioration beginning at different ages and occurring at different rates. That said, although part of this age-related decline is specific to a given domain, part is global and shared across all domains (Salthouse, Fristoe, & Rhee, 1996; Schaie, 2005a; Wilson et al., 2004; Backman et al., 2004 Christensen et al., 2004; Hedden et al., 2004). To illustrate this latter point, consider Salthouse et al. (1996). A range of cognitive tests were administered to 259 adults aged between 18 and 94 years old. Analysis suggested that, on average, 58% of the variance associated with age across tests was shared, "indicating that much of the age-related variance in a variety of different variables is shared and is not all independent and specific" (p. 282). Thus, while mental abilities display unique and independent changes with increasing age they also decline partly in concert due to some common effect or process.

1.4.3. Variability in cognitive ageing

Whilst the definition of 'old' is those aged around 60 years and over, it is important to remember that this is only a guideline. Even individuals of identical chronological age show remarkable variability in their health status, independence and participation (World Health Organization, 2002). Likewise, there exists substantial variation in the course of cognitive ageing across individuals. "Some persons experienced precipitous cognitive decline, some declined more gradually, and many others stayed the same or improved" (Wilson et al., 2004, p. 287). As the cognitive trajectories recorded across persons are highly variable, it is likely that a number of factors are responsible for the observed individual differences, covering both genetic factors and those from the environment (Christensen et al., 2004). A key goal would be to determine if mutable factors accounting for this change could be identified, such that these could be promoted or discouraged as appropriate, or manipulated as part of delivered interventions, to delay, reduce, or indeed reverse this decline. It must be noted that healthy elderly individuals are often expected to show a degree of decline, often termed 'normal' ageing above. There is, however, a caution against terming any process of decline 'normal' – these processes may still be preventable or at least open to modification (Hendrie et al., 2006). The outcome envisaged would therefore be future generations in which a larger proportion of individuals maintain a satisfactory level of cognitive function, or indeed, experience successful cognitive ageing.

1.5. Pre-morbid ability and cognitive change

Whilst the potentially malleable determinants of later life mental ability will be the focus of subsequent chapters in Part II, before considering these, it is necessary to take into account a predictor which, by later adulthood cannot, by its nature, be altered: earlier mental ability. This is a central issue in cognitive ageing research and concerns the stability of intellectual performance across time. To illustrate, consider the Nun Study, a research project examining members of the School Sisters of Notre Dame (Midwestern, Eastern and Southern United States). Six hundred and seventyeight sisters were examined at baseline in 1991-1993, with annual evaluations and brain autopsy upon death (similar to the Religious Orders Study). Importantly within this group, 180 individuals had written autobiographies at a mean age of 22. From these, it was possible to derive a measure labelled idea density, defined as "the average number of ideas expressed per ten words, computed for the last ten sentences of each autobiography" (Riley, Snowdon, Desrosiers, & Markesbery, 2005, p. 342). Although far from being a perfect measure of early ability, such insufficience must often be accepted in investigations of this nature as no single study is ever likely to be panoptic. An average of 58 years elapsed from the sisters writing their autobiographies to being enrolled in the Nun Study, when they completed a battery of cognitive tests. The mean age at baseline was 80 years old, and at the seventh follow-up examination was 86.

The percentage prevalence of low idea density was greater in the more cognitively impaired groups. For the sisters with a memory impairment at the first exam, those showing mild cognitive impairment were 5.3 times more likely to have written autobiographies scoring poorly on idea density (with those having intact cognition as the reference group). The correlation of idea density with Mini Mental State Examination score [MMSE (Folstein, Folstein, & McHugh, 1975): often used as an index of global cognitive function] was .65, delayed word recall was .48 and verbal fluency was .32. The results suggested that lower idea density displayed in an autobiography written in young adulthood was associated with poorer cognitive function in later life, supporting "a strong inverse relationship between early-life linguistic ability and late life cognitive function, including mild cognitive impairments" in those groups showing memory impairments (Riley et al., 2005, p. 345). Within the sample, participants covered the complete continuum of cognitive functioning, from intact, through mild impairment, to global impairment and dementia. The authors therefore stated that the "relative homogeneity of the sisters' adult lifestyles and environments suggests that those with low linguistic ability [as assessed by idea density, related to vocabulary and general knowledge] in early life brought risk factors with them when they joined the religious congregation at an early age" (Riley et al., 2005, p. 346). A measure of early ability has thus been shown to be a major predictor of later life ability: in the Nun Study, idea density indexed from written accounts at about 22 years of age predicted just over 40% of the variance in MMSE scores assessed around 6 decades later.

The importance of baseline function was highlighted in the NIH review, which reported that this was among the "protective factors [of cognitive outcomes] most consistently reported" (p. 20). Of the 3 studies which assessed it, 2 showed a significant protective effect of higher baseline functioning (the 3rd study adjusted for baseline performance: Hendrie et al., 2006), although this review was "a descriptive summary" only so there was no discussion regarding whether ability was protective of *decline*, or whether this was just a prior-current ability correlation. Also, the review "was not intended to represent a systematic meta-analysis of predictors of cognitive…health" (p. 21) as it did not include many of the major longitudinal studies discussed above (including the SLS, for example) and was limited to studies with populations aged about 65 or over. Whilst this "reflects reality in that studies of longer time frames are both costly and hard to come about" (Lyketsos, 2006, p. 86), it neglects the importance of factors operating before this time, primarily cognitive function across the lifespan. Discovering a strong association between intellectual function in early and later life has major implications for research in this domain. For all studies attempting to investigate later life changes in mental ability it is critically important to have a measure of earlier function.

1.6. Requirements of cognitive ageing studies

Much as "the process of healthy ageing cannot be understood without considering the entire human life history" (Westendorp et al., 2005, p. 420), so too cognitive ageing cannot be investigated without a knowledge of the studied individuals' cognitive ability history. However, the Nun Study is that *rara avis* in cognitive ageing research – a study with a measure of pre-morbid intellectual function, albeit an imperfect one. None of the other studies discussed thus far can combine an early measure of ability with a follow-up into old age (the SLS begins with individuals as young as their early 20s, but the numbers of these individuals followed to their later years is presently relatively small). A measure of prior ability is required when one begins to look for predictors of the level of, and change in, later life mental function as prior ability may itself confound – or indeed precede and predict – other determinants of cognitive ageing. It is crucial that any study of successful ageing includes a full life course perspective, due to the importance of early life influences on many aspects of the ageing process.

The life course perspective is also highlighted in the need for such studies to be longitudinal. Cross-sectional data are inadequate for the purpose of examining the ageing process as they cannot demonstrate individual differences in mental ability change (Wilson et al., 2004), and are also confounded by potential generational variation in ability (Schaie et al., 2004; Schaie, 2005a). Cross-sectional studies (either across a continuous range of ages or as an extreme young-old comparison: Hertzog, 1996) may be easier to conduct, but as mentioned previously, cohort effects ["group differences that result from historical influences, such as educational opportunity, cultural factors and socioeconomic status" (Hedden et al., 2004, p. 88)] can overestimate the decline associated with the ageing process. "Age differences detected in a cross-sectional data set are inextricably confounded with cohort differences…[and] no information is available on intraindividual change" (Schaie, 2005a, p. 21). However, both cross-sectional and longitudinal methods are subject to selective recruitment. Variations in where the participants are enrolled and/or tested may skew the composition of the sample under investigation (whether contacted through, and visited at, institutional or care settings, for example, or volunteers who are required to visit an external facility) – this will have consequences for the patterns of age-related change observed (Hedden et al., 2004; Hertzog, 1996).

Longitudinal designs also have idiosyncratic methodological problems. Repeated assessment on a number of occasions introduces the possibility of practice effects, more apparent with younger samples or shorter test-retest intervals. Coupled with non-random attrition, whereby those returning for repeat testing are not representative of the baseline sample on one or more salient characteristics (including initial cognitive ability, for example), change across time may be underestimated: "longitudinal panel studies may overestimate stability unless special efforts are made to measure individuals who might otherwise be lost through attrition due to late-life decline (Hertzog, 1996, p. 29). Variations across testing occasions (including different examiners or procedures) can also affect the results obtained. In single-cohort longitudinal studies, the validity of any age-related changes may not be generalisable beyond the given historical period of the cohort if they are ultimately due to some time-specific environmental exposure or situation. Finally, regression to the mean – "the tendency of variables containing measurement error to regress toward the population mean from one occasion to the next" (Schaie, 2005a, p. 27) – can be particularly apparent in longitudinal studies testing participants only twice. Combining cross-sectional and longitudinal procedures into a cross-sequential design (as in the SLS) to reduce the inherent methodological weaknesses of each is rare, and studies are generally one or the other. Longitudinal methods allow actual change to be studied (Hultsch, 2004). In addition,

> the most powerful and unique contribution of a longitudinal study of adult development is made due to [the] fact that only longitudinal data permit the investigation of individual differences in antecedent variables that lead to early decrement for some persons and maintenance of high levels of functioning for others well into very advanced age (Schaie et al., 2004, p. 310-311).

Studying successful ageing implies studying potential determinants; this can only be achieved longitudinally, and preferably prospectively.

A number of possible determinants of mental ability in later life have been investigated. From Schaie et al.'s (2004) summary of the SLS, favourable cognitive outcomes may be related to the absence of chronic disease (particularly cardiovascular disease), high socioeconomic status leading to an advantageous environment, or having a spouse of high ability, for example.

> Many individual-difference variables within demographic (e.g., education, sex), social (e.g., activity levels), genetic (e.g., apolipoprotein E genotype), and health-related (e.g., circulatory factors, vitamin status, depressive

> symptoms) domains contribute to the variation of cognitive performance in very old age (Backman et al., 2004, p. 238).

The notion that disuse may be a major predictor of cognitive decline has been proposed, suggesting that the chief cause of cognitive ageing may be reversible, to a degree (Schaie et al., 2004). The most promising predictive factors would be those which are remediable at some point in the lifespan, such that interventions could be suggested as a possible avenue to prevent future cognitive decline:

> there may be a number of life style...factors, that may be amenable to change at midlife, whether through the individual's own conscious decision process, or mediated by environmental interventions designed to facilitate life style changes (Schaie, 1984, p. 464).

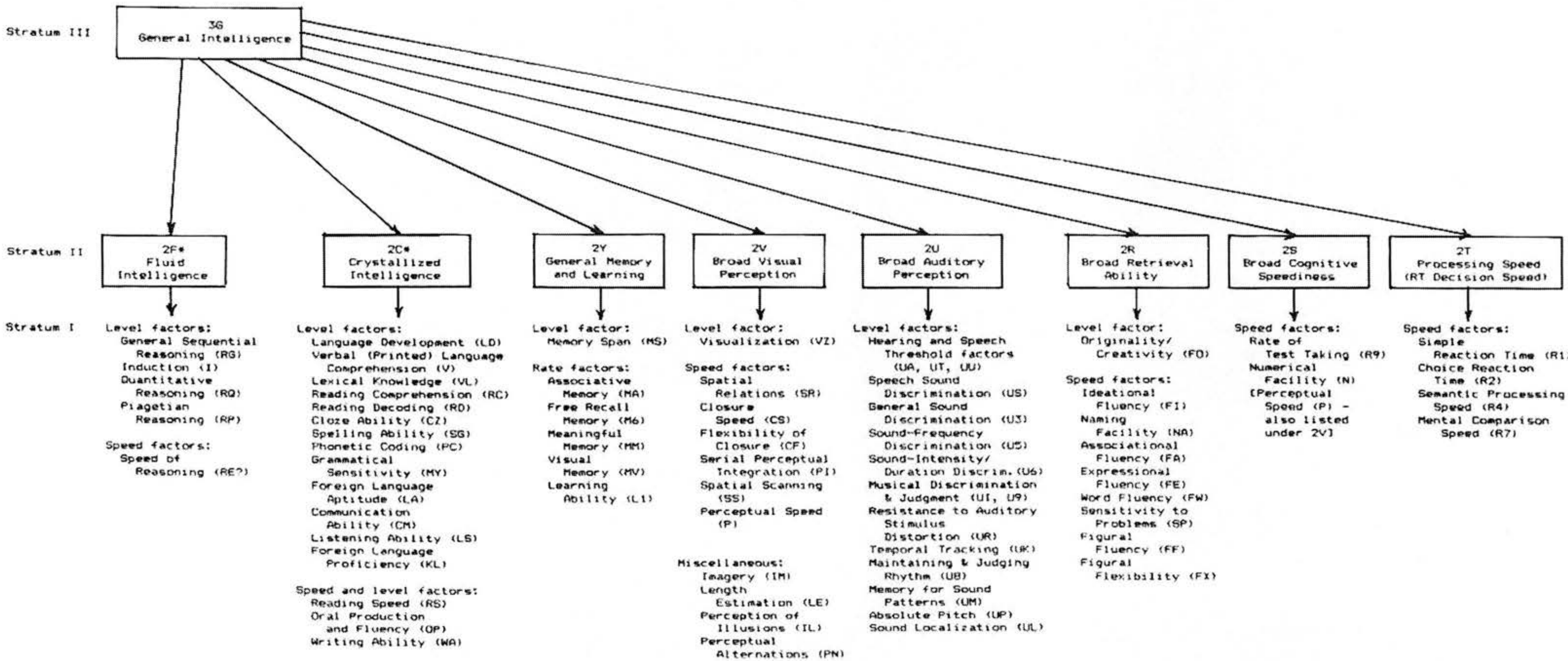
A number of these factors will be introduced and discussed further in Part II.

1.7. Summary

Although exact predictions are difficult, it is undeniable that the population is ageing. This is a local challenge, a national challenge and a global challenge. The recognised demographic shift towards an increasingly elderly population has made it ever more important to investigate the functional changes often associated with old age. Aspects of mental ability generally deteriorate with increasing age although the course of such change is highly variable. Consequently, it is possible to identify older individuals who could be described as ageing 'successfully', with respect to cognition, in relation to their peers. By examining ageing individuals and assessing their thinking and memory skills across time, it should be possible to determine what factors allow certain individuals to maintain their abilities with age whilst others experience deleterious changes limiting their independence and reducing their quality of life. The most beneficial protective factors would be those from lifestyle domains amenable to intervention. Longitudinal studies are necessary to identify such factors from across the lifespan, however, an early measure of ability is also vital due to the predictive power of this for later ability level and change.

The subsequent 2 chapters of Part I will introduce an ageing cohort which has been studied longitudinally (the Lothian Birth Cohort 1921: LBC1921), and for whom data is available concerning childhood mental ability collected as part of the 1932 Scottish Mental Survey. This unique national survey will be described in detail, before an explanation of how follow-up studies (including the LBC1921) have been derived from it, detailing the major findings which have resulted to date (Chapter 2). Novel analyses concerning the pattern of cognitive ageing observed in the LBC1921 will then be presented in Chapter 3. With this foundation in place, Part II will introduce 3 credible predictors of cognitive change (occupational characteristics, social networks and support, and activity participation), examining each in turn with respect to successful cognitive ageing in the LBC1921.

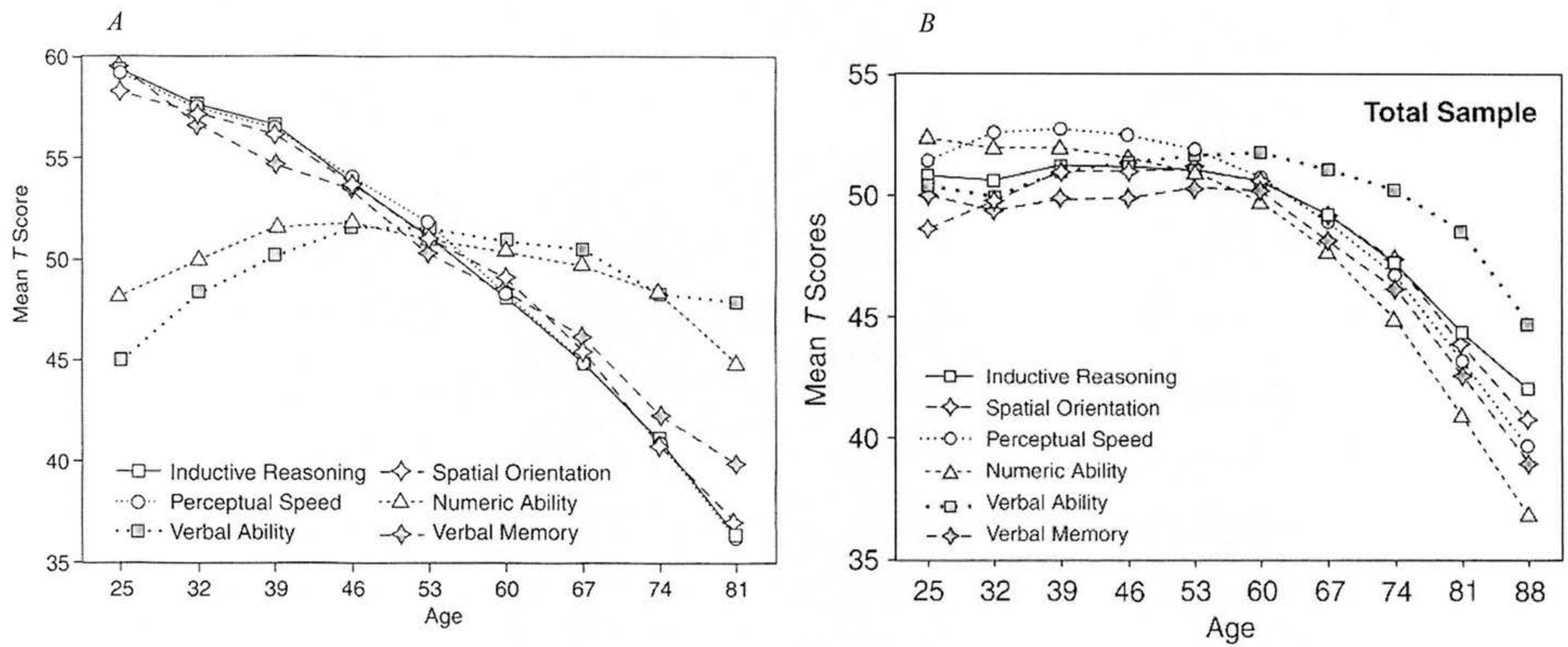
Figure 1.1 The three-stratum structure of cognitive abilities



* In many analyses, factors 2F and 2C cannot be distinguished; they are represented, however, by a factor designated 2H, a combination of 2F and 2C.

Note. A general ability factor defines stratum III, followed by broad and specific ability factors respectively. Reproduced from Carroll (1993).

Figure 1.2 Cross-sectional and longitudinal patterns of cognitive change



Note. Data from the Seattle Longitudinal Study showing the mean *T* scores for the latent ability constructs: *A* Cross-sectional age differences in ability; *B* Estimated age changes from 7-year longitudinal data. Cross-sectionally, almost linear declines are suggested in a range of abilities, whereas longitudinally, abilities are relatively stabile until declines become apparent at about 60 onwards. Reproduced from Schaie (2005).

Chapter 2: The legacy of the 1932 Scottish Mental Survey

A prerequisite for the comprehensive study of cognitive ageing would be the existence of early and valid mental ability data for those elderly individuals being followed longitudinally. Information of this nature – as discussed in Chapter 1 – is routinely lacking. This recurrent insufficiency is driven by the length of time between the collection of pre-morbid cognitive data to the start of the follow-up in old age; such a timescale is outwith the lifetime of most research projects. However, in some rare and exceptional circumstances, as with the Nun Study (Riley et al., 2005), archival information may have been recorded for individuals many years previously. If a repository of valid cognitive test data were to exist then it is reasonable to assume the persons on whom this information is held could be traced. Ideally, retesting would occur several decades after the initial assessment allowing the now aged individuals to be followed. The elderly cohort on which this thesis is based fulfil this criterion. For these individuals, there exists archived cognitive data from their childhood, the collection of which is now described.

2.1. The 1932 Scottish Mental Survey

The 1932 Scottish Mental Survey (SMS1932) was a national investigation in which almost all 1921-born Scottish children were given a test of mental ability in 1932 (when aged between 10½ and 11½ years old). In the preface to the first report of the survey, it is noted that the "most ambitious project which the Scottish Council for Research in Education have so far undertaken is the 1932 Scottish Mental Survey" (Scottish Council for Research in Education, 1933, p. vii). This remained the case until a second mental survey was conducted in 1947 (to determine whether the level of intelligence in Scotland was falling, as was popularly believed: Scottish Council for Research in Education, 1949). However, this does not diminish the achievement of conducting the SMS1932. Indeed the later, more extensive SMS1947 would not have had such utility if the SMS1932 data did not exist for comparative purposes

(Scottish Council for Research in Education, 1949). In total, 87,498 children were assessed in the SMS1932, being "truly national" as it included all 35 Education Committees in Scotland (Scottish Council for Research in Education, 1933, p. vii).

2.1.1. Purpose of the SMS1932

The purpose of the SMS1932 was to assess the "capacity", or intelligence, of Scottish children. A letter from the honorary secretary (of the council) sent to the directors of education sets out the rationale for this.

> In spite of the many statements, some of them rash and misleading, which have from time to time been made regarding the mentality of Scottish school pupils, no investigation has yet been undertaken on a sufficiently extensive scale in Scotland to admit of valid inferences regarding the distribution of intelligence in the community. The Scottish Council for Research in Education…has consequently constituted a Mental Survey Committee to secure the best evidence it can on the point. This Committee is desirous of testing out a complete age-group, viz. all pupils born in 1921, and of making the investigation as comprehensive as possible: only thus can adequate data be secured on which to base general conclusions (Scottish Council for Research in Education, 1933, p. 19-20).

These "general conclusions" were to guide solutions to the problems associated with developing curricula and teaching techniques, such that educational systems would be in place to cater for individuals displaying a wide range of abilities (Scottish Council for Research in Education, 1933). As alluded to in the extract above, claims had been made about the increasing prevalence of mental deficiency; the SMS1932 was intended to collect factual data on the distribution of intelligence. A similar survey for this purpose had been conducted in selected English areas and the objective was to repeat this in Scotland. Indeed, Scottish educationalists had long relied upon English and American data to estimate the level of intellectual variation in the school population. The SMS1932 was therefore to provide previously unavailable information relating directly to Scotland. The original proposal – suggested in 1931 – was for a "survey of mental deficiency" (Scottish Council for Research in Education, 1933, p. 5) assessing $^1/_3$ of an age-group. The remit was quickly extended as the problems associated with achieving a representative, random sample were perceived to be "insurmountable" (p. 7), and the committee organising the survey realised the advantage of making a full cross-sectional survey its main objective.

Thus it was decided a whole age-group should be tested, including those with mental and physical disabilities as far as was practicable (with the exclusion of blind and deaf children). The Mental Survey Committee approved the SMS1932: the first national survey of the level of intelligence of an entire age-group. Scotland remains the only country to have tested an entire year-of-birth cohort, as a national survey of this nature has been achieved only once more, being the 1947 Scottish Mental Survey (Deary, Whiteman, Starr, Whalley, & Fox, 2004b; Scottish Council for Research in Education, 1949).

Children aged 10½ to 11½ were selected as the group to be surveyed in the SMS1932 as they were old enough to be assessed by standardised tests yet young enough to provide the opportunity for follow-ups, should this be deemed necessary (an older age-group would have been unsuitable as they may have already taken group tests of mental ability, or be in the process of formal examinations). For simplicity, the year of birth 1921 was chosen as the eligibility criterion for the survey, and the test was scheduled for 1st June, 1932 (Scottish Council for Research in Education, 1933). Only 2 education areas did not test on the 1st (Wednesday), but instead on the 2nd or 3rd.

2.1.2. The test

The Research Council's International Examination Enquiry Committee anticipated making use of the results of the survey and so met the associated costs, using a grant received from the Carnegie Corporation of America (Scottish Council for Research in Education, 1933). Due to the expense of purchasing a proprietary test, the committee chose to develop its own instrument. Professor Godfrey H. Thomson led the development of the Group Test, basing it on materials he had previously created and used, namely the Moray House Test (MHT) Number 12. This test had been employed in English areas as a means of selecting children suitable for secondary education (Scottish Council for Research in Education, 1933). The Group Test consisted of 2 pages of picture items (the Picture Test – included for those of lower ability), followed by 5 pages of verbal items (the Verbal Test – based on the MHT). The Verbal Test portion of the Group Test (often simply referred to as the MHT below) is shown in Appendix I; the items and scoring of this will be described in more detail in Chapter 3. The final test was described as "a valid measure, if not of exactly the same "intelligence" as is measured by a Binet Test, at least of something closely allied thereto" (Scottish Council for Research in Education, 1933, p. 60). From an estimated 100,300 individuals born in 1921, 87,498 (44,210 boys and 43,288 girls) scores were tabulated for the Group Test (Scottish Council for Research in Education, 1933; Scottish Council for Research in Education, 1949).

2.1.3. Preliminary findings

In a sub-group of 500 children, the Picture and Verbal Tests correlated about .50, but little further use was made of the Picture Test scores due to a number of problems with the completion of these items (scores were extremely skewed with the test showing a marked ceiling effect). In the whole SMS1932 sample, although the distribution of ages was limited to 12 months, increasing age was associated with higher mean scores on the Group Test. [This was also recorded over a 3 year period, as in one district, all children born in 1922 and 1923 were additionally tested on 1st June, 1932 – those born in later years achieved lower scores.] Overall, the boys did slightly better, with a mean score of 34.50 compared with the girls' mean of 34.41. However, boys' scores were found to be more variable than those of the girls, with a higher percentage scoring high or low marks and a greater standard deviation (15.9 versus 15.0: Scottish Council for Research in Education, 1933).

2.1.4. Validating the test

To obtain IQ estimates from the raw Group Test scores, 1000 children (500 of each sex) were tested individually. They were distributed across Scotland in roughly the same proportions as the SMS1932, although it was impossible for an exact match due to the constraints of time on those available to conduct the testing. It was suggested the children individually tested should be born on, or near, 1st June, 1921 (to provide a random sample), although this was necessarily relaxed and birthdays ranged from March to November (Scottish Council for Research in Education, 1933). The Stanford Revision of the Binet-Simon Test was used (with additional modifications to increase the appropriateness of the test for Scottish children), and the group were later referred to as the "Binet Thousand".

Those in the Binet Thousand were not entirely representative as they had slightly higher scores on the Group Test than the full SMS1932 sample. Nevertheless, their scores were used to estimate the IQ of the national group. The analysis suggested boys and girls were not likely to be significantly different with respect to IQ, both having a mean of around 100. The lack of a truly representative Binet Thousand – due to the over-representation of higher ability children, and the variation which may have been introduced by the number of different testers – led to a further attempt at individually assessing a random sample, to enable the group test results to be correctly understood (Macmeeken, 1939). Children born in 1926 on the 1st of 4 months (February, May, August and November) were given the Stanford Revision of the Binet-Simon Test between September 1935 and November 1937 (average age 10 years 5 months). Data were collected for 873 children (which included all children in the selected group but 1) from across the whole of Scotland, comprising a "truly random sample" (Macmeeken, 1939, p. 135). The results were in agreement with those of the SMS1932, reporting a mean Binet IQ of 100.11 (15.58), and a greater variation in the boys' scores (though the latter difference was not significant, perhaps as a result of the smaller sample size).

2.1.5. SMS1932 conclusions

The Research Council noted that the survey discovered the variation in intelligence in children of the same age was greater than previously thought. In addition, they concluded that between 1.5% and 3% of the population tested had an IQ of less than 70 – the cut-off "separating the dull from the "mentally deficient"" – with a greater proportion of boys in this grouping (Scottish Council for Research in Education, 1933, p. 123).

The endeavour, though ambitious, was "entirely successful" (Scottish Council for Research in Education, 1933, p. 121). Exceptions to the survey were few and included those absent on the day of testing (the date chosen for the test ensured this would be at a minimum), or pupils from the small number of private schools which did not participate, "but with these negligible exceptions, all children born in 1921, enrolled in the private and public schools and institutions of Scotland, were given a group test during the first week of June 1932" (Scottish Council for Research in Education, 1933, p. 121). And yet, once the survey fulfilled its purpose, no further research was suggested with the information collected on the almost 90,000 1921-born individuals. Consequently, the SMS1932 data were collated, reported and then stored.

2.2. Rediscovering the SMS1932

Researchers investigating the determinants of cognitive ageing recognise the importance of early life ability data (Riley et al., 2005), yet few studies of cognitive ageing possess data from childhood through to later life. Fortunately, the SMS1932 "nominal Rolls, giving each pupil's score in the Picture and Verbal Tests separately, [had] been bound for each area, and are preserved for future reference in the office of the Research Council" (Scottish Council for Research in Education, 1933, p. 13-14). Although SCRE were aware of the existence of this "remarkable resource", it was not until the late 1990s when the SMS1932 data were 'rediscovered' by psychologists interested in cognitive ageing (Deary et al., 2004b, p. 132). Once uncovered, a research team realised the potential afforded by this information – a catalogue of the childhood mental ability of an entire birth cohort. As "it is of the utmost importance to society to know what happens to individuals with varying degrees of intelligence" (Scottish Council for Research in Education, 1949, p. 149), the unique opportunity provided by the SMS1932 data had to be pursued.

2.2.1. Purpose of the SMS1932 follow-ups

When the SMS1932 data were made known to Deary, Whalley, Starr and colleagues, the individuals who participated in the original survey were then in their late seventies. If it were feasible to trace or collect information about them, then it would be possible to determine the stability of intelligence from childhood to old age, and to investigate the determinants of lifetime cognitive change (Deary et al., 2004b). This was the main aim of the planned SMS1932 follow-ups. Few studies are able to investigate this fully due to the lack of valid prior ability information, and those that do are often based upon unrepresentative samples. The follow-up research resulting from the SMS1932 can be categorised under 2 main groupings:

- **Linkage studies:** linking individual test scores from age 11 to other information collected on the same individuals held in local or national databases (this could include nationally available data on mortality, for instance, or data from other large surveys which may have included SMS1932 participants);
- **Cohort survivors:** tracing individuals who participated in the SMS1932, and recruiting them into follow-up studies to assess their cognitive and health status in old age.

To date, both approaches have been pursued, producing a body of research far beyond the original scope of the SMS1932. It is an investigation arising from the latter approach which provides the main focus of this thesis (the Lothian Birth

Cohort 1921 Study). Before describing this, a summary of the findings resulting from the follow-ups of the SMS1932 will be provided.

2.2.2. Data linkage studies with the SMS1932

In the SMS1932 Nominal Rolls stored by SCRE, each pupil's name, date of birth, school and score on the Group Test (separately for the Picture and Verbal Tests) were recorded. The demographic information would be sufficient to trace entries for these individuals in local and national records (via anonymised linkage), and therefore investigate the relationship of childhood mental ability to a variety of outcomes without recourse to physically tracing each participant for a follow-up. The outcomes investigated in this manner to date have included mortality (Whalley & Deary, 2001) and lifetime contact with psychiatric services (Walker, McConville, Hunter, Deary, & Whalley, 2002).

2.2.2.1. Childhood mental ability and mortality

The data from the SMS1932 allowed the effect of childhood mental ability on longevity to be examined (Deary et al., 2004b). In Aberdeen, 2792 children sat the SMS1932. Using national registers (public health records) it was possible to trace 2230 of these individuals and determine their vital status on 1st January 1997: in total, 646 men and 438 women had died (Whalley et al., 2001). The individuals who had died were found to have significantly lower age-11 mental ability. Comparing individuals differing by 15 points in IQ (1 standard deviation), those of lower mental ability had a 79% chance of being alive compared with those of higher ability. Age of death was also significantly associated with age-11 IQ ($r = .18$, $p < .001$), such that those dying at a younger age tended to have a lower age-11 IQ; this remained significant even when father's occupation and overcrowding (indicators of socioeconomic status and deprivation) were controlled. Whalley and Deary (2001) concluded that a higher IQ in childhood increases the chance of being alive to age 76. Few studies are able to highlight in a broad, representative sample how traits from a young age can have an impact in later life, including major outcomes such as survival. The effect of cognitive ability on survival is well replicated [for example, childhood ability predicted survival in men to their mid-50s (Kuh, Richards, Hardy, Butterworth, & Wadsworth, 2004; Osler et al., 2003)].

The analysis of the SMS1932-linked mortality data was extended by additionally considering the cause of death, specifically those attributable to cancer (Deary, Whalley, & Starr, 2003b). Lower childhood mental ability was associated with an increased risk of dying from cancer: for each standard deviation drop in IQ, the chance of death due to cancer was increased by 40% in women and 27% in men. When individual types of cancer, for example lung or breast cancer, were examined, individuals who died as a result of stomach, lung or an unspecified cancer had lower mean IQs compared to those whose deaths were not attributable to cancer (Deary et al., 2003b).

Mechanistic explanations for the childhood mental ability-mortality association would necessarily highlight the influence of early ability on later lifestyle choices, for example smoking behaviour or diet, with their consequent effects for overall health. However, it is also possible that higher initial ability allows entry to safer environments throughout life (including work), or that increased childhood ability may itself be a reflection of the integrity of an individual's bodily systems, being better adapted to cope with the vicissitudes of life (Whalley et al., 2001).

2.2.2.2. Childhood mental ability and mental health

The SMS1932 data have also been utilised to determine whether lower mental ability in childhood is related to mental health outcomes. For example, of the 8073 individuals who were tested at age 11 in the North East of Scotland, it was possible to determine that 4199 had remained in the area until adulthood and could therefore potentially be linked with area health records concerning psychiatric contact (Walker et al., 2002). Records showed that 1008 individuals born in 1921 had contact with psychiatric services at some point during their life; 435 of these could be linked to a score in the SMS1932 (after 6 cases had been excluded due to diagnoses of learning disabilities). The subsequent analysis compared those individuals who had a score recorded in the SMS1932, were still resident in the North East of Scotland area and who had (N = 435) or had not (N = 3764) had psychiatric contact. Those in the former group had a lower mean childhood test score; younger age at first contact with psychiatric services was also related to lower childhood IQ (Walker et al., 2002). Each 15 point decrease in IQ (1 *sd*) was associated with a 12% increase in the risk of developing a psychiatric disorder requiring professional assistance.

2.2.2.3. Birth weight and childhood mental ability

Of course, it is important to consider that early ability is itself predicted by a number of factors. Linking the SMS1932 with medical records taken before age 11 has allowed an investigation of the predictors of childhood mental ability, including the effect of birth weight on later cognitive functioning. Birth records from the Edinburgh Royal Maternity and Simpson's Memorial Hospitals had been retained, which included births from the year 1921 – the year in which the SMS1932 participants were born. At these 2 hospitals, there were 985 live singleton births in 1921, of which, 449 could be linked to SMS1932 data (Shenkin et al., 2001). Using regression analysis, 5 predictors explained 15.6% of the variance in age-11 MHT score (including age at MHT, illegitimacy of birth and maternal parity), with the largest contributions from birth weight (3.8%) and social class (6.6%: Shenkin et al., 2001). This relationship supports the hypothesis that factors operating early in childhood (that is, evident even before birth) may have a lasting influence on later health and functioning (Deary et al., 2003b). Childhood ability is not only antecedent to later health outcomes, but is, in addition, a mediator and an outcome of factors operating earlier in the lifespan, such as birth weight and parental social class (Shenkin, Starr, & Deary, 2004).

2.2.2.4. Linking the SMS1932 to the Midspan studies

In the preceding investigations, the SMS1932 data have been linked with information collected as part of routine recording and monitoring: birth weight, mental health and mortality. However, the blanket coverage of the SMS1932 meant that any sizeable research project conducted in Scotland from 1932 onwards might have included SMS1932 participants, if large enough samples of the population were recruited. This was found to be the case with the Midspan studies. These were carried out in the 1960s and 1970s and assessed cardiorespiratory factors in adults (Davey Smith et al., 1998; Hawthorne et al., 1995). It was discovered that 1251 Midspan participants were born in 1921 and were therefore likely to have been included in the SMS1932. In total, 1032 Midspan participants were matched with an entry in the 1932 records and 938 had a test score listed (Hart et al., 2003b; Hart et al., 2003a). To date, this linkage has resulted in the effect of childhood ability on a number of midlife outcomes being examined.

Poorer performance on the MHT at age 11 has been linked to: lower social status and increased deprivation by mid-adulthood (Deary et al., 2005b; Hart et al., 2003a); greater probability of being ever-married compared to never-married (Taylor et al., 2005b); a reduced likelihood of smoking cessation (Taylor et al., 2003); higher blood pressure in midlife (Starr et al., 2004b); increased risk of cardiovascular disease, coronary heart disease and stroke (Hart et al., 2004); smoking-related hospital admissions, cancer (Taylor et al., 2005a); and mortality (Hart et al., 2003b). To illustrate a couple of these findings in more detail, Taylor et al. (2003) were investigating the link between ability in childhood and smoking cessation. Whilst there was no difference in ability level between ever and never smokers, each standard deviation increase in childhood IQ conferred a 33% advantage to giving up smoking by midlife, although this was reduced to 19% and no longer significant after controlling for deprivation category, occupational social class and sex. Nonetheless, the trend highlights the link between childhood ability and health behaviours. Information about the health risks of smoking was simply not available when the cohort would have started smoking, suggesting that the more able individuals are those more likely to heed public health messages once these filter through (Taylor et al., 2003). Childhood IQ was also predictive of mortality in the 25 years following the Midspan screening. Controlling for deprivation and social class, each standard deviation decrease in IQ resulted in a 12% increase in the risk of death (Hart et al., 2003b). Health inequalities by midlife have been linked to childhood ability, clearly reducing quality of life or indeed shortening the lifespan as a result. The effect may potentially work directly and/or indirectly via social factors or health behaviours.

2.2.3. Limitations of linkage

Research linking the data collected in the SMS1932 to existing local and national health records or large epidemiological studies has led to several interesting findings relating childhood mental ability to various health-related outcomes. Childhood ability emerges in these sizable, representative samples as an important predictor of a range of later life endpoints, including mortality. These useful insights notwithstanding, this methodology is clearly limited by the records that exist and that can be successfully linked. Although the procedure can examine the predictive power of childhood ability for such outcomes, it is insufficient to examine the process and predictors of the current topic – cognitive ageing. To investigate the stability of intelligence across the lifespan, the lifetime determinants of cognitive change and the effect of early ability on other outcomes of interest (for example, occupational attainment or quality of life), it would be necessary to not only trace the individuals, but recruit them into a longitudinal follow-up study (Deary et al., 2004b). Follow-up studies of SMS1932 survivors have been conducted in 2 areas of Scotland: Edinburgh and Aberdeen. This thesis will focus on follow-ups of the Edinburgh based group (known as the Lothian Birth Cohort 1921), but the recruitment, testing and published findings from both areas will be discussed presently.

2.3. Recruiting survivors of the SMS1932

In both areas, Community Health Indices (listing individuals registered with a General Practitioner) were used to recruit survivors by identifying people born in 1921. These individuals were contacted and invited to take part in a follow-up of the SMS1932 if they were at school in Scotland when aged 11. Additionally, recruitment was also conducted through survey publicity and the media; the majority of participants recruited in Edinburgh had responded to the media calls. Recruitment of 1921 born individuals began in 1997 in Aberdeen, and 1999 in Edinburgh (and the surrounding areas, the Lothians). The individuals subsequently recruited constituted the Aberdeen Birth Cohort 1921 (ABC1921) and the Lothian Birth Cohort 1921 (LBC1921) respectively. Additionally in 1999, individuals resident in the Aberdeen area who sat the SMS1947 were recruited into the Aberdeen Birth Cohort 1936 (ABC1936). Participants in each of the cohorts have attended at least one clinic visit during which a number of assessments were conducted relating to their cognitive, physical and mental health (Deary et al., 2004b). Results from the follow-ups of the Aberdeen Birth Cohorts are summarised below. As the present research is based on the LBC1921 Study, this cohort and associated findings are described in greater detail later (2.6 The Lothian Birth Cohort 1921). In each instance, it is important to remember the follow-ups of these cohorts are unique as an *actual* measure of pre-morbid ability is available.

2.3.1. Aberdeen Birth Cohorts

Two hundred and thirty four individuals were recruited into the ABC1921, and over 400 into the ABC1936; the ABC1936 are 15 years younger than the ABC1921 (Deary et al., 2004b). With the Aberdeen Birth Cohorts, it is possible to compare 2 similar groups of individuals who sat the same test of mental ability at the age of 11, and who were then given the same tests of mental ability in the same setting in later life. The ABC1921 follow-up allowed the stability of psychometric intelligence to be investigated over the longest recorded period from childhood to late adulthood. When this cohort repeated the MHT as a group aged 77 (a period of 66 years to the day since they first sat the test), data were available for 101 individuals at both 11 and 77 years old. MHT scores from early and later life were found to correlate .63 ($p < .01$: Deary, Whalley, Lemmon, Crawford, & Starr, 2000). This increased to .73 after disattenuation for the restriction of range (compared with the full national sample from which they were drawn, the test scores of the cohort sample were less widely distributed), highlighting the remarkable stability in mental ability across the whole lifespan. In essence, 40-50% of the variance in MHT scores at age 77 was accounted for by test scores at age 11. That prior ability is revealed to be such a major predictor of later ability only emphasises the necessity of a measure of early ability in cognitive ageing research (Deary et al., 2000); individual variation in early intelligence *must* be accounted for otherwise the extent to which later life changes in this can be indexed is somewhat limited. Nevertheless, that childhood ability explains about 50% of the variation in later cognitive function also underscores the degree of change observed across several decades; that is, the other 50% of the variance must be explained by factors other than early ability. Over a lifetime, intellectual function exhibits both marked change and marked stability.

Ninety-seven individuals from the ABC1921 also completed Raven's Progressive Matrices (RPM: Raven, Court, & Raven, 1977) and the National Adult Reading Test (NART: Nelson et al., 1991). RPM scores correlated .57 with age-77 MHT, thus providing concurrent validity for the MHT (Deary et al., 2000); NART correlated .73 (.78 after disattenuation) with age-11 MHT, thus providing validity for the NART as an index of prior ability (Crawford, Deary, Starr, & Whalley, 2001). The NART is perhaps the most commonly used measure of pre-morbid function in studies that lack a true early measure of ability. Participants are required to read a list of irregular words and successful pronunciation is believed to index pre-learned knowledge of the word. Performance on this task is therefore an estimate of prior functioning, before the onset of any age-related or other deficits. The associations reported in the ABC1921 provided crucial confirmation as to the NART's validity; this had previously only been possible over shorter term follow-ups or with concurrently assessed ability (Crawford et al., 2001). [Later work reaffirmed this finding and demonstrated that after childhood ability was controlled, there was no difference in NART performance between the cognitively healthy members of the LBC1921 and a group with dementia comprising 1921-born individuals attending a memory clinic and individuals from the ABC1921 with a dementia diagnosis (McGurn et al., 2004).]

Many of the ABC1921 participants have attended repeat cognitive testing sessions on multiple occasions since the baseline follow-up, at durations of about 15 months (Bain et al., 2003). The first follow-up after the initial age-77 test (1997) is referred to as Wave 1, the second as Wave 2, and so forth. Using NART and Raven's Progressive Matrices completed at 77 and 78 years old, the difference between these measures was criterion validated as an *estimate* of lifetime cognitive change against the MHT-Raven's difference (an *actual* measure of lifetime cognitive change), and also confirmed the stability of this estimate over a 1 year interval (Deary, Whalley, & Crawford, 2004). Each wave of testing has further examined a number of possible consequences of individual differences in age-11 mental ability, or the determinants of later cognitive function that can be investigated for the first time entirely independently of pre-morbid ability.

2.3.1.1. Childhood cognitive ability and health

For example, research with the ABC1921 allowed the first look at the impact of childhood mental ability on health in old age. This had previously not been possible due to the lack of validated mental ability data in ageing cohorts. Two-hundred and eight members of the ABC1921 underwent extensive mental and physical health screening, and information was collected on socioeconomic status in childhood and adulthood. With respect to the presence of current disease, there was no significant difference in age-11 MHT score when comparing those with or without any disease (Starr, Deary, Lemmon, & Whalley, 2000). When specific diseases were examined, those developing dementia had lower age-11 MHT scores, though this association was no longer significant once education and occupation were controlled. In a further analysis (Whalley et al., 2000), members of the ABC1921 without dementia were used as controls for those with dementia in the cohort. Additionally, 1921-born dementia sufferers who were not participants in the study were identified using local and national health indices and were linked to their record in the SMS1932. Childhood ability was associated with the occurrence of late, but not early, onset dementia. Individuals developing late-onset dementia achieved significantly lower MHT scores at age 11. The results provided:

> support for a link between age-related brain changes and late-onset dementia in which the link is modified by childhood mental ability (Whalley et al., 2000, p. 1458).

Whilst the relationship between prior ability and dementia had been reported previously, this replication was important as it was based on an actual measure of childhood ability rather than a proxy measure.

Returning to the analysis of childhood ability and health (Starr et al., 2000), age-11 MHT performance was significantly associated with functional independence (assessed using the Barthel index); no other socioeconomic factors entered the model after pre-morbid ability (Starr et al., 2000). The mechanism for the link between lower childhood mental ability and increased disability in later life (independent of socioeconomic status) may be partly explained by higher ability individuals being able to adapt more successfully to physical impairments acquired throughout life. Or similarly, individuals able to solve problems associated with disease-related impairment may be better problem-solvers in general, and would consequently score higher on tests of mental ability (Starr et al., 2000).

2.3.1.2. Childhood ability and quality of life

In Wave 3, 88 participants of the ABC1921 were interviewed at home to assess quality of life (QoL). The data collected suggested that those individuals in the lowest QoL tertile were slightly younger, had lower age-11 IQ, lower RPM, decreased optimism (assessed by the Life Orientation Test) and increased symptoms of anxiety and depression (from the Hospital Anxiety and Depression Scale: HADS). Regression analysis suggested about 28.9% of the variance in QoL was accounted for by HADS (19.2%), optimism (2.7%) and age-11 IQ (7.0%: Bain et al., 2003). Current ability (assessed using the MMSE and Raven's Progressive Matrices) did not enter the model. This ABC1921 analysis was the first to link childhood mental ability and quality of life in old age. The association is believed to result from the stability of cognitive function across the lifespan, and would suggest that those of higher ability are better able to cope with adverse changes as they age.

> Childhood mental ability (together with its determinants and consequences) is an important influence on QoL in old age. As individuals age, they progress into old age with a repertoire of behaviours with which to face adversities. Those with higher childhood mental ability have probably enjoyed more opportunities to master life problems more successfully and acquired a substantial body of knowledge with which to age more successfully (Bain et al., 2003, p. 836).

2.3.1.3. Nutrition and adult cognitive ability

Of course, early ability is not only an independent predictor of major life outcomes (as shown with the earlier survival analyses, for example: Whalley et al., 2001), it is also a fundamental factor that must be controlled when attempting to predict the determinants of later cognitive function. Diet and nutritional factors have been implicated in the ageing of cognitive abilities; however, as diet (being a health behaviour) may be partly determined by ability, it is important to examine this association whilst adjusting for the impact of prior functioning. Vitamin B-12, folate and homocysteine concentrations were assessed in members of the ABC1921 and ABC1936 in Wave 2. The analysis suggested that concentrations of vitamin B and folate were positively related to mental ability. Increased homocysteine concentration (a known neurotoxin previously related to impaired memory functions) was associated with poorer cognitive function in later life, but only in the ABC1921, accounting for about 7-8% of the variance after controlling for early ability (Duthie et al., 2002). Homocysteine concentrations were lower in the ABC1936, and so it was concluded nutritional interventions in early old age may allow this to be controlled, and therefore promote healthier cognitive ageing. It is possible that resistance to the harmful effects of homocysteine is reduced in the ageing brain (Whalley, Starr, & Deary, 2004).

In a related vein, the use of dietary supplementation was assessed in the ABC1921 using a food frequency questionnaire to investigate the possible impact of this behaviour on health and cognition at age 77. The results suggested that those who used dietary supplements had higher levels of α-carotene and vitamin C plus lower levels of homocysteine and γ–tocopherol. Interestingly, users scored better on the

MHT at age 11 but their concurrent cognitive function (assessed by MMSE and Raven's) was not significantly different to non-users, either before or after controlling for age-11 ability (Whalley et al., 2003a). However, over 3 waves of testing, there was a significant interaction between time and supplement use; for Raven's performance there was "a slight but significant relative retention of cognitive ability…associated with continuing DS [dietary supplement] use" (p. 775). Whalley et al. (2003a) did highlight the uncertainty in the mechanism behind this finding. The association may be a consequence of a genuine effect of the supplements, or related to the better health of supplements users. Whilst dietary supplements may have benefits for health in general, it appears that benefits to cognitive health require replication in prospective trials. [Results from the ABC1936 have since tentatively linked better cognitive performance at age 64 with the use of food supplements and levels of fatty acids (Whalley, Fox, Wahle, Starr, & Deary, 2004).]

2.3.1.4. White matter lesions and adult cognitive ability

Members of the ABC have also undergone brain scanning (Magnetic Resonance Imaging) to investigate the relationship between various physical parameters in the brain (for example, the extent of white matter lesions – WML) and mental ability. Initially, 133 ABC1921 participants were randomly selected and invited to undergo a scan. From the resultant 95 scans, it was revealed that the severity of WML was associated with concurrent performance on a range of neuropsychological measures. However, pre-morbid ability was not associated with the severity of lesions suggesting their aetiology cannot be ascribed to differences in ability in early life, but must be independent of this (Leaper et al., 2001).

The analysis was extended when further ability tests were considered and the effect of certain medical conditions (notably hypertension) were also included (Deary et al., 2003). The results were consistent with the earlier report: childhood ability and WML both made significant and independent contributions to the variation in general cognitive ability in later life. Hypertension also accounted for part of the WML effect on later ability, whilst also independently affecting later functioning to a small extent (Deary et al., 2003). The study suggested that white matter lesions affect general cognitive ability rather than specific abilities. Furthermore, white matter lesions were associated with balance problems, whilst concurrent ability and gait speed were related (Starr et al., 2003). From work with the ABC, it is clear that there exist multiple links between mental ability, brain parameters and functional and health outcomes. Theses outcomes will clearly have an impact on quality of life and maintained independence with age.

2.3.1.5. Brain volumes and cognitive ability

Grey matter volume was assessed using MRI scans, with 82 individuals having complete data for analysis (at a mean age of 78.5 years). In this sample, grey matter volume was associated with the concentration of plasma folate and vitamin C, and negatively with plasma homocysteine, cholesterol and LDL all measured from blood samples (Whalley et al., 2003b). Vault size was partialled out of all correlations, which were between .2 and .3 in magnitude. The results confirmed the belief that "plasma constituents believed to be harmful in excess (homocysteine, cholesterol) correlated negatively [with grey matter volume]; constituents believed to be beneficial correlated positively" (Whalley et al., 2003b, p. 175). Age-associated brain shrinkage may be affected by variation in the levels of these factors which is in agreement with the previous work that reported a link between homocysteine level and poorer cognitive function (Duthie et al., 2002).

Predictors of brain size are interesting because of the link between brain size and ability; factors which directly affect the volume of brain regions may have an impact on the course of cognitive decline. However, it was unclear whether differences in brain volume are associated with changes seen in specific mental abilities, or more general cognitive ability. Ninety-eight members of ABC1921 had scans that were adequate for the analysis; 66 of these participants were still alive and free from dementia 4 years later (Staff, Murray, Deary, & Whalley, 2006). It was reported that, once childhood ability was controlled, there were associations between brain volumes and performance on specific cognitive tests. When the tests were combined to give a general cognitive ability factor, this was also associated with brain volumes. Once the variance associated with the general factor was removed from the individual cognitive tests, there were no significant correlations between test performance and brain volume. The team concluded:

> the cognitive decline observed appears to be general, and we find no evidence that specific cognitive domains are associated with differences in brain volume (Staff et al., 2006, p. 1438).

The follow-ups of the ABC1921 and ABC1936 are ongoing.

2.4. The Lothian Birth Cohort 1921

Five-hundred and fifty individuals were recruited into the LBC1921 and tested between 1999 and 2001 (Deary et al., 2004b; the full recruitment procedure will be detailed in the methods and procedures of Chapter 3). All were ambulant and living independently at the time. At the initial LBC1921 follow-up, the mean age was 79.1 years; this has previously been referred to as age 80 (i.e. Deary et al., 2004b), but will be denoted hereafter as age 79 to avoid confusion with later methodology. Each participant was given a number of cognitive tests when aged 79, including the MHT they sat when they were 11. The correlation between the MHT scores from childhood and old age was .66 (.73 after disattenuation for the restriction of range). When these were converted to IQ-type scores and corrected for age in days at the time of testing, the association between IQ at ages 11 and 79 was .66; age-11 IQ accounted for about 43.4% of the variance in age-79 IQ. These results are in accordance with those previously reported for the ABC1921, but are from a sample over 5 times as large. The follow-up of the LBC1921 (and ABC1921) has allowed the stability of mental ability across the lifespan to be investigated over a longer period than was previously possible (Deary et al., 2004b).

2.4.1. Gender and adult cognitive ability

In the LBC1921, when childhood ability was controlled, sex accounted for about 1.7% of the variance in MHT scores at age 79; women experienced greater relative cognitive decline (Deary et al., 2004b). With increasing age, men's abilities in the tests used (different results may be seen with other tests) seem to be relatively spared compared to women's. The explanation for this difference may lie in the differential mortality rates of men and women. Men experience a shorter lifespan and so those tested in the LBC1921 (and ABC) may represent a healthier male survivor group who have been relatively spared the processes of cognitive decline. Also, as longevity is related to childhood ability (Whalley et al., 2001), the remaining, fewer men are likely to have higher IQs.

2.4.2. Smoking, prescribed medications and adult cognitive ability

As with the ABC Studies, the LBC1921 participants have provided information about a range of medical, genetic, social and lifestyle factors. Smoking behaviour predicted later cognitive function. In 470 LBC1921 participants with full data (including if they were a current, former, or never smoker, and the age they started/ceased smoking where appropriate), current smokers had significantly lower age-79 MHT scores than former and never smokers (Deary et al., 2003a). This effect was independent of prior ability. Medication use was also comprehensively assessed. The analysis suggested that individuals medicated with neuroactive drugs (such as antidepressants and tranquilisers) appeared to have a poorer age-79 cognitive function. Polypharmacy was also related to reduced cognitive performance in old age, whilst statins (used to treat cardiovascular disease) had a positive effect (Starr et al., 2004a). These associations remained significant after a number of factors were controlled, including years of education and social class. However, in the final analysis entering all the significant predictors of later ability, the only factors which remained in the model were sex, the total number of drugs (accounting for 2.2% of the variance) and use of statins (2.8%). The effect of medication use on the change in ability from childhood to later life was small but significant at a population level. The authors concluded it was not apparent whether it is the increased burden of disease indexed by a higher number of prescribed medications, or the medications themselves, which lead to the reduction in late-adult ability. Certain drugs may have cognitively protective effects, notably statins (Starr et al., 2004a). Reverse causality, however, could not be ruled out – it is possible that those of higher ability are more likely to request certain medications, or are successful in being prescribed them.

2.4.3. Vitamin B-12, serum folate and lifetime cognitive change

Blood samples taken from the LBC1921 at age 79 were used to assess levels of vitamin B-12 and serum folate. Levels of these compounds were related to both childhood and late adulthood ability. When age-11 ability was controlled, the association between age-79 ability and folate was completely attenuated; however, lower concentrations of vitamin B-12 were associated with a relative decline in ability from 11 to 79 years old (Starr, Pattie, Whiteman, Deary, & Whalley, 2005; Starr, Pattie, Whiteman, Deary, & Whalley, 2004). Vitamin B-12 accounted for under 1% of the variance in late-adulthood cognitive function.

2.4.4. Brain parameters and adult cognitive ability

Two subsamples of the LBC1921 have undergone brain scanning procedures. In a group of 30, diffusion tensor magnetic resonance imaging revealed that brain parameters were related to cognitive ability assessed across the lifespan [for example, fractional anisotropy in the centrum semiovale was associated with MHT performance at ages 11 ($r = .42, p = .003$) and 79 ($r = .41, p = .003$)], thus confirming the need to control for early ability in studies assessing white matter structures and cognitive ageing (Shenkin et al., 2003). Forty participants underwent scanning when aged 83 as part of a second wave of follow-up with the LBC1921 (Deary et al., 2006). The age-83 wave of testing will be described in more detail in

Chapter 3. When childhood ability and age-83 information processing efficiency were controlled, the association between general ability and centrum semiovale fractional anisotropy was reduced by 85%. Deary et al. (2006) concluded that white matter integrity is associated with early ability, ability in later life and information processing efficiency.

2.4.5. Genetic influences on adult cognitive ability

Genetic analyses have also been performed on the LBC1921 in order to examine the heritable component of intellectual stability and change (Deary et al., 2002). Notably, APOE status was determined in 466 participants with full cognitive data. Age-11 IQ was not significantly different in those with one or more APOE ε4 allele, compared to those with none (presence of the ε4 allele is a recognised predictor of later-life cognitive decline); however, those with the ε4 allele were found to have significantly lower age-79 IQ. In modelling cognitive change, age-11 MHT score, sex and the presence of ε4 were all significant predictors (the model was unchanged when those with an MMSE equal to or less than 28 were excluded: Deary et al., 2002). The presence of the APOE ε4 allele explains a similar proportion of the variance in cognitive change across the lifespan to smoking behaviour, about 1-2% (Deary et al., 2003a). Moreover, the available evidence concerning APOE status and cognitive change suggested that the ε2 allele may also be related to mental function. In a further analysis making use of a broader range of tests (and not solely IQ scores derived from the MHT), presence of the ε4 allele was associated with poorer performance on a test of verbal memory (Logical Memory from the Wechsler Memory Scale – Revised: Wechsler, 1987); presence of the ε2 allele was associated with improved performance on this test. In the LBC1921, APOE status (that is, the presence of the ε2 or ε4 allele) is associated with verbal memory (positively and negatively, respectively) at age 79 (Deary et al., 2004a).

A great deal of genetic analyses have been carried out using the LBC1921 (and also ABC samples). Various genes have been linked to later life functioning, independent of childhood ability (Harris et al., 2006) or to the lifelong trait of intelligence [that is, the gene is linked to childhood ability, but not to later ability after early function is adjusted (Deary et al., 2005a)]. A summary of the LBC1921 genetic findings is presented in Table 2.1. This work may help us to learn more about the development of intelligence or the mechanisms underlying cognitive ageing. Nevertheless, interventions are unlikely to be suggested from such work which ageing individuals themselves can immediately act upon.

2.5. Summary

From data linkage studies connecting local and national databases to individuals who participated in the 1932 Scottish Mental Survey, and follow-ups of groups of survivors of this with the Lothian and Aberdeen Birth Cohorts, it is clear that early ability has a major impact on later cognitive function and health. If disattenuated estimates are used, early ability accounts for about 50% of the variance in later life ability. The ongoing aim of the ABC and LBC studies is therefore to identify what factors determine this stable 50% (genetic and environmental factors from early life), and importantly, where the remaining 50% of the variance can be found (Deary et al., 2004b). Small contributions to lifetime cognitive change have already been accounted for in the follow-ups of the SMS1932 by genetic factors, smoking, medication use, nutrition, and brain white matter abnormalities, for example. A full list of the publications arising from this research is given in Appendix II.

The continued follow-ups of the SMS1932 are "uniquely suited to inquiring about the determinants of cognitive aging, because they can provide early-life mental ability data and, combined with cognitive data from later life, allow the calculation of actual cognitive change" (Deary et al., 2004b, p. 143). However, the assessment of lifestyle variables in the follow-ups has been somewhat limited to date, often covering aspects of health behaviour such as smoking or diet. If lifestyle modifications are ever to be suggested as a viable means of protecting future generations against cognitive decline, a thorough assessment across a range of lifestyle domains is necessary. This broad evaluation has now been carried out in the LBC1921.

From the preceding description of the SMS1932 (and also SMS1947) follow-ups, the utility of a valid measure of childhood ability is clear. It has allowed an investigation of the ageing process – both physical and mental – with reference to pre-morbid information that is so often lacking. This research continues. And yet, the foregoing discussion considered 2 available data points for the LBC1921 (from ages 11 and 79). Therefore, before turning to the predictors of cognitive change in the LBC1921 (Part II), a new phase of the study will be introduced. In the next chapter, the methods of the initial LBC1921 recruitment will be summarised, followed by a detailed and previously unreported account of this second wave of cognitive testing. This recent follow-up allows the calculation of the changes observed in mental ability from age 79 onwards, that is, the continuing course of cognitive change in the LBC1921.

Table 2.1 Genes and cognitive ageing in the Lothian Birth Cohort 1921

Gene	Age-11 IQ	Age-79 IQ	Other	Publication
APOE	No	Yes	Memory	Nature (2002) 418, 932 Psych & Aging (2004) 19, 367
Nicastrin	Yes	Yes		Neuroscience Letters (2005) 373, 110
KLOTHO	Yes	Yes		Neuroscience Letters (2005) 378, 22
COMT	No	No	Memory	Neuroscience Letters (2005) 385, 1
PRNP	No	Yes		Neuroscience Letters (2005) 386, 116
DISC1	No	Yes: ♀		Neuroscience Letters (2005) 389, 41
BDNF	No	Yes		Molecular Psychiatry (2006) 11, 505

Note. Table shows the presence or absence of an association between the named gene and IQ in childhood or late adulthood. Effect sizes small; replication needed (but *APOE* well replicated).

Chapter 3: Lifetime cognitive change in the LBC1921

In the preceding chapter, the background to the Lothian Birth Cohort 1921 Study was explained and the initial published findings related to childhood ability, late adulthood ability and lifetime cognitive change were summarised (from the LBC1921 and allied SMS1932 follow-ups). A comprehensive account of the LBC1921 recruitment now follows, before an investigation of cognitive change in old age in this group. The battery of cognitive measures completed by the cohort at ages 79 and 83 (reported in the full cohort for the first time) will be described and subsequently analysed. The aim is to examine the course of later life cognitive change in the LBC1921 (from age 79 to 83), and to produce summary scores to be used in subsequent analyses in Part II, alongside the previously described and analysed cognitive measures (that is, age-11 and age-79 IQ derived from the Moray House Test).

The timeline of the longitudinal follow-up of the LBC1921 is illustrated in Figure 3.1. Points of interest – to be discussed throughout – are indicated along this timeline using bold letters (A-E). In the methodology which follows (and subsequently in Chapters 5, 7 and 9), reference will be made to this timeline to highlight at which point in the follow-up the assessment being described occurred.

3.1. 1932 Scottish Mental Survey

3.1.1. Group Test procedure

The 1932 Scottish Mental Survey (SMS1932) tested almost all 1921-born children at school in Scotland on 1st June 1932 (Scottish Council for Research in Education, 1933). [On the LBC1921 Study timeline (Figure 3.1), the SMS1932 is labelled **A**.] Test papers and administration instructions were sent either directly to the schools, or via their education authorities. A Preliminary Practice Test lasting 10 minutes preceded the Group Test to familiarise the children with the details to be completed on the cover sheet and the format of the test items and answers. The practice test papers were distributed to the pupils, and time was allowed to complete the cover sheet. For each pupil, their name and surname, sex, school, date of birth and name of county, burgh or parish were requested; their class in school was recorded by their teacher (Scottish Council for Research in Education, 1933).

The Group Test followed after a short interval, beginning with the pupils completing the same information on the cover sheet. Forty-eight minutes of working time were allowed for the test proper: the first 2 pages [Picture-Digit Substitutions (1 minute) and Pictorial Classifications (2 minutes)] were timed separately (the results from which were little used, and will not be discussed further), before 45 minutes were allowed for the Verbal Test. The latter (reproduced in Appendix I) contained 71 numbered items, 75 items in total, with a maximum score of 76, and was based on the Moray House Test Number 12 [this Verbal Test portion of the Group Test will hereafter simply be referred to as the Moray House Test, or MHT, as it has been described in previous reports of the LBC1921 follow-up (Deary et al., 2004b)]. The items of the MHT were classified as (with the number of items in each category shown): Following Directions (14), Same-opposites (11), "Different" Word (10), Analogies (8), Practical (6), Reasoning Tests (5), Proverbs (4), Arithmetical (4), Geometrical (4), Mixed Sentences (3), Cypher Test (2) and Other items (4). Although classified as such, these headings did not appear on the test paper, with the items appearing in an ""omnibus" form, i.e. items of different sorts were mixed together" (Scottish Council for Research in Education, 1933, p. 55). Many of the results were marked and tabulated by the participants' teachers (each page was also checked by a second individual), with the remainder being scored by staff and students at Moray House Training College, Edinburgh. The raw scores were archived in Nominal Rolls at the Scottish Council for Research in Education Headquarters in Edinburgh. The mean MHT score (out of 76) was 34.50 (*sd* = 15.93) for boys and 34.41 (*sd* = 15.02) for girls (Scottish Council for Research in Education, 1933).

3.1.2. Individual Test

One thousand children were also tested individually using the Stanford Revision of the Binet-Simon scale. These children – the Binet Thousand – were to be a representative, control sample for the whole survey population. Additional information collected from the Binet 1000 included father's occupation and current address so that the distribution of social class in this sample could be examined. The Binet Thousand had their individual and group results linked, which showed this sample were slightly more able than the whole survey population. The Binet IQ-MHT score correlations were .81 for boys and .78 for girls, providing concurrent validation for the MHT (Scottish Council for Research in Education, 1933, p. 100).

3.2. Lothian Birth Cohort 1921 Study

3.2.1. Age-79 Cognitive Testing procedure

The recruitment of the Lothian Birth Cohort 1921 (LBC1921) has been described in detail previously (Deary et al., 2004b). In summary, survivors of the SMS1932 from Edinburgh and the surrounding areas were traced either through the Community Health Index or as volunteers replying to media calls, and recruited into the LBC1921 Study (a follow-up of those tested at age 11 to investigate the determinants of cognitive ageing). In the former method, 1921-born individuals listed on the Community Health Index – a list of individuals registered with a General Practitioner (GP) in a given area – were identified, and leaflets were sent via their GP inviting them to participate in the study. One thousand one hundred and twenty individuals were mailed in this way. Replies were received from 728 individuals (59.6%), of which 501 (68.8% of the replies) were eligible for inclusion in the study; 260 individuals (51.8% of those eligible) agreed to participate (Deary et al., 2004b). Four hundred and twenty-three requests for further information were received as a result of media advertisements, of which 368 (86.9%) were from individuals eligible for inclusion in the study; 321 (87.2%) of these agreed to participate (Deary et al., 2004b). This longitudinal follow-up began in 1999 [labelled **B** on the LBC1921

Study timeline (Figure 3.1)], and 550 individuals (234 men and 316 women) were tested individually at the Wellcome Trust Clinical Research Facility (WTCRF) at the Western General Hospital, Edinburgh, by 2 trained researchers – Alison Pattie and Martha Whiteman. The participants (known as the LBC1921) were given the MHT as part of the test session, in addition to the collection of other cognitive, psychological, social, medical and physiological data. The mean age of the LBC1921 at the 1st MHT administration was 10.9 years (*sd* = 0.3) and at the 2nd was 79.1 years (*sd* = 0.6). For simplicity, these are referred to as ages 11 and 79 throughout.

3.2.2. Age-79 cognitive battery

At age 79, a battery of cognitive tests was administered to the LBC1921.

3.2.2.1. Moray House Test

The MHT was delivered as at age 11, with only 2 minor item alterations due to changes in the monetary system and word usage since 1932:

> 5. If 19d is the same as 1/7 write G, if not write R

was replaced with

> 5. If 19 inches is the same as 1 foot and seven inches write G, if not write R;

and in

> 49. Underline the ONE of the four correct answers to each statement which seems to you to be correct:-
>
> Vitamine is found in–(fresh milk and fruits, lard, dried fruits, stale bread),

"Vitamins are" replaced "Vitamine is".

A valid age-11 MHT score (a mark out of 76) was listed for 496 of the 550 LBC1921 (mean age-11 MHT score = 46.4, *sd* = 12.0), whilst 542 individuals had an MHT score recorded at age 79 (mean age-79 MHT score = 59.2, *sd* = 10.8). The stability of

MHT scores from age 11 to 79 was $r = .66$ ($p < .001$), N = 486. [Note: Deary et al. (2004) reported that 493 participants were linked to a record in the SMS1932. The database has since been updated with age-11 MHT scores added for a further 3 participants. The mean score was not altered by this, but the standard deviation was previously reported as 11.9 and the age-11 and age-79 MHT correlation was based on 485 participants, although its magnitude remained the same.] The raw MHT scores were corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15).

At age 79, participants also completed the Mini-Mental State Examination (MMSE), the National Adult Reading Test (NART), Raven's Progressive Matrices (RPM), Verbal Fluency (VF), and Logical Memory (LM).

3.2.2.2. MMSE

The MMSE (Folstein et al., 1975) is commonly used as a screening tool for dementia. It is a brief measure and scores of less than 24 correct (out of 30 items) are often used as an indicator of mild dementia (Lezak, 1995).

3.2.2.3. NART

The NART (Nelson et al., 1991) requires participants to pronounce 50 irregular words of graded difficulty, and is often used as a marker or estimate of pre-morbid IQ, that is, maximal ability (Lezak, 1995). Participants are unlikely to guess how to pronounce the words due to their phonemic irregularity, and so previous familiarity is required for successful completion. Performance is the number of words correctly pronounced. NART score at age 77 correlated .73 ($p < .001$) with age-11 IQ in the ABC1921, providing validity for the test as an indicator of prior cognitive function (Crawford et al., 2001).

3.2.2.4. Raven's Progressive Matrices

Raven's Matrices is a pattern-completion test consisting of 60 items requiring non-verbal reasoning and induction. Participants are required to choose the correct response (from a choice of 6 or 8) to complete a larger pattern. The LBC1921 were time limited to 20 minutes, and performance was the number of correct responses in this time (Raven et al., 1977).

3.2.2.5. Verbal Fluency

Verbal Fluency is a measure of executive function and requires participants to produce words in a specified grouping (Lezak, 1995). In the LBC1921, participants were required to name as many words as possible beginning with a target letter. After a brief practice with the letter S, 1 minute was allowed for each of 3 letters (C, F and L); the 3 scores were summed to give a Verbal Fluency score. The instructions highlighted that proper nouns and numbers were not acceptable, and that essentially similar words with a different ending (for example, see and seeing) would only be counted once (Deary et al., 2004b).

3.2.2.6. Logical Memory

Logical Memory is a subtest of the Wechsler Memory Scale – Revised (WMS-R: Wechsler, 1987) assessing verbal declarative memory. Participants are instructed to listen carefully to 2 short stories, and after each, their (immediate) recall from memory is assessed (with a maximum score of 25 for each story). After a period of time, their (delayed) recall of the stories is then assessed. Performance on the immediate and delayed recall of the 2 stories is the number of items correctly recalled, which were summed to give a Logical Memory score (maximum score = 100).

3.2.3. Age-83 Cognitive Testing procedure

All retained LBC1921 participants (that is, all individuals except those who had withdrawn or had died since age-79 Cognitive Testing) were sent a letter inviting them to participate in this next stage of the follow-up, accompanied by a more detailed information leaflet. Four hundred and fifty-four participants were mailed (Figure 3.2), 20 individuals at a time. About one week after mailing, the participants were telephoned to determine whether they wished to participate and to make an appointment (transport to and from the session was offered to participants). In total, 119 individuals (26.2% of those mailed) did not take part in this wave of testing: 10 had died, 16 withdrew from the study after being contacted, 80 were unable or did not wish to participate and 13 were no longer contactable; 335 participants (73.8% of those mailed) agreed to attend the cognitive testing session, and 321 were tested (70.7% of those mailed; 58.4% of the original LBC1921). Testing commenced in December 2003 and was completed in September 2005 [labelled ***D*** on the LBC1921 Study timeline (Figure 3.1)], and was conducted by 2 trained researchers – Alison Pattie and Alan Gow – in the Visual Psychophysics Laboratory at the Princess Alexandra Eye Pavilion (Royal Infirmary of Edinburgh). Each participant was tested individually in a session lasting between 2½ and 3½ hours.

Of the 321 participants tested, 45.2% (145) were male and 54.8% (176) were female; 271 were assessed by Alison Pattie and 50 by Alan Gow. Mean age at testing was 83.4 years old (*sd* = 0.5), ranging from 82.0 to 84.6. This will be referred to as age 83 throughout. The mean follow-up time (between age-79 and age-83 Cognitive Testing) was 4.3 years (*sd* = 0.4), ranging from 3.1 to 5.8 years.

3.2.4. Age-83 cognitive battery

Participants were given a battery of cognitive measures which again included the MMSE, NART, Raven's Matrices, Verbal Fluency and Logical Memory. These were delivered as described above (3.2.2 Age-79 cognitive battery).

3.3. Results

3.3.1. Cohort description

3.3.1.1. MHT

Mean MHT score was 46.4 (*sd* = 12.0) at age 11 and 59.2 (*sd* = 10.8) at age 79 in the LBC1921 (Table 3.1). Considering age-11 MHT scores, those who attended age-83 Cognitive Testing performed better than those who did not [mean age-11 MHT for those who did attend at age 83 was 47.3 (11.7) versus 45.3 (12.4) for those who did not (Table 3.1)]; this difference was not statistically significant [$t(494) = -1.834$, $p = .067$]. However, there was a significant difference in age-79 MHT performance between those who did and did not attend the age-83 follow-up [mean for those who did attend = 60.9 (9.8) versus 56.9 (11.8); $t(422.26) = -4.213$, $p < .001$ (Table 3.1)].

3.3.1.2. MMSE

A valid MMSE score was recorded for 548 participants at age 79, and for 321 at age 83, with mean values of 28.2 (1.7) and 28.1 (1.9) respectively. Mean scores ranged from 18 to 30 at both ages. Compared to those who attended age-83 Cognitive Testing, those who did not attend had significantly lower age-79 MMSE scores [28.4 (*sd* = 1.5, range 22-30) versus 27.9 (*sd* = 1.9, range 18-30); $t(414.8) = -2.892$, $p = .004$ (Table 3.2)]. For those participants who were assessed at ages 79 and 83, MMSE scores correlated .47 ($p < .001$), with mean scores of 28.4 (1.5) and 28.1 (1.9) respectively. [The mean MMSE at age 79 differs from that reported above as this is for the returning subsample only.] The difference in MMSE scores across the 2 testing occasions was statistically significant [$t(318) = -2.907$, $p = .004$]; participants generally scored lower at the second follow-up. The MMSE descriptive results suggest the cohort is generally cognitively healthy as scores below 24 are often used as an indicator of possible dementia (Lezak, 1995); on both testing occasions, only 9 participants scored less than 24 points in the MMSE, although there was a small but significant decrease in MMSE performance over the 4 years of follow-up. MMSE scores are used for descriptive purposes in the LBC1921 only, and will not be analysed further.

3.3.1.3. NART

At ages 79 and 83, mean NART scores were 34.2 (sd = 8.3, range 9-49, N = 548) and 35.3 (sd = 7.7, range 13-49, N = 320) respectively. Age-79 NART scores were not significantly different between those who did or did not attend age-83 Cognitive Testing [34.7 (sd = 8.2, range 9-49) versus 33.4 (sd = 8.5, range 10-49); $t(546) = -1.889$, $p = .059$ (Table 3.2)]. For the participants who attended both cognitive test sessions, age-79 and age-83 NART scores were highly correlated ($r = .94$, $p < .001$), although there was a statistically significant improvement over the follow-up period [age-79 mean = 34.7 (sd = 8.2) and age-83 mean = 35.3 (sd = 7.7); $t(317) = 3.491$, $p = .001$]. Whilst NART scores were highly stable from age 79 to 83, participants showed a slight improvement over the 4 years of follow-up, possibly due to a practice effect. As with MMSE scores, the results from the NART will not be analysed further.

3.3.2. Age-79 and age-83 cognitive ability tests

3.3.2.1. Test descriptives

Descriptives for Raven's Matrices (N = 543), Verbal Fluency (N = 546) and Logical Memory (N = 548) performance at age 79 are presented in Table 3.2, with means displayed separately for those who did or did not attend age-83 Cognitive Testing. For each of the cognitive ability tests performed at age 79, performance was significantly lower in those individuals who did not attend the age-83 follow-up (Table 3.2).

Table 3.2 also shows the mean age-83 cognitive ability test scores (N = 317 for Raven's Matrices, and 320 for Verbal Fluency and Logical Memory). Performance at age 83 was lower on all 3 tests compared with age 79 levels (when comparing the age-79 means of those who attended the age-83 follow-up). The difference was significant for Raven's Matrices [$t(314) = -8.645$, $p < .001$] and Verbal Fluency [$t(316) = 3.059$, $p = .002$], but not Logical Memory [$t(317) = .1.084$, $p = .279$]; participants attending both age-79 and 83 Cognitive Testing sessions thus showed significant decline over 4 years on 2 out of the 3 cognitive ability tests delivered.

The associations between cognitive ability test performance at ages 79 and 83 are shown in Table 3.3. The 3 tests given at age 79 show small to moderate positive intercorrelations, ranging from .18 to .39 ($p < .001$). Similarly, the 3 tests show small to moderate positive associations at age 83 ($.29 < r < .40$, $p < .001$). Performance on any particular test at age 79 was highly correlated with performance on the same test at age 83 (Raven's Matrices $r = .79$, Verbal Fluency $r = .76$ and Logical Memory $r = .76$, $p < .001$). An individual's test performance at age 79 therefore accounts for at least (because period free reliability is not taken into account) 58-62% of the variance in later performance on the same test.

Age-adjusted scores were created for each of the cognitive ability tests by saving the standardised residual from a linear regression with test performance as the dependent variable and age in days at the time of testing as the independent variable. Table 3.4 presents the associations between these age-adjusted cognitive ability test scores and IQ at ages 11 and 79 (based on MHT scores, described previously: see 3.2.2.1). Correlations between age-11 IQ and the cognitive ability tests ranged from .26 (age-79 Logical Memory) to .51 (age-83 Raven's Matrices). Age-79 IQ showed moderate to high associations with the other cognitive ability tests, with values ranging from .39 (age-83 Verbal Fluency) to .71 (age-79 Raven's Matrices). [The age-79 Raven's Matrices-MHT association has previously been reported (Deary et al., 2004b), providing concurrent validity for the MHT assessment.] As expected, individuals with higher childhood or late adulthood IQ (calculated from MHT performance at ages 11 and 79) performed better on other tests of cognitive ability at ages 79 and 83.

3.3.3. Composite cognitive ability score

A principal components analysis (PCA) was run on the age-adjusted cognitive ability test scores (Raven's Matrices, Verbal Fluency and Logical Memory) to determine whether a single ability factor appropriately described the data. In this analysis, for example, Raven's scores at ages 79 and 83 were combined into a single column in the database [note the scores were not summed, but rather the age-83 scores followed *after* the age-79 scores, as if each score were from different individuals at a single testing occasion, rather than some being repeated measures]. This process was also carried out for Verbal Fluency and Logical Memory. The PCA was conducted in this way so that a comparison of the means across time would be meaningful. If PCA were conducted separately for ages 79 and 83, comparing the mean standardised scores would be spurious. The overall KMO measure of sampling adequacy was .60, with individual test values ranging from .57 (Raven's Matrices) to .65 (Verbal Fluency). The analysis suggested that 1 factor effectively described the data, accounting for 53.9% of the variance. The loadings of the cognitive tests on this first unrotated component are shown in Table 3.5, which ranged from .66 to .80. The standardised residual from the PCA was saved as a composite ability score, which was split according to whether it was based on tests completed at ages 79 or 83.

The association between the age-79 and 83 composite ability scores was high (r = .84, $p < .001$, N = 313), however, composite scores at the 2 testing occasions differed significantly [age-79 mean = 0.19 (0.96), age-83 mean = 0.01 (1.02); $t(312) = 5.628$, $p < .001$] indicating that decline was observed across the follow-up.

The associations between the composite cognitive ability scores (ages 79 and 83) and IQ (ages 11 and 79) are shown in Table 3.4. Age-11 IQ is positively correlated with age-79 and age-83 cognitive ability score (r = .49 and .52 respectively, $p < .001$), suggesting that childhood ability accounts for about 24-27% of the variance in these composite measures of later life cognitive ability. Age-79 IQ is highly correlated with age-79 and age-83 cognitive ability score (r = .73 and .67, $p < .001$). Increased intellectual ability (as assessed by the MHT) in childhood or late adulthood is associated with higher cognitive ability (from a composite of 3 tests) in later adulthood.

3.3.4. Later life cognitive change

Finally, measures of later life cognitive change (age 79 to 83) were computed. In each case, the age-83 age-adjusted cognitive test score was entered as the dependent variable in a linear regression; the age-79 age-adjusted test score was entered as the independent variable. The standardised residual produced was used as a measure of change for the particular cognitive test; a positive change score represents a relative increase in performance over the 4 years. A measure of change was computed for the composite cognitive ability score also. The correlations between these change scores and IQ at ages 11 and 79 are shown in Table 3.4. Age-11 IQ has small but significant positive associations with all measures of later life cognitive change, ranging from .13 to .17. Likewise, age-79 IQ is positively associated with all measures of later life cognitive change (r = .14 to .17). Individuals with higher ability in early childhood or late adulthood show more positive cognitive change in later life.

3.4. Discussion

3.4.1. Following-up the Lothian Birth Cohort 1921

The group under investigation in this thesis were given the Moray House Test (MHT) at age 11 as part of the 1932 Scottish Mental Survey. They were recruited into the Lothian Birth Cohort 1921 (LBC1921) Study – a follow-up aimed at discovering the determinants of cognitive ageing – aged about 79 when the MHT was re-administered. This phase of the study included 550 individuals and has been described and reported previously (i.e. Deary et al., 2004b). In addition to the MHT, a battery of cognitive tests was also administered at age 79 which included Raven's Progressive Matrices, Verbal Fluency and Logical Memory (the Mini-Mental State

Examination and the National Adult Reading Test were also included in the battery for descriptive purposes). Aged about 83, 321 participants returned for a second wave of testing. Analysis of this cognitive battery and the second wave of testing have not previously been reported. Using data from the LBC1921, it is therefore possible to investigate the course of cognitive change across the human lifespan (from age 11 to 79, and 79 to 83 years old).

3.4.2. Childhood IQ and ability in later life

The LBC1921 participants are rare in cognitive ageing research due to the presence of a validated measure of pre-morbid functioning combined with a substantial follow-up period (currently 72 years). This measure of childhood ability (expressed as an IQ score) was related to all of the tests completed (and composite measures of ability) at ages 79 and 83, with correlation coefficients ranging from .26 to .52. Furthermore, childhood ability was related to the change in test performance across the 4 years of later life follow-up. Those scoring more highly in childhood did better in later life and showed less decline. This is concordant with the studies of early ability and later functioning reviewed in Chapter 1 (for example, the Nun Study: Riley et al., 2005).

3.4.3. Participants versus non-participants at age 83

The LBC1921 are generally a cognitively healthy group; on each testing occasion, only 9 participants scored below the MMSE threshold which would raise concerns about possible dementia (< 24 out of 30: Lezak, 1995). [Note that unlike many studies of cognitive ageing, the MMSE is used here for general description and not as a major cognitive endpoint. Although one of the most commonly utilised measures, the MMSE displays marked ceiling effects making it a poor marker of change in a cognitively 'intact' group (Skoog, 2006).] It is, however, worth noting the cognitive differences between those participants who did or did not attend the age-83 follow-up. Those who did not participate in this second wave of testing scored more poorly on the MMSE 4 years before, and also on the MHT, Raven's Matrices, Verbal Fluency and Logical Memory. This may be indicative of early decline causing some participants to withdraw, those of lower baseline ability being less likely to wish to continue with such a study or being in poorer health at the time of the follow-up. Interestingly, there was no difference between those who participated in the age-83 testing and those who did not when considering age-79 NART performance. The NART is often used as a measure of pre-morbid functioning and this result would suggest that there is no difference in prior ability between those who did or did not continue with the study. This is supported by the *actual* measure of prior function in the LBC1921 (age-11 IQ from the MHT) as the mean level of this did not differ across age-83 participants versus non-participants.

Retention in a longitudinal study such as the LBC1921 appears to be dependent not on early ability (which may be one of the determinants of initial entry into the study) but on the declines experienced in later life. This selective loss of participants is a potential weakness of the LBC1921 follow-ups, as it is with any other longitudinal study (Kuller, 2006; Schaie, 2005a; Hertzog, 1996). It can make studying average, or normally distributed factors, problematic due to the cohort under investigation becoming progressively skewed. Whilst impossible to remove this bias entirely, the high response rates achieved with the LBC1921 have reduced this as far as is possible. Regarding childhood ability, the LBC1921 were more able than the population from which they were drawn. This is as would be expected from a study of this nature as "recruitment methods that place high demands on older people, such as volunteering to come to a university for testing, might over-represent the highest performing older adults" (Hedden et al., 2004, p. 88). Within the LBC1921 Study, however, the presence of early ability data allows this potential confound to be controlled to an extent not possible in other projects.

3.4.4. Cognitive change in later life

For those participants who were tested at 79 and again at 83 years old, it is possible to investigate the changes in performance on the cognitive measures across this time. Considering the MMSE, there was a statistically significant drop in the mean score which would suggest the cohort are doing less well on this very general measure of ability. Such a decline was not observed for the NART, which, in fact, showed the opposite trend. Performance actually improved on this test from age 79 to 83. The reasons for this are unclear, however, the NART assesses crystallised abilities (in this case lexical knowledge) which are less likely to decline with age (Hedden et al., 2004; Schaie, 2005a). Furthermore, this particular test may be susceptible to a practice effect if participants remember specific words they had difficulty with during the initial test presentation.

At the age-83 follow-up, the mean level for Raven's, Verbal Fluency and Logical Memory were also lower when compared to the levels 4 years previously, the former 2 significantly so. As with the longitudinal studies of cognitive ageing discussed in Chapter 1 (for example: Wilson et al., 2004; Christensen et al., 2004), over time, the members of the LBC1921 are experiencing observable cognitive decline. As expected, increased age is associated with poorer performance across varied cognitive domains. When the tests were combined to give a composite cognitive score (a 'general' intelligence factor), significant decline was detected over 4 years in this also. It must be remembered, however, that although statistically significant decline has been recorded, the cognitive tests and composite ability measure all display high test-retest associations, highlighting the stability of mental function across time. This stability and the impact of prior ability on later functioning means that discovering determinants of the level of, and change in, later ability is problematical.

> One cannot expect to predict changes on abilities if a sufficient range of individual differences in change has not yet occurred (Schaie, 1984, p. 464).

3.4.5. Calculating cognitive change scores

The principal advantage of conducting longitudinal research lies in the assessment of the same participants on two or more occasions, allowing the level of change across time, and individual differences in this, to be investigated (Hertzog, 1996). As summarised above, the LBC1921 experienced significant cognitive decline over time. However, in addition to describing the changes across time which have occurred, there are various methods for characterising this as a change score (Frerichs & Tuokko, 2005). This is particularly important for the next stage of analysis where the determinants of this measure of cognitive change will be sought. It is possible to use a simple difference across occasions, the standard deviation method whereby change greater than a standard deviation is regarded as significant, or standardised regression-based techniques (the later being the chosen alternative in this thesis). Using the simple difference method, for example, later performance on a given test is subtracted from earlier performance on the same test. This measure of change is appropriate as long as the tests are not prone to floor or ceiling effects, and is "conceptually the simplest and most readily interpretable measure of growth [or decline] in a two-wave design" (Collins, 1996, p. 39). The 'best' method to use is a matter of debate, but may be determined by the nature of the study, including the tests employed and the follow-up interval, although the results obtained may not differ greatly (Frerichs et al., 2005).

In the foregoing analysis with the LBC1921, residualised change scores were used, "where initial score is partialed out of a later score in an attempt to "control for" initial status" (Collins, 1996, p. 51). It is, however, not always simple to interpret the score calculated from this method. Each cognitive change score calculated in this thesis has, by definition, a mean of 0 and a standard deviation of 1. A change score above 0 indicates a *relative* improvement in the specific test over the 4 years, whereas scores below 0 indicate *relative* decline. Therefore, the lower and more negative the change score, the greater the extent of cognitive decline which has occurred. This has been described, along with the alternative methods of calculating change, as "reasonably accurate in defining normal change" (Frerichs et al., 2005, p.

330). Furthermore, previous research has indicated that the measures of change produced from the regression and simple difference approaches may be highly related (Singer, Lindenberger, & Baltes, 2003). In the LBC1921, when the simple difference between composite cognitive ability at ages 79 and 83 was calculated as a measure of change (not reported above), this correlated .98 ($p < .001$, N = 313) with the regression-based standardised residual measure of change. Singer et al. (2003) also reported a correlation of .98 between a raw difference score and residualised (gain) score as measures of change in a composite measure of intelligence. The regression-based method benefits from the fact it takes account of the baseline from where change is being calculated, which may account for part of the subsequent change observed. It is the measures of change produced from this approach which will be used in subsequent analyses.

3.4.6. Summary of cognitive variables

Throughout the subsequent chapters of Part II, associations between psychosocial factors and cognition assessed across the lifespan will be investigated in the LBC1921. For these purposes, the following measures of mental ability, as described above, will be used:

age-11 IQ (MHT score at age 11, corrected for age in days at time of testing and converted to an IQ score);

age-79 IQ (MHT score at age 79, corrected for age in days at time of testing and converted to an IQ score);

age-79 cognitive test scores for Raven's Matrices, Verbal Fluency and Logical Memory (corrected for age in days at time of testing);

age-79 cognitive ability (standardised residual of age-79 Raven's Matrices, Verbal Fluency and Logical Memory from a PCA of the age-corrected cognitive tests at ages 79 and 83);

age-83 cognitive test scores for Raven's Matrices, Verbal Fluency and Logical Memory (corrected for age in days at time of testing);

cognitive ability age 83 (standardised residual of age-83 Raven's Matrices, Verbal Fluency and Logical Memory from a PCA of the age-corrected cognitive tests at ages 79 and 83);

later life (79 to 83 years old) cognitive change (standardised residual from a linear regression with age-83 cognitive test/composite cognitive ability score as the dependent variable and age-79 cognitive test/composite cognitive ability score as the independent variable).

The presence of childhood ability allows the investigation of the effect of a range of potential determinants of later functioning whilst simultaneously removing the shared variance associated with this measure. A range of cognitive domains have been assessed and combined into a composite cognitive ability score. Predictors of the level of, and change in, this measure will be examined, as will the change in the 3 separate cognitive tests, to determine whether the lifestyle factors assessed affect cognition firstly in a general sense, or act on more specific functions. As discussed by Schaie and colleagues (2004, 2005), abilities decline at different rates; using only a general measure of ability may mask these differences.

3.5. Part II outline

"The 1932 survey asked very few questions in respect of the children tested" (Scottish Council for Research in Education, 1949, p.142); only the most basic demographic information was taken and no immediate follow-ups were planned. [The lack of demographic data was improved somewhat in the SMS1947, when a sociological schedule was completed for each child, with further information collected from a random sample: those born on the first 3 days of each month (the 36 Day Sample) and all twin pairs (Scottish Council for Research in Education, 1949).] There is a consequent paucity of information between this point (age 11) and the inception of the LBC1921 Study. Furthermore, the SMS1932 follow-ups have had a generally medical or genetic basis with less emphasis on the effect of psychosocial factors on cognition. But enquiring in greater detail about the lifestyle histories of the

LBC1921 participants can rectify this and is likely to present a valuable opportunity to investigate the determinants of cognitive ageing.

> A topic of great interest in the study of age-related individual differences is the characterization of those older adults who tend to perform as well as younger adults. What is unique about these 'successful seniors' and how might we improve the likelihood of mimicking their success? (Hedden et al., 2004, p. 93).

The subsequent chapters of this thesis are an attempt to address this question. Each will review a domain with potential predictive and protective effects for later cognitive change. Chapter 4 will cover occupational characteristics, Chapter 6 will focus on social networks and support, whilst Chapter 8 will deal with one of the most popular areas investigated in the field of cognitive ageing, that of engagement in activities of a physical, social or intellectual nature. Specific issues related to each of these domains will be dealt with in the appropriate chapter. Immediately following each review chapter, the assessment of the particular lifestyle factors in the LBC1921 will be described (which has included participants being asked to supply details in a major self-report at age 80, shortly the after age-79 follow-up, and a retrospective self-report questionnaire booklet completed at age 83) before an analysis of the predictive power of these areas with respect to successful cognitive ageing (in Chapters 5, 7 and 9).

With the noted demographic shifts, "the need to preserve optimal levels of cognitive…functioning in this aging population" becomes a major focus of research (Hendrie et al., 2006, p. 13). Discovering modifiable, lifetime determinants of successful cognitive ageing in the LBC1921 are now the subjects of Part II.

Table 3.1 Mean Moray House Test performance at ages 11 and 79

	MHT			
	Total Sample	Did not attend age 83	Did attend age 83	*t* (sig)
Age 11	46.4 (12.0) N = 496	45.3 (12.4) N = 202	47.3 (11.7) N = 294	-1.834 (p = .067)
Age 79	59.2 (10.8) N = 542	56.9 (11.8) N = 224	60.9 (9.8) N = 318	-4.213 (p = .000)

Note. MHT = Moray House Test. Did not attend age 83 = age-11/79 mean MHT score for the participants who did not attend the age-83 follow-up; Did attend age 83 = age-11/79 mean MHT score for the participants who returned for the age-83 follow-up; *t* (sig) = the t-test value (and significance level) for the difference between mean age-11/79 MHT scores for those who did or did not attend age-83 Cognitive Testing. Figures shown are mean MHT scores with standard deviations in parenthesis.

Table 3.2 Mean cognitive ability test performance at ages 79 and 83

	Age 79			
	Did not attend age 83	Did attend age 83	*t* (sig)	Age 83
MMSE	27.9 (1.9) N = 229	28.4 (1.5) N = 319	-2.892 (p = .004)	28.1 (1.9) N = 321
NART	33.4 (8.5) N = 230	34.7 (8.2) N = 318	-1.889 (p = .059)	35.3 (7.7) N = 320
Raven's Matrices	29.3 (9.0) N = 225	32.5 (8.4) N = 318	-4.303 (p = .000)	29.7 (9.2) N = 317
Verbal Fluency	38.1 (12.3) N = 228	41.4 (12.2) N = 318	-3.090 (p = .002)	39.8 (12.7) N = 320
Logical Memory	28.8 (12.5) N = 229	33.7 (12.7) N = 319	-4.488 (p = .000)	33.0 (14.4) N = 320

Note. MMSE = Mini-Mental State Examination, NART = National Adult Reading Test. Did not attend age 83 = mean age-79 test scores for the participants who did not attend the age-83 follow-up; Did attend age 83 = mean age-79 test scores for the participants who returned for the age-83 follow-up; *t* (sig) = the t-test value (and significance level) for the difference between mean age-79 test scores for those who did or did not attend age-83 Cognitive Testing. Figures shown are mean cognitive test scores with standard deviations in parenthesis.

Table 3.3 Correlations between cognitive ability test performance at ages 79 and 83

	1	2	3	4	5	6
1. Raven's Matrices age 79	-					
2. Verbal Fluency age 79	.29***	-				
3. Logical Memory age 79	.39***	.18***	-			
4. Raven's Matrices age 83	.79***	.27***	.39***	-		
5. Verbal Fluency age 83	.32***	.76***	.24***	.37***	-	
6. Logical Memory age 83	.38***	.16**	.76***	.40***	.29***	-

N = 539-545 for the intercorrelations of the age-79 tests, 317-320 for the intercorrelations of the age-83 tests, and 314-318 for the correlations between the age-79 and age-83 tests.
$^{**}p < .01$, $^{***}p < .001$

Table 3.4 Correlations between cognitive ability tests across the lifespan

	Age-11 IQ	Age-79 IQ
Raven's Matrices age 79	.46***	.71***
Verbal Fluency age 79	.34***	.41***
Logical Memory age 79	.26***	.45***
Raven's Matrices age 83	.51***	.67***
Verbal Fluency age 83	.34***	.39***
Logical Memory age 83	.31***	.42***
Cognitive ability age 79	.49***	.73***
Cognitive ability age 83	.52***	.67***
Raven's Matrices change	.17**	.15**
Verbal Fluency change	.13*	.15**
Logical Memory change	.15*	.17**
Cognitive ability change	.15*	.14*

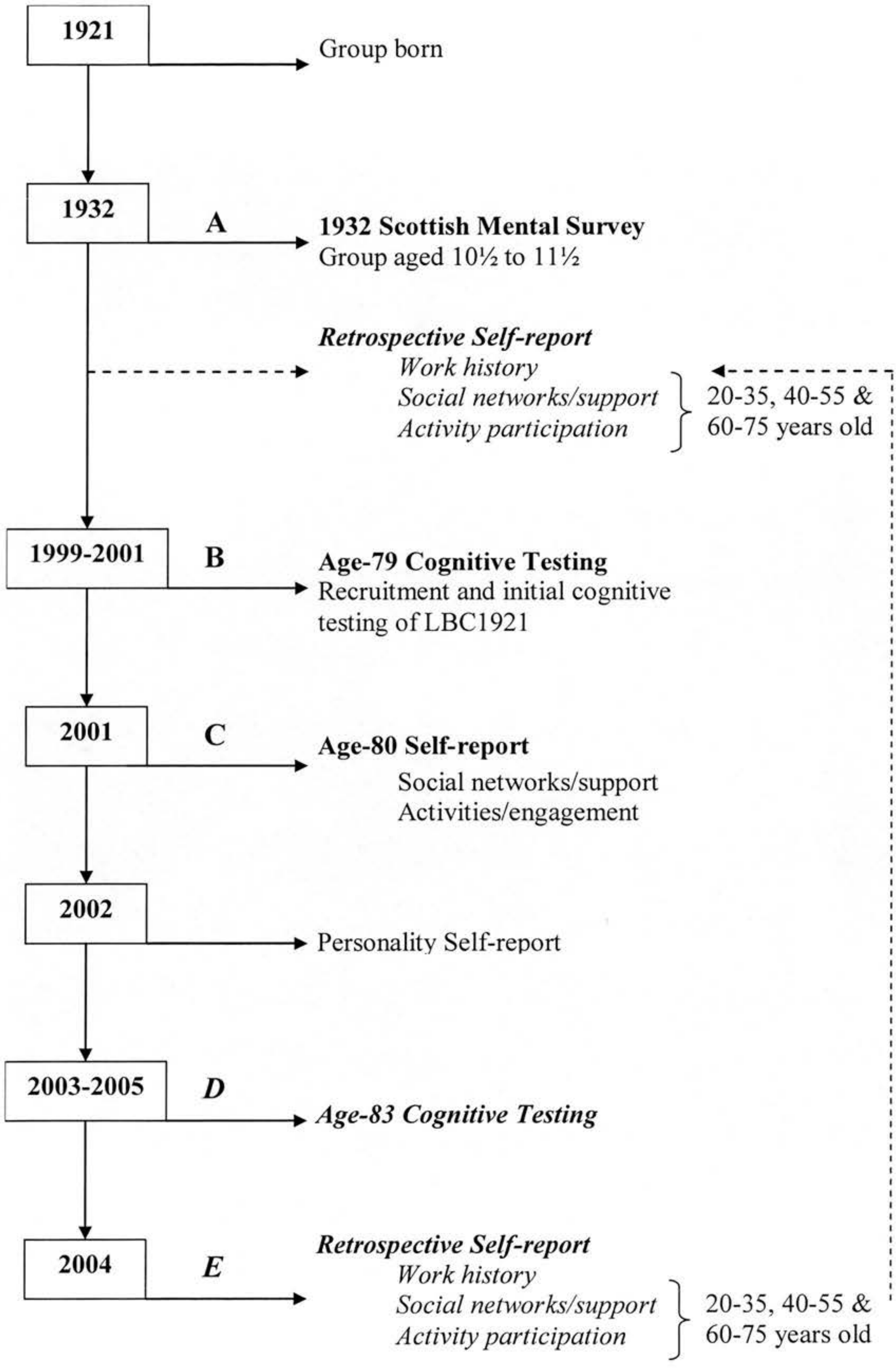
Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Individual cognitive ability test scores are corrected for age in days at time of testing. Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Change scores are the standardised residuals from a linear regression with the age-83 score as dependent variable and age-79 score as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. N = 481-539 for associations with the age-79 cognitive scores, 288-316 for associations with the age-83 cognitive scores, and 287-316 for associations with the cognitive change scores.
$*p < .05$, $**p < .01$, $***p < .001$

Table 3.5 First unrotated component loadings of the cognitive ability tests

	1st unrotated component
Raven's Matrices	.80
Verbal Fluency	.66
Logical Memory	.74
Percentage variance explained	53.9%

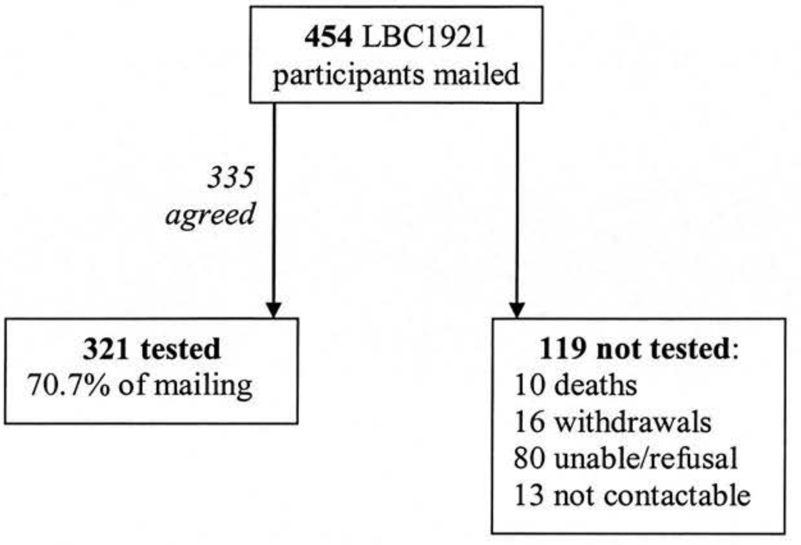
Note. Cognitive ability test scores are corrected for age in days at time of testing. In the PCA, scores for age-79 and 83 test sessions were analysed together.

Figure 3.1 Lothian Birth Cohort 1921 Study timeline



Note. The bold letters (A-E: reference points from Chapters 3, 5, 7 and 9) mark the LBC1921 assessments which form the basis of this thesis. Those also in italics indicate data was collected – in whole or in part – by the author.

Figure 3.2 Age-83 Cognitive Testing flowchart



Part II – Lifetime determinants of cognitive ageing

> Cognitive aging is not a uniform phenomenon, but is highly differentiated across abilities, and moreover...cognitive aging occurs at differential rates depending on a variety of demographic and other personal characteristics (Schaie, 1989, p. 492).

Assuming that the course of cognitive change with increasing age is malleable, there should exist modifiable factors from an individual's environment which will influence this change. A mainstay of cognitive ageing research is the identification of such factors. In this part of the thesis (Part II), potentially mutable psychosocial and lifestyle factors that could be predictive of successful cognitive ageing will be considered. To be truly useful as potential interventions for future generations, these factors should be concerned with areas of human life common to the greatest proportion of individuals possible; the current research will focus on factors drawn from the domains of occupation, social networks and support and activity participation. The current state of knowledge about factors from each domain with respect to their impact on later life cognitive ability will be reviewed in turn (Chapters 4, 6 and 8 respectively) before examining these factors and lifetime cognitive change in the LBC1921 (Chapters 5, 7 and 9).

Chapter 4: Occupational characteristics and cognitive ageing

Occupation is, more or less, a "common life event" (Avolio & Waldman, 1990, p. 44). Although occupational experiences will vary a great deal across people, there are aspects of work which can be assessed by standardised means in order that their impact on employee health and well-being might be investigated. Occupational characteristics can be considered in a variety of ways. For example, only the broad occupational classification may be used, or in more detail, how physically demanding or hazardous the work is, how much support an individual receives from coworkers or how mentally challenging and stimulating work tasks happen to be can also be assessed. It is this latter aspect – an indicator of how cognitively engaged an individual is in their job – which has been seen as a potential determinant of cognitive ability and change, yet there have been remarkably few empirical attempts to investigate the associations between occupational characteristics and later life cognitive function and change. This dearth is all the more surprising as:

> the most prevalent activity throughout our lives is work. Work provides most of the ingredients that have been associated with the preservation of cognitive and emotional health (socialization, purpose, and use of the mind, the body, or both) (Lyketsos, 2006, p. 87).

Essentially, these occupational 'ingredients' may partly determine mental ability in adulthood due to the continued deployment, and therefore maintenance, of cognitive functions in the working environment. The current chapter will review the evidence accrued thus far.

4.1. Principal lifetime occupation and cognitive decline

By far the most common approach to studying the relationship between occupational characteristics and changes in intellectual function deals simply with broad job classifications. If an association exists between particular occupational types and cognitive change, then it is assumed this link is due to the underlying nature of the jobs comprising each category. These studies can vary in numerous ways, including the job classification system employed, the cognitive assessment timescale (from a single time-point cross-sectional survey to a longitudinal follow-up measured in years), and the cognitive endpoints used (performance on a range of tests or the presence/absence of dementias).

4.1.1. Cross-sectional studies

The occupational type-cognition relationship has been investigated cross-sectionally in the Paquid study based in France, which tested over three and a half thousand individuals aged 65 and over at baseline (mean age of 75.2: Dartigues et al., 1992), and in an Italian study of 524 individuals with a mean age of 77 years old at the time of the examination (Frisoni, Rozzini, Bianchetti, & Trabucchi, 1993). The aim of both studies was to examine the predictors of a variety of age-related outcomes (including cognitive vitality) in large, community-dwelling elderly samples. A variety of potential lifestyle determinants of cognitive ageing have been measured in each. The Mini-Metal State Examination [MMSE (Folstein et al., 1975): a dementia screening tool, whereby scores less than 24 out of 30 are indicative of possible dementia] was used in both studies to assess cognitive function. Participants (or proxies where necessary) supplied details of their principal lifetime occupation, being the job held for the longest time. Dartigues and colleagues (1992) classified these into 23 categories, according to the Institut National des Statistiques et Etudes Economiques (categories included, for example, farm managers, primary schoolteachers, or skilled blue-collar workers). In the analyses, the 23 categories had to be collapsed into 7 superordinate groupings due to small numbers of individuals in many of the more specific categories. The 7 broad groupings were: farmworkers, farm managers, domestic service employees, blue-collar workers, craftsmen and shopkeepers, other employees (white-collar workers, nurses, middle executives) and intellectual occupations (teachers, managers, lecturers, executives, professionals). Cognitive impairment was defined as achieving less than 24 out of 30 on the MMSE; 908 individuals (24.5% of the 3699 who completed the MMSE) met this criterion. Logistic regression analysis suggested that, compared to more 'intellectual' occupations (the teachers, managers, etc.), farmworkers, farm managers, domestic service employees and blue-collar workers had a significantly higher risk of cognitive impairment. Dartigues et al. (1992) therefore concluded "occupation during active life appears to be one of the most important correlates of cognitive impairment in the elderly independent of age, sex, educational level" (p. 985), yet the results may not reveal any more than the fact that people who start with lower mental ability end with lower mental ability.

The Frisoni study (1993) reported similar findings although principal lifetime occupation was classified into 6 groups: white-collar workers, tradesmen and craftsmen, blue-collar workers, farmers, housewives and other. White-collar workers had the highest mean MMSE score and the lowest standard deviation [28.2 (1.51)], whilst farmers had the lowest score and highest variation [23.6 (5.14)]. Due to the confounding effects of age, education and financial dissatisfaction on the relationship between occupational grouping and MMSE performance, these factors were controlled. The adjusted difference between farmers and white-collar workers although smaller (reduced from 4.6 points to 2.3 points), remained significant (Frisoni et al., 1993). In both studies, the broad occupational groupings used may not be any more informative than those of standard measures of social class or socioeconomic status. Indeed, the Paquid study highlighted the difficulty of trying to assess occupations using more detailed and idiosyncratic categorisation, which resulted in too few participants in certain groupings to allow a full and proper analysis. Furthermore, as these studies were cross-sectional in nature they could not control for the possible confounding effect of baseline cognitive function, far less the effect of prior ability on subsequent occupational attainment. Whilst both adjust for educational attainment, this may be insufficient for current purposes, as will be covered in more detail below.

4.1.2. Case-control design

An effect of principal lifetime occupation on cognitive impairment in older individuals after retirement was also reported by researchers who employed a case-control design and a follow-up of between 1 and 4 years (Li, Wu, & Sung, 2002). Two cohorts – numbering 2198 individuals – were tested in either 1993 or 1996, and again in 1997 using the Short Portable Mental Status Questionnaire, with cognitive impairment defined as more than 5 errors from 10 questions. Using this criterion, 290 individuals (about 13% of the original sample) were identified as cognitively impaired, 259 being incident cases at follow-up. Two controls were randomly sampled from the original study group for each case from the same gender and within 5 years of age. The principal occupation held (recorded from proxies for all cases and some controls in 1997) was classified by 2 independent raters into 11 categories by the Standard Occupational Classification System (legislators/government administrators/business executives and managers; professionals; technicians and associate professionals; clerks; service workers and shop and market sales workers; agricultural/animal husbandry/forestry and fishing workers; craft and related trades workers; plant and machine operators and assemblers; elementary occupations; servicemen; and housekeepers). For more than 50% of the participants, the principal lifetime occupation was held for over 40 years. Those whose main job was classified as legislator/government administrator/business executive and manager were used as the reference category. Logistic regression analyses suggested that a number of occupational groupings were at an increased risk of cognitive impairment, including those employed in agriculture and forestry or housekeepers, for example. The effect remained after adjustment for age, gender and education, with odds ratios ranging from 2.2 to 14.7 (Li et al., 2002).

Principal occupation was further classified into 4 occupation-based social classes: higher level white-collar, lower level white-collar, skilled blue-collar and unskilled blue-collar workers. In this categorisation, unskilled blue-collar workers were at a 2.4 times higher risk of cognitive impairment compared to higher level-white collar workers, "with a significant dose-response relationship…between social class and risk of cognitive impairment" (Li et al., 2002, p. 10). In conclusion, the authors stated that occupational class was a greater predictor of later life cognitive decline than educational level, going on to suggest that a causal interpretation was possible as the determinant (principal occupation) was causally precedent to the decline assessed in later life. This may seem a sound assumption as the occupation did indeed precede decline as currently assessed. However, as with the studies already discussed, again the lack of prior ability information makes this conclusion premature.

A serious point to note is the continuity of intelligence from early to later life (discussed in Part I). Furthermore, inclusion into a particular occupational grouping will also have been determined by prior intellectual functioning. Pre-morbid cognitive ability is therefore a *major* confounder of any reported link between occupational type and later life cognitive ability. If a measure of early ability were available, and then adjusted for, any remaining effect of occupational type on cognition could then, and only then, be seen as evidence of a significant, independent effect (assuming, of course, that all other potential confounders were addressed). Otherwise, the associations reported are open to alternative interpretations, notably that those of lower ability enter occupations with lower status or cognitive demands. These individuals later experience more apparent cognitive decline as a direct result of their low initial ability (which thus appears to act via their principal lifetime occupation). Ideally, a study would possess a prior measure of ability to be controlled, assess work characteristics, and then follow the individuals longitudinally into old age assessing them on a broad battery of cognitive measures (rather than the single, limited measures reported above).

4.1.3. Occupation and the ABC1921

There is one study in which occupational classification and cognitive outcomes have been investigated where there exists a valid measure of childhood intellectual functioning: the Aberdeen Birth Cohort 1921 (Staff, Murray, Deary, & Whalley, 2004). In this analysis, a subsample who underwent MRI scanning was used. Ninety-two participants had an acceptable MRI scan, and completed Raven's Progressive Matrices (a measure of non-verbal reasoning: Raven et al., 1977) and the Auditory

Verbal Learning Test (a measure of verbal memory: Rey, 1958) aged about 79 years old. These cognitive outcomes were considered separately as the dependent variables in multivariate analysis, whilst controlling for age-11 Moray House Test score (the all-important measure of prior ability), gender, and an index of age-related white matter lesions (assessed from the scans). Occupational level (taken as the highest level achieved) was classified in 9 categories according to the Office of Population Statistics: managerial, professional, lesser professional, secretarial, skilled manual, semi-skilled ii, semi-skilled i, unskilled ii, and unskilled i. This occupational classification accounted for about 5% of the variance in memory and 5% to 8% for reasoning (Staff et al., 2004). The analysis was repeated using the number of years of education as a predictor. This suggested that educational level accounted for about 6% of the variance in memory performance – over and above childhood (initial) ability – but did not contribute to reasoning ability. Unfortunately, there was no simultaneous inclusion of education and occupation so it is not possible to conclude definitively which factor may have the greatest influence; the lack of a reasoning-education link may, the authors suggest, reflect the educational focus of the 1920s and 1930s, where rote learning was emphasised over problem-solving. The latter skill may have come to the fore in certain work-related roles.

The ABC1921 study highlighted that even controlling for prior ability, there is still an effect – moderate in size – for occupation in the determination of later life ability: "a more cognitively complex occupation predict[s] higher cognitive ability in old age than would be expected for a person's childhood ability and accumulated brain burden" (Staff et al., 2004, p. 1196-97). As no analyses were recorded without controlling for childhood ability, it is difficult to estimate the level to which this factor attenuates the occupation-cognition association, and therefore, how much of an overestimate studies which are unable to control for this are making. It was also noted that using education as a proxy for prior ability, as is often the case, is insufficient as educational attainment is predicted by childhood ability but also adds unique, independent variance to later life cognitive ability.

4.1.4. Principal lifetime occupation and dementia

Further studies have investigated the link between occupation and cognitive function in later life longitudinally, but the focus has shifted towards the occurrence of dementia (Helmer et al., 2001). With up to a 10-year follow-up (mean of 6.4 years) available in the Paquid study, 393 incident cases of dementia were identified (13.3% of 2950 non-demented individuals at baseline). Principal lifetime occupation was coded into 7 categories although these varied slightly from before: housewives and inactives were grouped together rather than being excluded from the analysis, and farm managers and farmworkers were both classified as farmers. Cox proportional hazards models suggested that farmers and blue collar workers were at an increased risk of developing dementia (as assessed by a senior neurologist where follow-up had been suggested by poor psychometric test performance) compared to the reference group of professionals and managers, controlling for age and sex. The adjusted relative risk was 1.67 (95% confidence interval (CI) = 1.23-2.27) for farmers and 1.51 (95% CI = 1.23-2.27) for blue-collar workers. Further adjustment for education removed the differences across occupational categories (although an effect remained for dementia with parkinsonism, however, only 27 participants met this diagnosis).

4.1.5. Educational level as a confounder of the association

Corresponding results have emerged from a number of other studies similarly investigating the link between occupation and the development of dementia and Alzheimer's disease (Seidler et al., 2004; Paykel et al., 1994; Qiu et al., 2003; Stern et al., 1994; Karp et al., 2004; Smyth et al., 2004). Follow-ups of the Kungsholmen Project (Karp et al., 2004; Qiu et al., 2003) have reported an increased risk of Alzheimer's disease in those whose principal lifetime occupation was of a manual nature. Logistic regression analysis suggested that those in manual versus non-manual employment were at a 50-60% increased risk of developing all dementias or Alzheimer's disease. This effect was attenuated after controlling for educational level. Further subdivision of the manual category into service or goods production suggested that those in the latter classification remained at a higher risk of developing Alzheimer's disease even after controlling for educational level (RR = 1.6, 95% CI = 1.0-32.5: Qiu et al., 2003). This was in accordance with Stern and colleagues who suggested that there might be a synergistic link between education and occupation, with those in both the lowest educational and occupational groupings at the highest risk of developing Alzheimer's disease (Stern et al., 1994). Later simultaneous analysis with both education and occupation-based socioeconomic status in the Kungsholmen Project highlighted the greater importance of education in predicting incident Alzheimer's disease (Karp et al., 2004). The increased risk of Alzheimer's disease associated with low educational level was not mediated by occupational class. From this, broad occupational categorisation would not appear to be an independent predictor of later life cognitive impairment.

4.2. Limitations of principal lifetime occupation

The preceding discussion has again highlighted the importance of factors operating earlier in the lifespan for later cognitive outcomes. For the studies detailed above, this earlier factor, when assessed, was education. However, Karp et al. (2004) lamented "many studies, like ours, lack an independent measure of intelligence, the importance of early-life cognitive abilities is difficult to evaluate" (p. 181). None of the studies were able to control for early ability in their analysis, except, of course, for the ABC1921 study. Each of the studies using principal lifetime occupation also suffers the limitation that this is a classification system based on broad groupings. Occupational category alone is problematic because it is:

> at the same time an indicator of exposure to chemicals or other environmental factors, the reflection of psychosocial characteristics of people, particularly cognitive stimulation through life, a socioeconomic indicator of medical care and attitude to health, and a surrogate marker of premorbid intelligence (Helmer et al., 2001, p. 303).

Such classification of occupations by type is relatively crude, and often does not take into account the actual skills needed in a given job. They are generally little more than taxonomies often used as indicators of socioeconomic status (Dartigues et al., 1992; Frisoni et al., 1993), and do not assign indices based on, for example, a measure of the mental complexity of the working environment.

4.3. Beyond principal lifetime occupation

4.3.1. Occupational complexity and cognitive function during working life

Within the framework of cognitive ageing research, the mental component of a person's occupation may be seen as important.

> The basic proposition tested can be stated as follows: If a job is considered more cognitively complex, then cognitive abilities are more likely to be regularly used on the job and, therefore, should display less differences with increasing age... Conversely, jobs that do not require frequent use of cognitive abilities may, in turn, result in lower cognitive functioning with increasing age (Avolio et al., 1990, p. 44).

Measuring the mental component of work has been attempted using different methods, including self-report and expert ratings. These differing approaches will be considered below in studies where the degree of cognitive challenge faced at work has been linked to cognitive ability and/or change.

4.3.2. Cross-sectional analysis

Avolio and Waldman (1990), noting the paucity of studies in this area, set out to investigate the effect of individual job characteristics on the maintenance of mental ability over the life course. Specifically, they were interested in occupational type and job complexity as potential predictors of later life age-related changes in cognitive function. Their hypothesis, stated above, was that more complex jobs requiring a greater use of cognitive abilities result in less cognitive decline over time (Avolio et al., 1990). To investigate this, they made use of a US Employment Service database which contained information collected between 1970 and 1984 on 24,219 individuals aged 18-74 years old (mean age 32.47 years). For each individual, a record of mental ability and job complexity was available. The authors suggested that if the association between age and ability was seen to vary by job complexity, it would be suggestive of a cognitively protective effect of mentally challenging work.

Cognitive ability was assessed by the General Aptitude Test Battery (GATB: summary scores were available for general cognitive ability, verbal ability and numerical ability). [It is not clear from the report whether the US workers were selected into their job based on GATB performance. If that were the case, it would be expected that there would be a substantial overlap between a person's ability and the subsequent complexity of their occupation.] A job complexity score was assigned to each participant's occupation based on job analysts' assessments "according to the general intelligence, verbal ability, and numerical ability required to perform the job" (Avolio et al., 1990, p. 45). These 3 ratings were combined with codings provided by the Dictionary of Occupational Titles (DOT), which contains ratings for each job's activities in relation to people, data and things [only the data score was used in the Avolio and Waldman (1990) analysis]. The resultant job complexity measure had a reported Cronbach's alpha (a measure of internal consistency) of .70.

In this large, representative US sample, job complexity was found to correlate .36 with the measure of general intelligence, and .33 and .31 with verbal and numerical abilities respectively (Avolio et al., 1990). Furthermore, hierarchical regression indicated that age explained about 3% of the variance in general intelligence (whereby, increasing age was associated with lower ability), whilst experience (assessed in terms of the amount of time in the current occupation), did not add significantly to this; job complexity was the greatest predictor of general intelligence, accounting for about 13% of the variance. Similar results were obtained across numerical and verbal ability. Crucially for Avolio and Waldman's hypothesis, the interaction terms for job complexity and age, experience or both did not significantly improve on the model, indicating there was no protective effect of cognitively demanding jobs with increasing age.

Each job was further classified according to occupational type into one of ten groupings: small assembly operations, large assembly operations, clerical I, clerical II, machine repair, crafts, technical plant operations, service, health care, and inspection (with a number of occupations outwith this categorisation, the final sample in the analysis was just over twenty-one and a half thousand individuals). In a separate hierarchical analysis, occupational type accounted for about 8% of the variance in test performance with an age-occupational type interaction accounting for a further 1%. The latter result suggests that the association between age and cognitive ability varied across the 10 occupational groups: the age-general ability association ranged from -.25 for health care, to -.05 for clerical I. It was concluded that "occupational type may moderate the relationship between age and cognitive ability test scores…job complexity did not" (Avolio et al., 1990, p. 48).

The authors suggested that the lack of an effect for job complexity may have been a consequence of the method employed in assessing this construct; aspects of complexity may not have been fully covered, such as the memory loadings for different tasks or creative problem solving on the job. Moreover, the complexity ratings of experts and those from pre-determined occupational listings may serve to reduce the variance across individuals, as each individual with a particular occupational title is assigned the same complexity score (Bosma et al., 2003a). The sample used, whilst exceptionally large and representative, was nevertheless also young, with a mean age of less than 33. Consequently, the effect of occupational factors on age-related cognitive change were necessarily cross-sectional; the directionality used in the analysis (predicting intelligence based on job complexity/occupational type) was a result of the hypothesis under investigation. Causality could not be attributed (Schooler, Mulatu, & Oates, 1999). The findings are therefore difficult to interpret within the framework of job complexity altering the level of, and change in, cognitive ability across the lifespan. To satisfactorily address this, and the associated issue concerning the confounding of initial ability level on occupational attainment and resultant complexity, information must be collected longitudinally (Avolio et al., 1990).

4.3.3. Longitudinal analysis

A limited number of studies have attended to this, chief among those being initiated by Kohn and Schooler whose work began over 40 years ago. As the initial baseline investigation was cross-sectional by design, it is the more recent findings (Schooler et al., 1999; Schooler, Mulatu, & Oates, 2004) based on the 1974 and 1994/95 follow-ups of this which are more interesting and informative, examining in particular the "possible reciprocal causal relationships between intellectually demanding work and intellectual functioning throughout the work life" (Schooler et al., 1999, p. 483). This strikes at the core of the current thesis: what factors from a person's everyday life (specifically, in this instance, their everyday work-life) might be beneficial (or indeed detrimental) to their later mental ability?

In 1964, a nationally representative US sample numbering 3101 employed civilian men aged over 16 years was recruited to investigate psychological outcomes of occupational conditions. A sub-sample was randomly selected for follow-up in 1974, taken from those under the age of 65; in total, 687 were interviewed at this time. Concurrently in 1974, the researchers also recruited the wives of their male participants, resulting in a sample of 555 women, aged 26-65 years old. Two hundred and sixty-nine of the women interviewed worked for 10 hours or more per week. Finally, the 1994-95 follow-up targeted those individuals who were employed at that time; 160 of the men and 73 of the women traced were in this group, with a median age of 57 (ranging from 41-83 years old: Schooler et al., 1999).

4.3.3.1. Substantive complexity of work and intellectual flexibility

For each participant, the substantive complexity of their current work – "the degree to which performance of the work demands thought and independent judgement" (Schooler, 1984, p. 261) – was assessed (for the men in 1964, and for both men and women in 1974 and 1994/95). This index of substantive complexity indicates the complexity of the work environment, and comprised the following ratings: an appraisal of the complexity of an individual's work with things and data (both on a 9-

point scale) and people (on a 10-point scale; for example, ratings of the complexity of work with people ranged from no significant relationship to mentoring) based on participant's responses to a series of questions which were rated according to the Dictionary of Occupational Titles (DOT) classifications [Note that the participants descriptions of their job tasks were given a DOT code rather than a DOT rating simply being applied to their occupational title. As mentioned previously, there may be methodological weaknesses in applying the same occupational ratings to individuals based solely on occupational title, rather than asking for their subjective assessment]; an indication of the amount of time spent working with things, data and people; and also an overall complexity rating on a 7-point scale from not at all complex to setting up of a complex system of analysis, synthesis or both. A composite of 5 measures was used to assess the mental ability of each participant, termed intellectual flexibility: "defined as cognitive flexibility in coping with the intellectual demands of complex situations" (Schooler et al., 1999, p. 486). Only one of these 5 measures was a standard psychometric test (performance on part of the Embedded Figures task). The others were the interviewer's rating of the participant's intelligence on a 5-point scale, from dull, uncomprehending to much above average intelligence; a rating of the perceived adequacy of the participant's answer to a question requiring both sides of an argument to be discussed; a rating of how satisfactory a participant's response to deciding on the location of a fast food stall (from 2 possibilities); and the frequency of agreement with agree-disagree questions. At the 1994/95 follow-up, 6 psychometric measures of cognitive function were also incorporated, including immediate recall (ability to remember a list of 20 words studied for 3.5 minutes), category fluency (1.5 minutes to name as many types of furniture as possible) and a verbal meaning test (choosing the correct definition of a target word from 5 choices). These indices of standard cognitive function correlated .87 with concurrently assessed intellectual flexibility (Schooler et al., 1999).

For the men with data available over a span of 30 years, the modelling analyses extending the original 1964 to 1974 model to the latest 1994/95 wave suggested that earlier substantive complexity of work predicted later levels of substantive complexity; likewise, earlier intellectual flexibility predicted later intellectual flexibility. These pathways indicate a degree of stability across time, with standardised path coefficients of .40 and .56 respectively. Importantly, substantive complexity "continued to have a notable and significant effect on Intellectual Flexibility" (Schooler et al., 1999, p. 487). This conclusion was based on the fact that the paths between the 1994/95 measures of intellectual flexibility and substantive complexity were only significant in the complexity to intellectual flexibility direction (there had been a significant reciprocal effect of intellectual flexibility on substantive complexity in 1974). The men doing more complex work were assessed as having greater intellectual capacity although it is not clear from the report whether the interviewers were blind to the occupational type of the participants. The analysis using the women's data did not differ from that of the men (including only 1974 onwards), however, the resultant model combining all data for both men and women suggested that the pathway from 1994/95 intellectual flexibility to substantive complexity was significant (Schooler et al., 1999).

The results were further analysed by splitting the group at the median age (57 years). Whilst the 2 models obtained were similar, it was interesting to note that, across time, substantive complexity of work and intellectual flexibility decreased. The mean level of substantive complexity in the young group was 3.94 in 1974, falling to 3.62 in 1994/95. In the older group, the decrease was from 4.00 to 3.62. Considering intellectual flexibility, this changed from 2.30 to 2.10 in the younger group and 2.21 to 2.03 in the older group during the same period (Schooler et al., 1999). Additionally, for both the younger and older groups, the path linking substantive complexity and intellectual flexibility in 1994/95 was significant in both directions although the magnitude of the path coefficient from substantive complexity to intellectual flexibility was "significantly and markedly different" (p. 489), being almost twice as large in the older group (standardised coefficient of .50 versus .26 respectively). To reduce the possible criticism of the use of intellectual flexibility as a measure of ability, this was shown to correlate .87 with the standard cognitive function tests delivered in 1994/95. Moreover, the final models were unaltered when the 1994/95 intellectual flexibility measure was supplemented with the standard cognitive measures. The authors concluded that the substantive complexity of work affects intellectual function more generally than that initially assessed by their measures of intellectual flexibility.

In summary, Schooler and colleagues concluded that there exist significant relationships between the complexity of an individual's occupation and their cognitive functioning (as indexed by expert ratings and actual cognitive test performance), and vice versa, with the former association being stronger in older individuals (Schooler et al., 1999). Across the follow-up period, the complexity of work continued to affect cognitive performance such that "paid work that is substantively complex appears to raise the level of participants' intellectual functioning" (p. 491). The longitudinal nature of this study allowed the investigation of potential pathways between these factors across 20 years (counting the 1974 to 1994/95 waves only as this includes data for both men and women). Yet as the authors note, the models used only investigated contemporaneous reciprocal pathways – it was not possible to include cross-lagged effects (that is, effects from earlier substantive complexity on later intellectual flexibility, for example). For current purposes, it is these cross-lagged pathways which are surely more interesting: does the level of early substantive complexity significantly affect cognitive ability at a later date? The data from this study have not been analysed in a fashion that would allow this to be investigated. It is also worth highlighting again that the pathways discovered are *reciprocal*. Substantive complexity may indeed influence intellectual functioning, but the reverse is apparent also. Moreover, while the assessment of occupational characteristics was based on interview ratings for each participant, the final rating was assigned by an independent interviewer according to open and closed answers from the participant, rather than asking the individuals themselves to directly self-report. It is not clear how closely these ratings reflect an individual's actual mental engagement in their occupation. The sample under study were all employed at the initial assessment, and continued to be so at each subsequent follow-up. A full spectrum of cognitive function is therefore not being assessed if those who withdrew from employment did so for reasons of poor health, including perceived declining mental capacity. Only following those still in employment – coupled with the fact the group were relatively young – also means that it has not been possible to estimate any *continuing* effect of substantively complex work beyond retirement into old age.

4.3.3.2. Occupational self-direction and intellectual flexibility

Schooler and Oates (2004) extended their findings with a consideration of occupational self-direction, a measure comprising closeness of supervision, routinisation and substantive complexity of work. Complexity was similarly derived as before, from the complexity of work with data and people ratings, an overall complexity rating, plus the time spent working with data and people. Closeness of supervision was assessed by 4 items relating to the level of supervision and decision making ability. Finally, routinisation was assessed by one item concerning how predictable and repetitive the work was. Using full information maximum likelihood modelling, a significant pathway was recorded from occupational self-direction to intellectual flexibility (both assessed in 1994/95). The reciprocal pathway was only significant when the sample was split into younger and older groupings. Direct pathways also existed from education to each of these constructs assessed in 1974. From this re-analysis it was reported that "the experience of occupational self-direction continues to increase levels of both intellectual functioning and self-directed orientations even late in individuals' work careers" (Schooler et al., 2004, p. 186). However, occupational self-direction does not appear to differ substantially from the earlier measure of substantive complexity. Indeed, in the final model splitting the sample by age, substantive complexity had a very high loading (.99) on the occupational self-direction factor in the 1994/95 wave; the loadings of closeness of supervision and routinisation were over 3-fold lower at -.31 and .29 respectively. Although this was an attempt to achieve a greater assessment of work-related factors, it was perhaps less than adequate (routinisation was assessed by only 1 item). It is unclear what this extra analysis adds to the field, over and above their work reported previously.

4.3.4. Environmental complexity hypothesis

Schooler and colleagues have suggested that "as workers grow older, Substantive Complexity of work has a continuing and, if anything, increasing effect on Intellectual Flexibility" (Schooler et al., 1999, p. 490). This is supported by their finding a link between these factors; however, as discussed above, this association has only been noted contemporaneously (and indeed reciprocally), and as yet, there is no prospective evidence of a protective effect of substantive complexity. As such, it is difficult to determine the real-world significance of this relationship although it appears to be in accordance with the previous cross-sectional findings of a greater association between work complexity and cognitive ability in an older group (Avolio et al., 1990). Substantively complex, self-directed work would appear to provide nourishment for intellectual functioning, whilst less challenging work may result in a decrement. Schooler (1984) noted:

> the complexity of an individual's environment is defined by its stimulus and demand characteristics. The more diverse the stimuli, the greater the number of decisions required, the greater the number of considerations to be taken into account in making these decisions, and the more ill-defined and apparently contradictory the contingencies, the more complex the environment (Schooler, 1984, p. 259-260).

In this theory, the mechanism by which an occupational effect will become manifest is that, in an environment which rewards cognitive effort, individuals will be motivated to improve their abilities and generalise these to other, non-occupational environments and situations. Conversely, less complex environments may not provide the rewards necessary to develop or maintain intellectual function, resulting in a loss of capacity (Schooler, 1984). Based on their longitudinal findings, Schooler and colleagues have suggested increased participation in activities of an intellectually complex nature (including those related to occupation) should be promoted as advantageous for improved intellectual functioning in the future (Schooler et al., 1999).

Nevertheless, it is important to note certain caveats to this notion with respect to the research discussed thus far. The aforementioned sample is limited by including only those who were employed at the time of the original study and continued to be so when the follow-ups have been conducted. The study has therefore not truly investigated the 'continuing effects' of work complexity. Schooler's (1984) theory posits that adaptation to a complex (or simple) environment may occur at any age and so the loss of a stimulating working environment due to retirement may have a negative impact on the cognitive functioning of older individuals. As older workers also do less complex work, it may be that it is this decrease in complexity which is a partial predictor of normal age-related changes in ability. Thus, if complex work does indeed lead to greater intellectual functioning, it is important to understand whether this effect continues to be generalisable to those beyond their working years, or whether it dissipates. Individual differences exist in the level of cognitive functioning, therefore it is likely the benefits and longevity of the effects of complex environments may vary across individuals as well (Schooler, 1984).The reciprocal finding that intellectual functioning continues to affect the complexity of the work undertaken is crucial; those with higher intellectual functioning are likely to do more complex work. The analyses thus far have been unable to determine whether the reciprocal effects discovered are contemporaneous or cross-lagged in nature, or indeed what the contribution from each of these is (Schooler et al., 1999; Schooler et al., 2004). Moreover, those remaining in demanding jobs are the ones who are capable, and/or wish to be there and feel capable.

Very few studies have investigated the complexity of occupation and cognitive decline in older people once they have ceased working. The dearth of studies surprised Avolio and Waldman 15 years ago, particularly given that intellectual ability has been shown the to be the strongest predictor of occupational level and performance (Schmidt & Hunter, 2004). Those studies investigating occupational demands and cognitive decline in later life will be detailed below.

4.4. Occupational demands and cognitive function in later life

4.4.1. Dementia

To rectify the lack of studies in individuals beyond working age, Smyth et al. (2004) investigated the 4 longest held occupations of their participants. Dictionary of Occupational Titles (DOT) classifications were used to assign factor scores to each for occupational demands in the social, mental, physical and motor domains. A case-control comparison (122 cases of Alzheimer's disease and 235 controls) was conducted using an analysis of covariance separately for each of the occupational demand scores. Cases had lower mental occupational demands overall, and in their 30s, 40s and 50s specifically (the demands in these decades were determined from the occupational histories collected), plus higher physical demands overall and in their 20s, 40s and 50s, controlling for education. The authors reported the mean differences (plus 95% confidence intervals) in the occupational demand measures as a graph only, making it difficult to gain an accurate indication of the magnitude of the effect. Roughly speaking, the adjusted mean difference in mental occupational demands was 0.2 and for physical occupational demands was -0.2 between cases and controls (where the demands measures were standardised with a mean of 0 and a standard deviation of 1). Their more detailed specification of work demands led the authors to suggest an 'all-or-nothing' approach to occupational classification by broad categories is insufficient to "disentangle the relative contributions of various occupational demands" (Smyth et al., 2004, p. 501). Whilst this may be true, as the authors failed to enter these broader categories in their analysis it appears an opportunity was missed to investigate more fully. This is all the more critical as a difference was recorded between cases and controls for occupational type, whereby cases were less likely to be classified as white-collar workers. The occupational category data was used for descriptive purposes only, and was not entered or controlled in later analyses. The authors cannot, therefore, conclude that distinct demands scores are 'better' than broad occupational types. It may be that these latter scores simply directly reflect the higher order socioeconomic categories. To fully examine occupational effects, socioeconomic status should ideally be adjusted. In this study – as well as those previously detailed – it can be considered an unmeasured confounder.

Similarly, Seidler et al. (2004) investigated the occupational characteristics-dementia link in a case-control study. Those with dementia (N = 195, 55-95 years old) were recruited though GPs (all cases were independently screened by the study authors), whilst 229 controls (aged 60-94 years old) were recruited from the same region. A complete job history was taken from participants (or nominated proxies) such that each occupation was linked to a job exposure matrix, giving measures of challenge at work, social climate, control possibilities, work load, perceived risks for error, social demands and supervisor support. Those with dementia of any aetiology were found to have had less challenging work, lower control and greater perceived risks of error (which concerned the risk of accident or damage as a result of mistakes whilst working) with odds ratios of 0.5, 0.5 and 2.1 respectively. A potentially protective effect (with respect to dementia at least) is again recorded for increased challenge at work, in addition to greater control possibilities (Seidler et al., 2004). Again, however, there was no control for prior ability (over and above education) or social class, and the nature of the design makes attributing causality difficult. Using a dichotomous endpoint reduces the large degree of variation that is apparent across ageing individuals.

4.4.2. Normal cognitive ageing

4.4.2.1. The Canberra Longitudinal Study

Whilst Seidler et al. (2004) and Smyth et al. (2004) both attempted to index job characteristics beyond simple groupings, their main concern was with the determination of an increased risk of dementia. As such, their studies do not give an indication as to how generalisable their findings are to normal age-related cognitive change. Although Jorm and coworkers (1998) were also interested in predicting dementia incidence, their study additionally reported findings concerning standard cognitive test performance in older people. Over 500 men enrolled in the Canberra Longitudinal Study (a major study into the determinants of dementia and depression: Christensen et al., 2004) aged at least 70 years old at baseline were re-interviewed approximately 3-4 years later (518 had full data at baseline, and 329 at wave 2). The cognitive battery delivered on both occasions included the MMSE and the National Adult Reading Test (NART: Nelson et al., 1991), plus a test of episodic memory and the symbol-letter modalities test. Each participant's main lifetime occupation was then classified according to Holland's taxonomy, which includes 6 classifications of occupations, comprising realistic, investigative, artistic, social, enterprising and conventional (Holland, 1985). Jorm et al. (1998) suggested this system "provides a classification of occupations according to their psychological demands which is well-suited to a test of the hypothesis that lifetime occupational activity may affect the rate of cognitive ageing" (Jorm et al., 1998b, p. 478).

Educational differences were observed across these different categories of occupation, and importantly, the cognitive test scores and incidence of dementia also varied across groupings. Those in the realistic occupations (for example, skilled trades, technical and some service occupations) had lower cognitive test scores and the greatest proportion of dementia cases at baseline, and also the lowest level of education. To control for this potential confounder, hierarchical regressions were conducted, and the occupational differences persisted, explaining around 2% of the variance in MMSE scores and about 9% in NART scores. [It is perhaps slightly odd to have predicted NART performance from occupational type as this is often defined as a measure of pre-morbid ability. The authors may have been justified in adjusting for NART performance instead.] However, when the longitudinal data were analysed, the mean level of change (separately for the 4 cognitive tests) did not differ significantly between the 6 occupational groups. This was true whether the analysis was a one-way ANOVA, or a hierarchical regression which also controlled for age, education and native English. It should be noted that change was simply calculated as the wave 1 score minus wave 2, and some of the occupational groups were limited in number by the follow-up (artistic N = 9, conventional N = 51 and social N = 62, for instance). As the greatest difference cross-sectionally was with NART performance, Jorm and co-workers (1998) noted that there may exist differences in prior intelligence rather than in decline across occupational categories. Indeed, the differential prevalence of dementia at baseline was only found when the classification system used (DSM-III-R) did not require the presence of cognitive decline; an alternative classification (ICD-10) which requires decline for a positive diagnosis was not related to occupational grouping (Jorm et al., 1998b). If pre-morbid intelligence is a major factor in this relationship (as indeed it is a major predictor of occupational attainment: Schmidt et al., 2004), it therefore becomes important to consider this from an earlier point in the lifespan. Whilst the authors note that the Holland taxonomy is "crude…it has the advantage of focusing on the common psychological demands of broad groups of occupations" (Jorm et al., 1998b, p. 482). This is similar to the use of other external databases to assign scores for mental complexity, for instance; however, this methodology may only serve to reduce the variation between those in the same occupation whilst highlighting differences across broad occupational types. Such a procedure might increase the chances of finding differences between types. Enquiring about levels of these characteristics (for example, mental demands) in individuals would be one way to address this issue.

4.4.2.2. The Maastricht Aging Study

Although a relationship between occupational characteristics (type or complexity) and cognitive outcomes has been reported, the results of Jorm et al. (1998) again suggest the relationship is far from being unequivocal; the evidence thus far has been inconsistent and there are few studies dealing with many different constructs. Additional studies that "collect information on specific work would help make specific interpretations of the observed effect" (Li et al., 2002, p. 12). The researchers of the Maastricht Aging Study (MAAS) recognised this also, and the fact that still "little is known about whether persons with mentally demanding jobs are protected against cognitive impairment and whether this association is independent of intellectual abilities and other confounders" (Bosma et al., 2003a, p. 33). As indicated by Jorm and colleagues (1998), an effect independent of initial ability may not exist. The individuals of the MAAS studied by Bosma and colleagues (2003a) were those aged over 50 years of age (in 1996-98), who had been tested 3 years earlier as part of the baseline examination. Eight hundred and thirty individuals were assessed from a potential sample of 1069 (the initial sample of the MAAS numbers almost 3500, and includes individuals ranging from 25 to 82 years old). The objective was to determine whether the prevalence of cognitive impairment over a 3-year follow-up might vary according to occupational demands. Those with cognitive impairment at baseline or no occupational experience were therefore excluded, giving 630 individuals in the final analysis.

Bosma et al. (2003a) defined cognitive impairment at wave 2 as performance in the lowest 10% of two or more of the 4 cognitive tests used (including the Stroop Colour-Word test, the Verbal Learning test, Letter Digit Coding test, and the Word Fluency test); 36 individuals were thus classified at the follow-up. Current or previous occupations were then assigned a composite mental work demands score based on expert ratings of the mental complexity of the work tasks (on 7-point scale from simple to complex) and previously collected survey data (De Zwart, Broerson, Van der Beek, Frings-Dresen, & Van Dijk, 1997), which established the

> percent of persons in each job title code that confirmed the following four questions: (1) Is your work mentally demanding? (2) Do you have to concentrate strongly during your work? (3) Does your work require great precision? (4) Do you regularly work under time pressure? (Bosma et al., 2003a, p. 36).

In order to improve on the shortcomings of the previous studies in the area, the authors recorded a number of confounders, including age at baseline and length of follow-up, sex, education and current employment status. A number of *potential* confounders were also assessed such as smoking and alcohol behaviour, physical activity, depression, family history of dementia, relevant diseases (cardiovascular diseases, diabetes and hypertension) and also baseline intellectual ability (about 3 years before the follow-up examination).

The analyses suggested that those individuals who were defined as cognitively impaired at the follow-up had significantly lower ratings on all measures of the mental work demands, with the exception of item (1) above (Bosma et al., 2003a). Regarding the composite mental demands of work measure (where the indicators had been standardised and combined: 0 = low load/few demands to 10 = high load/many demands), those who were cognitively impaired had a mean score of 4.5 (2.1) compared with 5.6 (2.1) for those who were not cognitively impaired. After adjustment for the basic confounders (although notably not socioeconomic status), each unit decrease in the mental demands composite score increased the odds of incident cognitive impairment by 21%. In the subsample classified as being previously employed (N = 357 with 21 cases of incident cognitive impairment), of the 6 indicators of mental workload [the expert rating of work mental complexity, the 4 mental demands items listed above and the composite score], 4 'significantly' predicted cognitive impairment with odds ratios ranging from 0.70 to 0.78 (one of the odds ratios was "marginally significant" (p. 37), that is, not significant at conventional levels). For those currently employed (N = 273 with 15 incident cases of cognitive impairment), only 1 of the 6 mental workload indicators 'significantly' predicted impairment with an OR of 0.68, 95% CI = 0.44-1.04 (again this was 'marginally' significant at $p < .10$). Splitting the sample may have resulted in a lack of power to detect an effect at standard levels of statistical significance. The authors noted there were no significant differences between the odds ratios reported for currently versus previously employed groups, and that the interaction between employment status and mental workload was never significant. Importantly, the odds ratios were unchanged when the potential confounders – including baseline ability, depression and lifestyle – were *separately* introduced into the models (Bosma et al., 2003a). No final model controlling for all potential confounders was presented. Furthermore, only 36 individuals were classified as cognitively impaired and the magnitude of decline was small. The age range of the sample (with a relatively young mean age of 62 years old) has made investigating cognitive change in this sample problematic, especially as the group is split by those currently and previously employed. It would have been interesting to have analysed cognitive performance as a continuous variable (with an adjustment for baseline performance), rather than dichotomising as in this instance, for power, if nothing else.

Bosma et al. (2003b) extended their investigation of the relationship between occupational demands and cognitive decline by coding educational level into 3 groupings (primary education and lower vocational secondary, intermediate vocational education and general secondary education, and higher vocational education, higher general secondary education and university). Educational level correlated .60 with mental work demands. In this report, the ability measures analysed were the Stroop Colour-Word test, the Verbal Learning test and the MMSE [Bosma et al. (2003b) do not explain why this later analysis was based on fewer cognitive measures than was previously available]. Greater cognitive decline (assessed by the change in these measures over the 3 years of follow-up) was associated with a lower educational level; for example, those in the lowest educational group showed a 0.89 points greater decrement on the MMSE compared to those in the highest educational group. Controlling for mental work demands reduced the education-cognitive decline association; mental demands explained about 42% of the association between lower education and greater cognitive decline (Bosma, van Boxtel, Ponds, Houx, & Jolles, 2003b). This was taken as evidence that factors acting across the adult lifespan, in this instance occupational demands, could potentially be altered in order to change the course of cognitive decline. Such factors are more amenable to change, the authors suggest, than earlier life factors including education. Indeed, this is to be achieved by "increasing work-related mental stimuli and challenges among the poorly educated subjects" (Bosma et al., 2003b, p. 166). It is, however, difficult to foresee a future working environment where those of lower ability are accepted into positions in which the tasks are beyond their current cognitive capacity, in the hope this increased stimulation might protect against later cognitive decline. Might a more logical approach be aimed at reducing the inequality closer to the source, whereby educational systems are targeted, rather than occupational ones? Interestingly, Bosma and colleagues (2003b) also control educational level for a vocabulary test completed at baseline (the Groningen

Intelligence Test: participants choose the synonym of a target word from 5 choices), which they describe as a measure of "crystallized intelligence, that is, a relatively stable measure of general intellectual ability" (p. 167). When educational level was adjusted for this and mental demands were controlled simultaneously, the association between educational level and cognitive decline on the 3 tests employed was attenuated. Due to the nature of the analysis, it is not easy to see the relative contributions from these factors. It would perhaps have been more useful to have employed a more stepwise approach to this analysis, with the declines observed first being adjusted for the measure of prior ability, followed by education, and finally mental work demands. This would follow the timeline of exposure.

Whilst the study is longitudinal in nature, it is important to remember that the follow-up occurred only 3 years later, and that perhaps a longer timescale would allow the examination of whether mental demands of work were still related to cognitive functioning after an extended period of time (particularly outwith the workforce), and when a greater proportion of the sample are experiencing cognitive decline. If anything, the associations reported in the earlier analysis appeared to be greater in the group which was no longer working [OR for incident cognitive impairment on the composite cognitive score was 0.76 (95% CI 0.59-0.98) for those previously employed compared with 0.86 (95% CI 0.60-1.23) for those currently employed – these OR did not significantly differ], although there is no information about the age composition of either subgroup (are those no longer working simply older, retired individuals, or are there also those who have left work due to early declines in mental capabilities?). With any such study, non-random attrition is also an issue; the response rate at the follow-up was 73% for those in the lowest third of the composite measure of workload compared with 85% in the highest third. If the relationships are the same in the non-responders then the actual associations are potentially greater than those reported. Perhaps the greatest limitation of the study is similar to many of the previous studies, however, in the use of proxy data to create mental demand scores. Although the authors state this should reduce individual response bias (Bosma et al., 2003a), differences across individuals with the same occupational title or across time will be nullified; it may be that these actual individual differences are what is important.

4.4.3. The effect of occupation?

From the preceding summary, a number of associations have been reported between occupational characteristics – be that at a broad level of categorisation, or on more specific constructs – and cognitive outcomes. However, the findings reported cross-sectionally have been difficult to replicate longitudinally when it is possible to control for a baseline ability measure. Not only is the link confounded by previous intellectual function, but also by educational attainment and socioeconomic status, with the latter factor barely considered. When these have been entered, the association between occupation and cognitive outcomes has often dissipated. The information available is currently patchy and inconsistent, due, in part, to the relatively few studies that have been conducted. This is coupled with the variance across studies in the conceptualisation and measurement of the occupational constructs. For example, when jobs are broadly categorised, there is often little explanation as to the groupings used, or in particular, how these might differ from standard measures of occupational status. However, none of the studies have asked participants to self-report on occupational characteristics, and the factors indexed have been almost singularly focussed on the mental component of work. There are a range of occupational characteristics which may be potentially protective or detrimental to later cognitive function. Before these are introduced, it is necessary to consider the mechanisms which may explain any link between occupation and cognitive change – assuming, of course, that such an effect exists.

4.4.4. Mechanisms relating occupation to cognitive change

For each of the studies discussed where an effect of occupation on cognitive function has been reported, this could be consistent with Schooler's environmental complexity hypothesis only if the job categorisations they employed actually reflect underlying differences in the mental demands of the occupations studied. It may not be permissible to state this as true when only occupational types were used. Instead, authors such as Jorm et al. (1998) and Li et al. (2002) suggest that the observation that certain occupational types are at an increased risk of cognitive decline may be the result of a number of other factors. Individuals in certain occupations may simply be better able to complete tests or may be favoured by the nature of the cognitive assessment procedure (mainly paper and pencil). For example, clerical staff showed the lowest association between age and general ability across 10 occupational groupings, which was attributed to the general similarity in the testing and working procedures for these individuals. Whilst this may be partially true, it cannot explain why those in health care showed the greatest age-related changes in cognitive function (Avolio et al., 1990). As further explanations of the occupational effect, it has been stated that doing certain occupations may delay the onset of cognitive decline; occupational exposure to harmful materials or solvents may modify cognitive abilities; those in occupations with low mental demands may be at a greater risk of exposure to a range of lifestyle factors which may adversely affect later cognition, with lower status associated with lower income, poorer health, and less access to healthcare and social support (Dartigues et al., 1992).

Bosma et al. (2003a) concluded that their findings support the suggestion that mentally demanding work may protect against cognitive impairment in adults aged 50-80 years old after controlling for a range of confounders. As discussed above, the association may be less compelling than has been suggested. But assume for current purposes that cognitive occupational demands do provide mental stimulation across the life course, then this would be consistent with a "use-it-or-lose-it" description of cognitive ageing (Bosma et al., 2003a). The mechanism by which this effect would operate is not clearly defined; however, it is posited that there may be some neuroprotective effect operating directly, or an indirect effect on "brain reserve" that can be altered throughout the lifespan, and may serve to delay the onset or detection of cognitive impairment. Furthermore, it is key to the issue that, in general, those principally employed in occupations classed as less intellectually demanding or 'non-intellectual' may begin with lower ability and therefore be more susceptible to cognitive decline in later life. Any effects of occupational characteristics on later life cognitive change may not be independent of initial ability (Frisoni et al., 1993; Jorm et al., 1998b); to date, this potentially crucial point has been addressed only once with the Aberdeen Birth Cohort 1921 (Staff et al., 2004). The subsequent chapter will allow a full examination in the Lothian Birth Cohort 1921. If there is an independent effect of occupational characteristics on cognitive change, a more detailed description of potential mechanisms will follow.

4.5. Additional occupational characteristics

In the preceding discussion, when occupational characteristics have been examined with respect to their effect on cognition, the focus has essentially been on factors expected to index the degree of mental engagement or stimulation at work. Nevertheless, it is possible that other aspects of lifetime occupational exposure are associated with cognitive decline. For example, greater physical demands at work were shown to be related to an increased risk of dementia (although this was a case-control design with no adjustment for concurrent or previous ability: Smyth et al., 2004). What other occupational characteristics might it be worthwhile to assess? Bosma et al. (2003a) proposed that future studies would benefit from "examin[ing] the likely beneficial effects of active jobs (high demands-high control) on successful cognitive aging" (p. 42). The notion that job control might be related to intellectual functioning was briefly investigated by Schooler and colleagues' (1999) assessment of occupational self-direction, whilst other researchers have also pointed to the need for a broader assessment of work characteristics (Avolio et al., 1990).

This is not to propose the assessment of job control instead of occupational complexity. Rather, as measures of mental demands and complexity may be so highly associated with prior ability as to render them redundant, it would be advantageous to investigate other potentially protective factors simultaneously, perhaps ones more amenable to modification: would increasing control opportunities (allowing an employee greater freedom to schedule what tasks are completed when) be a more likely occurrence in contrast to increasing the mental demands associated with the job? This question is purely hypothetical at present; the necessity of answering it is predicated on first finding a replicable effect of other occupational characteristics such as control on cognitive ageing. Further research in this area is warranted.

4.5.1. Karasek's demands-control model

Since the 1970s, there has been a concerted effort directed towards examining the effects of the psychosocial work environment on health outcomes. Perhaps the most widely used model in this endeavour is that elaborated by Karasek and Theorell (Karasek, 1979; Karasek & Theorell, 1990). In this conceptualisation, the psychosocial work environment can be characterised by a number of factors, but mainly decision latitude (combining skill discretion and decision authority) and the psychological demands of work. These form the main demands-control core of the model. It is not, however, the demands of work *per se* that may adversely affect health, but the level of control an individual possesses in their job to decide how to complete their work and utilise their skills.

> In many cases, elevation of risk with a demanding job appears only when these demands occur in interaction with low control on the job (Karasek et al., 1990, p. 9).

Thus, it is "not the bosses but the bossed who suffer most from job stress" (p. 16). Combinations of the levels of demands and control can produce 4 main types of work environment: high strain jobs (characterised by high demands and low control), low strain jobs (low demands and high control), active jobs (high demands and high control) and passive jobs (low demands and low control). The resultant psychological strain from these combinations of demands and control may have important health outcomes.

This core model has been supplemented by including social support and physical demands of work as well, and it has been suggested that an occupation characterised by increased psychological demands, decreased decision latitude, a lower level of skill, decreased social interaction and increased physical demands is likely to lead to the highest levels of psychological stress (Karasek et al., 1990). The Job Content Questionnaire (JCQ: Karasek, 1985) was developed to specifically measure these psychosocial job characteristics within individuals.

4.5.2. Occupational characteristics and health outcomes

Research examining the health correlates of the working environment has been extensive, and is beyond the scope of this thesis. However, a *précis* by Karasek and colleagues declared "that the JCQ and JCQ-like scales demonstrate substantial predictive validity with respect to stress-related chronic disease in international and U.S. research" (Karasek et al., 1998, p. 330). Much of this research has concerned cardiovascular outcomes, and suggests that, in general, lower control and higher strain jobs as well as reduced social support at work result in an increased risk of CVD (discussed in the reviews of Schnall, Landsbergis, & Baker, 1994, Theorell & Karasek, 1996 and Steenland et al., 2000, for example):

> high job strain influences health and quality of life in many ways, and none of these seem to be beneficial (Kristensen, 1995, p. 20).

It might be expected that high strain jobs will have a similarly detrimental effect on later life mental function. Psychosocial work factors assessed by the JCQ could therefore prove to be useful constructs to examine the effects of occupational exposures on cognitive decline, in addition to occupational cognitive demands.

4.6. Summary and LBC1921 objectives

- Work complexity and occupational type may be related to later life cognitive change, although it is presently unclear whether this is independent of prior ability or education.

- Other aspects of working life (such as demands and control opportunities) known to be injurious to health have yet to be investigated with respect to later cognitive decline.

The potential exists to learn from a full assessment of occupational characteristics and later life cognitive ability. To be useful and informative further investigation must deal with a number of issues.

The paucity of studies in this domain is surprising due to the fact that cognitive test performance is often cited as the best single predictor of subsequent job performance (Schmidt et al., 2004). Such a powerful finding ultimately serves to highlight the need to control for an early measure of ability when considering occupational effects on later cognition. If higher ability predicts career advancement, presumably to more complex occupational conditions, then this must be controlled in any analysis. The studies discussed in this chapter are either unable to control for early ability due to a cross-sectional design, or have a baseline measure of ability taken only 3 years previously. The latter studies' prior ability measure may itself have already been subject to change as a result of occupational conditions, if indeed an effect exists. An early measure of ability must be entered into the analysis, preferably one assessed at a point in time before working life begins; this will control for the level of ability of those entering different occupations and will not be confounded by potential occupational effects on cognition. In addition, to be useful in determining later cognitive change, a long follow-up into adulthood will be required to determine whether any occupational effects continue to affect cognition well into the retirement years.

For greater specification of the occupational characteristics under investigation, classification by job title alone is insufficient; assessment of a broad range of work factors should be based on actual participant reports of, for example, the levels of mental and physical demands, the opportunities for control and the support provided. There was an over-reliance on previously collected survey data and although some studies collected their own data, this was often in the form of expert ratings. It would be advantageous to have a full lifetime occupational history, collected prospectively from the individuals being followed longitudinally into old age. A study combining these specifications would not be impossible, but would be rarely attempted due to the length of follow-up specified, particularly as a result of the need for a true measure of pre-morbid ability.

In the subsequent chapter, the assessment of a range of occupational characteristics in the LBC1921 will be described. These factors will then be investigated for their predictive power with respect to cognitive change across the lifespan.

Chapter 5: Occupational characteristics and cognitive ageing in the LBC1921

Occupational characteristics are potential determinants of later life cognitive change; however, as discussed, a number of issues remain to be clarified. To address some of these, chiefly the lack of a valid measure of pre-morbid ability in most of the studies described, the LBC1921 were asked about their work history. Cognitive change across the life course in this group has been previously described (Chapter 3). The assessment of occupational characteristics was conducted by means of a self-report booklet sent to participants (Appendix III). [This booklet contained other sections, including lifetime social networks and support and activity participation, to be described later.] As this measurement asked participants to reflect on earlier points in their life, it is referred to throughout as the Retrospective Self-report. The procedure employed in distributing this booklet to the LBC1921 will first be described, as will the measures of work characteristics completed. The analysis of this information will be presented followed by the production of summary scores for the job features assessed. In the final stage of analysis, it will be possible to determine whether any of the occupational characteristics indexed predict cognitive change.

5.1. Retrospective Self-report

5.1.1. Procedure

At the time of the Retrospective Self-report (the booklet is shown in Appendix III), 488 participants were listed in the LBC1921. Some participants had incomplete data from previous stages, but each was mailed the questionnaire booklet to allow: a greater potential sample size for the subsequent psychometric analyses; and the collection of information on participants who might still be included in subsequent follow-ups. The mailing was sent out between 29th April and 4th May, 2004, labelled ***E*** on the LBC1921 Study timeline (Figure 3.1). A cover letter (Appendix IV) explaining the purpose of the follow-up was included. Participants were asked to complete as much of the booklet as they chose and were able to at their own pace, and return it in the prepaid envelope provided. General instructions for completing the questionnaires were contained on the first page of the booklet, with more specific instructions throughout. A telephone number was provided for any problems or queries the participants might have encountered during completion. If after approximately 7-8 weeks (21st to 24th June, 2004) no response had been received, a second booklet (and prepaid envelope) was mailed along with a reminder letter (Appendix V). When the booklets were returned and entered into the database, they were checked for omissions, multiple responses and incongruent answers. If any of these were found, they were detailed in a letter sent to the participants (Appendix VI), asking them if they would be willing to complete or correct the appropriate item(s) and return them in the prepaid envelope. If no response was received to the correction letter after about 5/6 weeks, a correction reminder letter was mailed (Appendix VII). In certain cases, a correction letter was not warranted as a change could be automatically applied to a response without consulting the participant. This was only done in instances where a more appropriate response was apparent (for example, if the participant supplied an answer as a range when a single number was needed, the midpoint of the range was used). A full report of this automatic entry is given in Appendix VIII.

In total, as shown in Figure 5.1, 411 participants responded to the initial mailing (84.2% of 488 mailed): 38 were refusals (9.2% of the 411 replies) and 372 participants returned booklets (90.5% of the 411 replies). A further 1 booklet (0.2%) was returned from a participant who had no corresponding data. Of the returned booklets, 114 (30.6%) were fully completed and 258 (69.4%) contained omissions or incompatible responses. Corrections were requested from 247 participants. This resulted in a further 195 complete booklets and 35 which remained incomplete after the return of corrections. Twenty-one participants were sent a correction reminder, which led to 7 more complete booklets, and 10 which remained incomplete on return of the correction reminder.

One hundred and twenty-one reminder booklets were sent (24.8% of the original 488 mailed), resulting in 21 refusals (17.4% of the reminders) and 12 returned booklets (9.9% of the reminders); 31 participants who were sent a reminder booklet subsequently returned the first booklet, included in the total above. Of the returned booklets, 2 were fully complete, and 10 were incomplete. Corrections were sent to 9 participants, resulting in a further 5 complete and 2 incomplete responses. Two participants were sent correction reminders. Both booklets remained incomplete (1 was incomplete after corrections and the other was a non-response).

Data collection ended on 3rd December, 2004, and the final response was as follows (Figure 5.1). Of the 488 participants mailed the booklet, 444 (91.0%) responded. This response included returned booklets from 384 participants (78.7% of those mailed), plus 1 which was not included in the database: at the end of the data collection period, 323 booklets (84.1% of those returned) were complete and 61 (15.9%) remained partially completed after corrections were requested, where appropriate. Fifty-nine participants (12.1% of those mailed) refused the booklet for various reasons, and 44 participants (9.0% of those mailed) did not respond.

5.1.2. Measures

The Retrospective Self-report booklet was constructed by Alan Gow and comprised 4 sections in order to assess work history, lifetime social support, lifetime activity participation and contemporaneous religiosity/spirituality, entitled Work, Support From Others, Activities, and Religious Activity respectively (Appendix III). [The Religious Activity section will not be discussed further in this thesis.] The booklet went through several iterations with comments from Ian Deary and Martha Whiteman before being finalised. This final version was checked by 3 individuals around the same age as the LBC1921 to ensure instructions and questions were clear. Each section was created either by using a previously validated measure as published (with permission and payment as appropriate), altering existing items to make them suitable for the current purpose, or creating new items based on an amalgamation of previous scales. The Work section will be described below.

5.1.2.1. Work

Part A: Your Employment

The main full-time job carried out by the participant was assessed (Part A: Your Employment, shown in Appendix III). Participants were asked whether their main adult job was full-time, part-time or whether they were not in paid employment (question 1). Those falling into the latter 2 categories were directed to Part B: Household Work of the Work section. Those in predominantly full-time employment were asked the full title of their main job (defined as the post they held for the longest period), the number of years they did this job and the average number of hours they worked at this job per week (questions 2-4). They were also asked how many years they were in full-time employment altogether, the age at which they retired, and whether this was their own choice or if they felt forced into it (questions 5-7).

The Job Content Questionnaire (JCQ: Karasek, 1985) was designed to measure the content of a individual's occupation, and can be used in a number of formats for different purposes. Permission was given to use items from this scale to assess the job characteristics of participants' main full-time jobs (Appendix IX). The 'core' measure contains scales covering Decision Latitude (skill discretion and decision authority), Psychological Job Demands, Physical Job Demands and Job Insecurity. For the current assessment, 45 items from the JCQ were used: skill discretion (6 items), decision authority (3 items), psychological job demands (9 items), physical job demands (5 items), supervisor social support (6 items), coworker social support (7 items), physical hazards (6 items) and toxic exposure (3 items). These JCQ items were additionally supplemented with: a 5-item scale (questions 28-32) for job complexity (with an alpha ranging from .75-.84: Vaananen, 2004); and a 4-item scale (questions 33-36) for mental work demands (De Zwart et al., 1997; Bosma et al., 2003a). The format of these items was altered to make them compatible with those of the JCQ (for example the question "Is your work monotonous or variable?" was reworded as a statement: "My work was monotonous"). The items of the JCQ and job complexity were re-worded to make them applicable to retrospective assessment. All were answered on a 4-point scale (strongly disagree to strongly agree), except for the physical hazards and toxic exposure items [8 of these items (questions 53-60) were scored on a 3-point scale from not exposed to exposed and it was a sizable problem; one item concerning voice level in the workplace (question 61) was answered on a 4-point scale from whisper to shout].

Part B: Household Work

In Part B, all participants were asked about the general level of household work they carried out during 3 age periods: 20-35, 40-55 and 60-75 years old. This would give an indication of the level of work carried out instead of, or in addition to, full-time paid employment. These age periods were chosen to reflect the full lifespan between the cognitive assessments (from age 11 to the start of the follow-up at age 79), divided into equal time frames. The items were based on those previously used by Frandin and Friedenreich (Friedenreich, Courneya, & Bryant, 1998; Frandin, Mellstrom, Sundh, & Grimby, 1995). For each age period, participants recorded on a 5-point scale the level of household work they did (from never or rarely to heavy, vigorous household work).

5.1.3. Response

Three hundred and eighty-four participants [157 (40.9%) men and 227 (59.1%) women] supplied answers to Section I (Work) of the Retrospective Self-report; 91.4% (351 out of 384) provided fully complete responses whilst 8.6% (33) omitted certain items, even after corrections were requested.

5.2. Results

5.2.1. Work history descriptives

Three hundred and eighty participants answered the item relating to their principal occupation (the job held for the longest time). For the majority (91.1%; 346) their principal occupation was a full-time position, for 20 participants (5.3%) it was part-time and 14 (3.7%) were never in paid employment. All 157 men who answered this item had a full-time principal occupation; of the 223 women responding, 14 (6.3%) were never in paid employment, 20 (9.0%) had a principal occupation which was part-time and 189 (84.8%) were full-time. One-way ANOVAs were conducted with the cognitive measures as the dependent variable. No significant differences in these were found between those participants whose principal occupation was full-time, part-time or those who were not in paid employment [age-11 IQ $F(2, 334) = .079$, $p = .924$; age-79 IQ $F(2, 365) = .775$, $p = .461$; age-79 cognitive ability $F(2, 363) = 1.696$, $p = .185$; age-83 cognitive ability IQ $F(2, 284) = .734$, $p = .481$; cognitive ability change 79-83 $F(2, 280) = 1.080$, $p = .341$].

The participants employed mainly full-time held their principal occupation for a mean of 23.1 years (*sd* = 12.7), ranging from 2 to 60 years, whilst the average working week ranged from 26 to 90 hours [mean = 43.6 hours (*sd* = 8.1)]. Overall, full-time employment lasted a mean of 35.1 years (*sd* = 14.7, range = 3 to 68 years). Retirement was at a mean age of 58.8 years old (*sd* = 12.0), occurring between 21 and 83 years old. The lower bound of this range is due to the women who left employment at a young age, presumably to raise their families (the youngest retirement age recorded by the men was 54 years old). The maximum age was due to a small number of participants who continued to work in later life; 35 participants retired after the age of 65, with the latest at 83 years old. Most participants (249 of the 342 who answered this item; 72.8%) felt that retirement was their own choice, although 93 (27.2%) felt forced into this decision.

The intercorrelations amongst the work history variables (regarding length of principal and total employment, working hours and retirement) are shown in Table 5.1. As would be expected, the total number of years an individual worked in their principal occupation was positively associated with the total number of years they worked in their lifetime ($r = .62, p < .001$), and their age at retirement ($r = .46, p < .001$). Likewise, a greater number of years worked altogether was associated with being older at retirement ($r = .65, p < .001$). Finally, the total number of years worked altogether and retirement age were negatively associated with the decision to retire [$r = -.23$ ($p < .001$) and -.15 ($p = .006$) respectively]; participants who worked a greater number of years or were older when they retired were more likely to have felt forced into retirement. When these intercorrelations were examined separately by gender (Table 5.2), for men, being older at retirement was positively associated with the number of years in the principal occupation, the average number of weekly hours in this job and the total number of years employed altogether ($r = .26$-$.34, p < .001$). For women, the number of years in the principal occupation was positively associated with the total number of years in employment ($r = .62, p < .001$) and retirement age ($r = .41, p < .001$). In addition, age at retirement was negatively associated with the average number of hours in the principal employment ($r = -.15, p = .037$). The number of years in full-time employment was positively associated with retirement age ($r = .58, p < .001$), and negatively with retirement choice ($r = -.15, p = .048$). In women, a greater number of years in employment was associated with feeling forced into retirement.

5.2.2. Work history variables and cognition

Table 5.3 shows the associations between these work history variables (regarding length of principal and total employment, working hours and retirement) and the cognitive measures. The only work history variable associated (negatively) with age-11 and age-79 IQ was the number of hours participants worked per week in their principal occupation [$r = -.14$ ($p = .016$) and -.19 ($p = .001$) respectively]. Individuals who worked a greater number of hours each week were likely to have lower mental ability in childhood and late adulthood. When childhood ability was controlled, the age-79 IQ-hours worked association remained significant ($r = -.13, p = .023$). This suggests the association in adulthood is not explained by individuals with lower initial ability working longer hours. Considering the composite measures of ability, the number of hours worked per week was negatively associated with this at age 79 ($r = -.14, p = .014$). The only work history variable associated with the change from age 79 to 83 was retirement age; those retiring younger declined less over the follow-up ($r = -.14, p = .023$).

The associations were also examined separately by gender (Table 5.3). There were no significant associations between any of the work history variables and the cognitive measures in men. However, in women, the number of hours worked per week was negatively related to age-11 IQ, age-79 IQ and the age-79 cognitive ability composite [$r = -.20$ ($p = .010$), $-.28$ ($p < .001$) and $-.20$ ($p = .007$) respectively]. Women who worked a greater number of hours had poorer mental ability in childhood and adulthood. Controlling for age-11 IQ reduced the association of hours worked with age-79 IQ to -.20 although it remained significant ($p = .012$). In addition, retirement age in women was negatively associated with age-79 IQ ($r = -.16, p = .035$). Later retirement in women was associated with poorer mental ability in late adulthood (age 79), however, this association was not significant after controlling for age-11 IQ ($r = -.11, p = .155$).

5.2.3. Job Content Questionnaire scoring

The psychometric properties of the Job Content Questionnaire (JCQ) have been well studied; it was therefore scored as instructed (Karasek, 1985). To compute the Skill Discretion score, the sum of the 5 items of this scale is multiplied by 2; for Decision Authority, the sum of the 3 items is multiplied by 4; for Psychological Job Demands (5-item version) 3 times the sum of JCQ19 and 20 is added to twice the sum of JCQ22, 23 and 26. Due to revisions of this instrument, certain scales can also be scored to include additional items. For example, the Psychological Job Demands scale originally contained 5 items, but has been supplemented with a further 4; for the longer Psychological Job Demands scale, the overall score is the simple sum of the 9 items. All other factor scores are simply the sum of the appropriate items.

Table 5.4 lists the internal consistencies (Cronbach's alpha) for each of the JCQ scales, including possible variations due to the inclusion of additional items. These ranged from .61 for Psychological Job Demands (5-item version) to .91 for Physical Isometric Loads. The 9-item revision of the Psychological Job Demands scale produced a higher internal consistency than the shorter 5-item version; only analyses with the longer scale will be reported. The 3-item Physical Exertion scale will also be used rather than the single item. For Coworker Support, both the 6 and 7-item versions had an alpha of .74; the shorter version was chosen for its conciseness. The 5-item version of Supervisor Support was chosen as although it had the lowest internal consistency of the 3 versions, it was still acceptable, and matched the version chosen for the Coworker Support scale.

From these basic scales, further higher-order factors can be created as follows:

- Decision Latitude = Skill Discretion + Decision Authority;
- Social Support = Coworker Support + Supervisor Support;
- Total Physical Hazards = addition of z-scored Hazardous Conditions + z-scored Toxic Exposures;
- Total Physical Stressors = addition of z-scored Physical Exertion + z-scored Total Physical Hazards.

The intercorrelations between the scales of the JCQ are shown in Appendix X.

5.2.4. JCQ scales and cognition

5.2.4.1. Age-11 and age-79 IQ

The associations between each of the JCQ scales and cognition are shown in Table 5.5; those with the cognitive measures derived from the MHT (age-11 IQ and age-79

IQ) will be detailed first. Where a statistically significant association between age-79 IQ and any of the JCQ scales is detected, a partial correlation controlling for age-11 IQ will be conducted. This will remove the effect of early ability on the relationship; any association which remains is therefore independent of age-11 IQ.

Individuals whose principal occupation was characterised by greater skill discretion and decision authority had higher age-11 and age-79 IQ (r = .13 to .19, $p < .05$). Increased decision latitude (produced by summing these 2 scales) was also positively related to the cognitive measures (r = .15 for age-11 IQ and .16 for age-79 IQ, both $p < .01$). Thus participants who held jobs requiring a greater variety of skills to be utilised and had more control over how these skills were deployed had higher ability in childhood and late adulthood. However, the associations with age-79 IQ were reduced and no longer significant when childhood ability was controlled (r = .11, .06 and .08 respectively, *ns*). There was no significant association between psychological job demands and early ability (r = -.11, p = .059), but individuals in occupations with higher psychological job demands (described as being often hectic and fast paced) had poorer cognitive ability at age 79 (r = -.13, p = .016). The latter association did not hold after adjustment for childhood ability (r = -.08, p = .161). That the associations of these work characteristics and later ability are attenuated when childhood ability is controlled suggests levels of skill discretion, decision authority, decision latitude and psychological job demands are not protective or harmful for cognitive function in old age; the unadjusted associations are due to the link between these factors and the lifelong trait of intelligence.

The level of support received from coworkers was not associated with either age-11 or 79 IQ [r = .04 (p = .533) and .09 (p = .124) respectively]. Increased supervisor support was not related to IQ at age 11 (r = .08, p = .184); however, there was an association with higher age-79 IQ (r = .17, p = .002). Individuals receiving more support from their supervisor showed improved cognitive performance in later life. When this association was controlled for childhood ability, the association held (r = .16, p = .006). The overall social support received at work (created by summing support from coworkers and supervisor) was related to age-79 IQ ($r = .17, p = .003$) but not age-11 IQ ($r = .09, p = .151$). Again, controlling for childhood ability did not substantially alter the age-79 IQ-social support association ($r = .15, p = .013$). It appears that the level of support received at work (in total and specifically from a supervisor) is not related to childhood ability, but is predictive of better functioning in later life.

Individuals whose occupations required more physical exertion (for example, rapid and continuous physical activity, or heavy lifting) had poorer cognitive ability at ages 11 and 79 ($r = -.36$ and $-.39$ respectively, $p < .001$). Similarly, an occupation characterised by increased physical isometric loads (working with the body or head and arms in physically awkward positions) was related to decreased IQ at 11 and 79 ($r = -.29$ and $-.32$ respectively, $p < .001$). For both these scales, controlling childhood IQ reduced the association with age-79 IQ, but these remained significant [being -.22 ($p < .001$) for physical exertion and -.18 ($p = .002$) for physical isometric loads]. Those in more physically awkward or demanding jobs were likely to have started with lower ability, however, this does not fully explain the association between physical demands and later life cognitive function.

Participants working in more hazardous conditions in their principal occupation (dangerous tools, machinery, or equipment, or exposure to fire, burns, or shocks, for example) had decreased age-11 and age-79 IQ ($r = -.23$ and $-.29$ respectively, $p < .001$). Similarly, increased toxic exposure (from chemicals, air pollution or disease risk) was associated with lower age-11 and age-79 IQ ($r = -.11$ and $-.13$ respectively, $p < .05$). Controlling childhood ability removed the age-79 IQ-toxic exposures association ($r = -.07, p = .213$), however, the hazardous conditions correlation remained ($r = -.19, p = .001$). This suggests individuals with poorer childhood ability experienced a higher level of toxic exposure at work, but this factor did not independently affect later ability level, whereas increased hazards at work, whilst also related to lower early ability, had an association with ability in old age independent of prior function. The total physical hazards score (computed by the addition of z-scored hazardous conditions and toxic exposures) was negatively associated with ability in childhood and late adulthood (r = -.19 and -.23 respectively, $p < .001$). Total physical stressors (computed by the addition of the z-scored physical exertion and total physical hazards) was also negatively associated with age-11 and age-79 IQ (r = -.32 and -.37 respectively, $p < .001$). Both these associations remained after adjusting for age-11 IQ (r = -.15 and -.22 respectively, $p < .05$), suggesting more dangerous or physically demanding work is detrimental to cognitive ability in old age.

Finally, a single item regarding noise levels at work ("How loud would you have to talk to be heard by someone standing next to you?" with answers ranging from whisper to shout) was not used in the calculation of any of the JCQ scales. This individual item was negatively related to age-11 IQ (r = -.18, p = .001) and age-79 IQ (r = -.28, $p < .001$). The latter association was attenuated but still significant after controlling for age-11 IQ (r = -.21, $p < .001$).

The associations detailed above were also examined separately by gender (Table 5.6); only the associations with the measure of lifetime cognitive change will be discussed (the partial correlations with age-79 IQ when age-11 IQ was controlled). With age-11 IQ partialled out of the association, in both men and women the correlation between age-79 IQ and hazardous conditions [men r = -.21 (p = .015), women r = -.27 (p = .001)], total physical hazards [men r = -.20 (p = .018), women r = -.17 (p = .028)] and total physical stressors [men r = -.27 (p = .002), women r = -.21 (p = .008)] remained significant. That is, when childhood ability is accounted for, individuals working in more hazardous conditions, or exposed to more physical hazards and stressors at work (for example, dirty or badly maintained areas, dangerous tools, machinery or equipment, jobs requiring a lot of physical effort, or exposure to dangerous chemicals) have lower ability at age 79. Furthermore, in both men and women, those less physically exerted at work achieved a higher IQ score at age 79, after controlling for childhood IQ [r = -.28 (p = .001) and -.18 (p = .027) respectively]. In women, increased physical isometric loads (the requirement to work in physically awkward positions) were associated with poorer age-79 IQ independent of age-11 IQ [$r = -.20$ ($p = .009$)], whereas in men, increased toxic exposure was detrimental to age-79 IQ, adjusting for age-11 IQ [$r = -.17$ ($p = .046$)]. For the item regarding voice level at work, a noisier working environment was associated with poorer age-79 IQ in men ($r = -.26$, $p = .001$), and in women, it was related to lower IQ at ages 11 and 79 ($r = -.25$ ($p = .001$) and -.32 ($p < .001$) respectively]. In both men and women, the association between voice level and age-79 IQ remained after controlling for age-11 IQ [$r = -.24$ ($p = .004$) and -.21 ($p = .006$) respectively].

5.2.4.2. Cognitive ability at ages 79 and 83

The correlations between the JCQ scales and cognitive ability at ages 79 and 83 (derived from Raven's Matrices, Verbal Fluency and Logical Memory) are also shown in Table 5.5. Those performing cognitively better at age 79 held principal occupations characterised by greater skill discretion, decision authority and decision latitude, lower psychological demands, increased supervisor and overall support and fewer physical demands, hazardous conditions and toxic exposures. A similar pattern of associations was apparent for cognitive ability at age 83; additionally the association between age-83 ability and coworker support was significant, although there was no significant correlation with decision authority, decision latitude, psychological job demands or toxic exposures. The noise level at work item was negatively related to cognitive ability at ages 79 ($r = -.23$, $p < .001$) and 83 ($r = -.25$, $p < .001$). The final column of Table 5.5 lists the correlations with cognitive ability change from age 79 to 83. There were small associations of coworker support ($r = .15$, $p = .019$), social support ($r = .14$, $p = .036$) and physical isometric loads ($r = -.14$, $p = .029$) with this measure of change. A significant correlation indicates an association exists between the occupational characteristic and ability at age 83 controlling for age-79 cognitive ability. That is, individuals who received increased support from coworkers, increased support from coworkers plus supervisors, or whose work was of a less physically awkward nature showed less cognitive decline from 79 to 83 years old.

Considering the change in cognitive ability from age 79 to 83 separately by gender (Table 5.6), none of the occupational characteristics were associated with cognitive change in the men. In women, increased psychological demands were negatively related to later life cognitive change ($r = -.21, p = .021$) whilst the level of coworker support was positively related ($r = .21, p = .019$).

5.2.5. Job Complexity (Vaananen, 2004)

A great deal of research has been conducted into the psychometric properties of the Job Content Questionnaire therefore the scoring of its scales was as instructed. For the Job Complexity and Mental Work Demands items, there is limited psychometric data available. A PCA will be conducted on each to ensure a valid scale can be produced.

The 5 Job Complexity items (for example, "My work was monotonous") were subjected to a PCA to determine whether an overall factor described the data effectively. The overall KMO Measure of Sampling Adequacy (MSA) was .75, with individual item MSA ranging from .70 to .82. The scree plot produced (Figure 5.2) suggested that a single factor explained 46.9% of the variance (Cronbach's alpha = .70). A Job Complexity score summing the individual items was therefore computed, with values ranging from 5.0 to 15.0, mean = 9.7 ($sd = 2.2$).

5.2.6. Job Complexity and cognition

Table 5.5 shows the associations between Job Complexity and the cognitive measures; increased complexity at work was associated with higher ability at all ages assessed [age-11 IQ $r = .22$ ($p < .001$), age-79 IQ $r = .26$ ($p < .001$), age-79 cognitive ability $r = .22$ ($p < .001$), age-83 cognitive ability $r = .17$ ($p = .007$)]. Adjusting for age-11 IQ reduced the Job Complexity-age-79 IQ association ($r = .16$), but this remained significant ($p = .006$). However, there was no link between complexity and cognitive change from age 79 to 83 ($r = -.05, p = .389$). When the associations were examined separately by gender, similar results were obtained (Table 5.6). The association between age-83 cognitive ability and Job Complexity was not significant for women ($r = .15$, $p = .100$).

5.2.7. Mental Work Demands (De Zwart et al., 1997)

For the 4 Mental Work Demands items (for example, "My work was mentally demanding"), the overall MSA was .71, with individual values ranging from .66 to .81. The scree plot (Figure 5.3) indicated that 1 factor explaining 55.9% of the variance described the items effectively (Cronbach's alpha = .72). A Mental Work Demands score was computed by summing the 4 items: mean = 7.2 (*sd* = 2.0, range = 0.0 to 12.0).

5.2.8. Mental Work Demands and cognition

The relationships between mental work demands and cognition are shown in Table 5.5; no significant associations were found between this index of the mentally demanding nature of a participant's principal occupation and any of the cognitive measures (*r* varied from .03 to .09 in the total sample, all *ns*). When the associations were examined separately by gender (Table 5.6), again no significant relationships were found. The lack of associations between this scale and cognition will be considered later.

5.2.9. Household work

During each of the 3 age periods assessed (20-35, 40-55 and 60-75 years old), the level of household work carried out ranged from 1 ("I did no household work or helped very rarely") to 5 ("I did household activities that increased the heart rate and caused heavy sweating such as those requiring lifting, moving heavy objects, rubbing vigorously for fairly long periods (heavy gardening, home-repairing, responsible for all domestic activities, light as well as heavy, weekly cleaning with vacuum cleaning, washing floors and window-cleaning)"). The modal level was 4 ("I did household activities that were not exhausting, increased the heart rate slightly and might have caused light perspiration (ordinary gardening, main responsibility for light domestic work such as cooking, dusting, clearing up and making beds)") in each period, although there was a slight increase in the mean level of household work across time (from 3.4 at 20-35 to 3.8 at 40-55, to 3.9 at 60-75). For women, the modal value was 4 during all time periods, while for men it was 1 ("I did no household work or helped very rarely") at 20-35 years old, and then 4 during the later 2 age periods. The level of household work mainly carried out from 20 to 35 years old correlated .63 ($p <$ .001) with the level at 40-55 and .46 ($p < .001$) at 60-75. The levels at 40-55 and 60-75 years old correlated .63 ($p < .001$). An indicator of lifetime household work was calculated by summing the values for the 3 age periods.

5.2.10. Household work and cognition

The associations between cognition across the lifespan and the measures of household work are shown in Table 5.7. There were no significant associations between household work and age-11 or age-79 IQ, age-79 cognitive ability or cognitive ability change from age 79 to 83, although a higher level of household work carried out between 60 and 75 years old was associated with increased cognitive ability at age 83 ($r = .14$, $p = .018$). In women, there was no association between household work and cognition. For men, increased household work between 60 and 75 years old remained associated with higher age-79 IQ after adjustment for age-11 IQ ($r = .25$, $p = .003$). Although household work was associated with cognitive ability at ages 79 and 83 in men, there were no significant associations with cognitive change across this time.

5.3. Regression analyses

The preceding results have examined the univariate associations between work-related variables and cognitive outcomes. The final stage of analysis will use significant correlations to guide the selection of variables in regression analyses. Firstly, the occupational predictors of age-79 IQ will be sought. In the results presented throughout, standardised β are reported.

5.3.1. Predicting age-79 IQ

The occupational characteristics which remained associated with age-79 IQ when age-11 IQ was adjusted may account for changes in cognition across the lifespan. These were the variables which were therefore selected for further analysis. A hierarchical regression was conducted with age-79 IQ as the dependent variable. Age-11 IQ and sex were entered as independent variables in block 1. In the 2nd block, the following variables were entered in a stepwise fashion: Supervisor Support, Physical Exertion, Physical Isometric Loads, Hazardous Conditions, Voice level at work and Job Complexity. In the first model, age-11 IQ ($\beta = .66, p < .001$) and sex ($\beta = -.10, p = .027$) accounted for about 43% of the variance in age-79 IQ (Table 5.8 *A*). Hazardous Conditions, Voice level at work and Supervisor Support entered in the next 3 models, accounting for 3%, 1% and 1% of the variance in age-79 IQ respectively. Individuals who were exposed to more hazardous working conditions, a noisier working environment and with less support from their supervisor showed poorer cognitive function at age 79, independent of childhood ability. The model was repeated including the number of years in full-time, formal education in the 1st block (Table 5.8 *B*). This did not substantially alter the final model, although model 1 (age-11 IQ, sex and years of education) now explained 45% of the variance in age-79 IQ, Hazardous Conditions explained about 2% and Supervisor Support and Voice level each explained about 1%.

Three higher-order scales which were formed by combining simple scales were also related to age-79 IQ independently of age-11 IQ (Social Support, Total Physical Hazards and Total Physical Stressors). The regression analysis was re-run including these higher-order scales, removing any constituent scales where appropriate (for example, to include Social Support in the analysis, Supervisor Support was removed as it was a component of the higher-order scale). This required running 2 further regressions because entering Total Physical Hazards required the removal of Hazardous Conditions, which then itself had to be removed to enter Total Physical Stressors. In each of these models, age-11 IQ, sex and years of education were entered in block 1. In the 2nd block, stepwise entry was used to input:

> Social Support (the sum of Supervisor Support and Coworker Support), Physical Exertion, Physical Isometric Loads, Total Physical Hazards (composed from Hazardous Conditions and Toxic Exposures), Voice level at work and Job Complexity;
>
> Social Support, Physical Isometric Loads, Total Physical Stressors (composed from Total Physical Hazards and Physical Exertion), Voice level at work and Job Complexity.

In both regressions, age-11 IQ, sex and years of education accounted for about 46% of the variance in age-79 IQ. The only other significant factor was Voice level at work, accounting for about 2% of the variance.

5.3.2. Predicting later life cognitive change

Regression analyses were also conducted with cognitive change from age 79 to 83 as the dependent variable. Age-11 IQ and sex were entered in the 1st block, followed stepwise by those variables with significant associations to the outcome in block 2 (age at retirement, Coworker Support and Physical Isometric Loads). Table 5.9 *A* summarises this analysis. In the 1st model, age-11 IQ and sex accounted for about 2% of the variance in cognitive change from age 79 to 83 (although sex did not significantly contribute). The only other variable entering the model was Coworker Support, also accounting for about 2% of the variance; participants who received more support from their colleagues showed less relative cognitive decline in later life. The analysis was re-run including the number of years of education in block 1 (Table 5.9 *B*). In this regression, age-11 IQ, sex and education accounted for about 2% of the variance in cognitive change (though none of these contributions were statistically significant). Coworker Support accounted for about 2% of the variance.

Finally, a model replacing Coworker Support with Social Support was run. In this model, age-11 IQ, sex and education accounted for about 5% of the variance in cognitive change from age 79 to 83, although only the contribution from age-11 IQ was significant. None of the occupational factors entered the model.

5.4. Discussion

The Lothian Birth Cohort 1921 were asked to provide information about their work history, covering background details of the length of employment and their average hours worked each week, for example, to a more specific scoring of the characteristics of their principal lifetime occupation covering the level of support received at work, the mental and physical demands of the tasks undertaken and the associated hazards in the workplace. The links between these factors and cognition assessed across the lifespan were examined. Where an association with age-79 IQ persisted after controlling for childhood IQ (assessed at age 11), it is suggestive that the particular occupational factor influenced cognitive change across the lifespan. The further impact of these same work characteristics on later life cognitive change from age 79 to 83 was also investigated.

5.4.1. Summary of results

A number of univariate associations were reported between occupational characteristics and cognitive function in the LBC1921. Lower ability in childhood was associated (correlation coefficients are shown in parenthesis) with holding a principal occupation characterised by lower Skill Discretion (.17), Decision Authority (.14), Decision Latitude (.15) and Job Complexity (.22), greater Physical Exertion (-.36) and Physical Isometric Loads (-.29), increased Toxic Exposures (-.11), Hazardous Conditions (-.23), Total Physical Hazards (-.19) and Total Physical Stressors (-.32), and a noisier working environment (-.18). When controlling for childhood IQ, associations between specific occupational characteristics and IQ at age 79 remained. These factors were therefore related to change in intellectual function across the lifespan. Increased support at work (specifically from a supervisor and the summed level from coworkers plus supervisor) and more complex work had a positive effect on lifetime cognitive change, while more physically demanding and awkward work, and hazardous and noisy working environments had negative effects. The magnitude of these adjusted associations (positive and negative) ranged from .14 to .20. In the regression analyses predicting later life IQ (controlling age-11 IQ, sex and years of education), Hazardous Conditions, noise level at work and Supervisor Support accounted for unique variance in the outcome, each explaining about 1-2% of the variance.

When the change in cognitive function in later life (from 79 to 83 years old) was considered, retirement age, support from coworkers and overall support, and the physically awkward nature of work were related to this measure (all at .14 or .15, though in both positive and negative directions). Regression analyses (controlling age-11 IQ, sex and years of education) suggested the only occupational characteristic contributing uniquely to the prediction of later life cognitive change was the level of coworker support, accounting for about 2% of the variance.

5.4.2. Complex, mentally demanding work and cognition

Although research investigating occupational characteristics and cognitive ageing has been limited, that which has been conducted has generally focused on the mental complexity of the work undertaken and the consequent effect on later cognitive ability or change. In the LBC1921, the complex, mentally demanding nature of participants' principal lifetime occupation was assessed by retrospective self-report items. These were drawn from previously used instruments, giving a measure of Job Complexity (defined by 5 items including "I had to keep on learning new things in my work" and "My work was monotonous", for example: Vaananen, 2004) and Mental Work Demands (4 items, such as "My work was mentally demanding" and "I had to concentrate strongly during work": De Zwart et al., 1997). The latter scale was not related to cognitive function. Whilst both scales had a high internal consistency, it may be that the Mental Work Demands scale is not an indicator of the complexity of work, but rather the overall mental stressors and strains. The example items listed above have face validity covering what might be thought of as the complexity of work, however, the remaining 2 items – "My work required great precision" and "I regularly worked under time pressure" – are more problematic. It is possible to imagine occupations at opposite poles of a mental demands spectrum which could both score highly on these items; for illustrative purpose, consider that being either a surgeon or production line operative would have required precise, timely completion of tasks, but with very different mental components. The limitations of this scale in the LBC1921 may be a consequence of the format used here. Bosma and colleagues (2003a; 2003b) made use of data collected on the 4 Mental Work Demands items from a large, independent survey of 44,486 individuals (De Zwart et al., 1997). The information available was the average percentage of individuals in a given occupation responding yes to each item; Bosma and coworkers (2003a; 2003b) matched this information to the job titles given by their participants. Furthermore, this data was not always used as a stand alone index but was supplemented in Bosma et al. (2003a) with expert ratings of the mental complexity of each occupation. The lack of cognitive associations with the Mental Work Demands scale in the LBC1921 suggests there may be methodological issues in using this scale as a simple self-report in a relatively small-scale study. The 9 items forming the Psychological Job Demands scale from the Job Content Questionnaire were similar in content to those of the Mental Work Demands scale, covering how quickly or intensely a person had to work (for example, "My job is very hectic" or "My job requires working very hard": Karasek, 1985). The Psychological Job Demands scale was not associated with childhood ability, but those with more hectic or demanding jobs performed more poorly at age 79. This association was not significant after adjustment for childhood ability. From the results with both the Mental Work Demands and Psychological Job Demands scales, it appears that occupations characterised by intense concentration, a hectic schedule or requiring speedy completion are neither beneficial nor detrimental with respect to lifetime cognitive change in the LBC1921. The scales which might be considered as more directly assessing the mental engagement required during work did, however, produce some associations of interest for current purposes.

The Job Complexity scale (Vaananen, 2004) was associated with IQ in childhood and late adulthood. Importantly, there remained a significant association between Job Complexity and ability at age 79 when childhood IQ was controlled: the correlation was reduced in magnitude from .26 ($p < .001$) to .15 ($p = .011$) by this adjustment. Individuals of higher ability in childhood attained jobs requiring greater complexity, where their knowledge and skills were utilised, and they needed to think and weigh decisions, for example. These individuals also obtained higher cognitive scores in adulthood. A large part of this cognitive performance in later life is due to their higher initial ability (explaining about 50% of the variance), but it appears there is a small, unique contribution from the complexity of their occupation. Early ability does not completely account for the relationship between Job Complexity and cognitive ability in old age. The Job Content Questionnaire also contained items relating to the mental aspect of work. These were scored as Skill Discretion (job required learning new things, creativity and a high level of skill, for example), Decision Authority (job allowed independent decision making and freedom to decide how to do work, for example) and Decision Latitude (a combination of Skill Discretion and Decision Authority). All 3 scales were related to ability at ages 11 and 79, though the latter associations were attenuated to non-significance when adjusted for childhood ability. The JCQ factors substantively assessing the mental component of work (particularly, in this case, Skill Discretion) were only related to later ability as a consequence of their being predicted by early ability. More able individuals were likely to attain occupational positions defined by greater levels of Skill Discretion and Decision Authority, but these JCQ-assessed characteristics did not independently contribute to improved cognitive function in old age. It is not clear why there would be a difference in the findings with Job Complexity and the JCQ scales, when they are comprised of common, almost identical items in some cases.

Increased Skill Discretion and Job Complexity were also associated with higher ability *level* at ages 79 and 83, however, there were no associations with the *change* in cognitive performance across this time. Challenging and stimulating work (as assessed by Skill Discretion and Job Complexity) may have a small role to play in preserving and perhaps enhancing cognitive ability across the lifespan, but beyond this, there does not appear to be any continued protection against the detrimental effects of cognitive ageing other than that associated with the resultant higher level of ability these individuals take with them into old age.

5.4.3. Potential mechanisms of mental engagement and cognitive function

If an association exists between mental engagement and stimulation provided by work undertaken and cognitive function in old age, mechanisms must be proposed to account for this. Schooler and coworkers promoted an environmental complexity hypothesis to account for such results. In this, it was suggested that individuals in more complex environments (workplace complexity being higher for those with more mentally engaging jobs, for example) will be rewarded for their cognitive effort. What form these 'rewards' might take is not specified, but may include career advancement or increased prestige. This reward creates a motivation to improve abilities and generalise across other external situations. From the same line of thinking, those in less complex working environments, where tasks are monotonous or there is a lack of skill deployment and development, may be less motivated to develop or enhance intellectual capability due to a lack of rewards. This would lead to a loss of function over time (Schooler, 1984; Schooler et al., 1999). This basic premise is similar to that often employed by other researchers in the field to explain their reported associations, although it is often extended with the potential biological or behavioural pathways through which this effect would operate. Whilst most of this previous research had dementia or Alzheimer's disease as the outcome, the mechanisms they suggest can be informative with respect to normal cognitive ageing.

Complex and mentally engaging work (which may be synonymous with Schooler's (1984) complex environment) may have a direct effect on the structure or function of the brain, creating a 'reserve' capacity via an increase in the number of synapses or neuronal activity, for example. Conversely, monotonous work or that lacking mental stimulation might damage this reserve by a reduction in synaptic activity, resulting in a decrease in their number over time. Any pathological processes would have an overt effect earlier in an individual with a lower reserve capacity (Dartigues et al., 1992; Smyth et al., 2004; Seidler et al., 2004; Stern et al., 1994).

Additionally, or alternatively, the reserve capacity produced may not be observed as changes in physical brain structures, but rather be of an outward behavioural nature (Stern et al., 1994). Skills and processes may be developed in complex and demanding jobs which are applicable to problem solving in general, everyday tasks. This repertoire of skills may also be relevant in the completion of cognitive tests, giving those who posses them an advantage. Moreover, individuals in more mentally demanding positions might simply be better able to utilise these learned skills to cope more effectively with any subsequent cognitive changes, or their increased capacity might delay the detection of impairment (Stern et al., 1994; Seidler et al., 2004; Smyth et al., 2004; Dartigues et al., 1992). It is possible that the mental aspect of work is not a direct determinant of later function, but rather that this is acting as a surrogate for some other lifestyle risk factor or factors (Stern et al., 1994). These other factors could include health behaviours, activity participation or diet (Helmer et al., 2001), such that:

> a high level of education [or, indeed, pre-morbid ability] often leads to employment that involves high levels of intellectual challenge and cognitive stimulation, which, in turn, can often lead to large incomes and, high levels of well-being, and other factors that are likely to shape lifestyle and engagement in activities over the adult life span (Kramer, Bherer, Colcombe, Dong, & Greenough, 2004, p. 942).

Of course, reverse causality is also a potential explanation of the effect (Seidler et al., 2004; Smyth et al., 2004). In a case-control study of the development of Alzheimer's disease, Smyth et al. (2004) noted that cases had lower mental occupational demands from their 30s and beyond. The level of these mental demands did not significantly change for cases through their 20s, 30s and 40s, while controls showed an increase across the decades. The authors suggested that perhaps early pathology associated with the progression of Alzheimer's limits the transition of cases through jobs with ever greater mental components. Thus it might be decline (existing from midlife) predicting lower mental challenge at work, rather than the reverse (Smyth et al., 2004).

Whilst the mechanisms above have been proposed, and used to describe previous findings of occupational demands predicting later cognitive function, it should be noted that in the current analysis, although an index of the complexity of work was related to lifetime cognitive change, this did not contribute to the multivariate models. Additional occupational characteristics were found to be more important with respect to cognition, contrary to a number of the studies discussed in Chapter 4. Only a few of those reviewed covered occupational aspects beyond the mental component as full occupational assessments are rare in this domain of research. The effects of some of these other occupational characteristics on normal cognitive ageing were investigated for the first time with the LBC1921.

5.4.4. Additional occupational demands

Whilst the Job Content Questionnaire has been widely used in health research, it has not been widely used by those interested in cognitive ageing. The JCQ was completed by the LBC1921 with reference to their principal lifetime occupation, and produced a number of work-related factors. [The JCQ scales related to the mental complexity or demands of work have been discussed above.] The scales showing interesting relationships with cognition could be generally split into 2 groups: those covering the level of support received from colleagues and supervisors and those assessing the degree of physical exertion and hazards encountered at work.

5.4.4.1. Support at work

Childhood ability was not related to the level of support received at work, whether from coworkers, supervisors or both. Increased supervisor support and support overall (combining that from coworkers and supervisor) were related to better late adulthood cognitive performance (age-79 IQ) both before and after adjustment for childhood IQ, suggesting individuals who received higher levels of support at work showed a more positive relative change in cognition across the lifespan. Furthermore, supervisor support was one of the factors which emerged from the multivariate analysis as a predictor of age-79 IQ (controlling for age-11 IQ, sex and education), accounting for about 1% of the variance. When the measure of overall support was entered into this analysis instead, this was not a significant predictor of the outcome. It would therefore appear to be something specifically related to the support from a supervisor (or indeed, an unmeasured factor that is correlated with this) which has produced the beneficial effect on later ability. Compare this with the change in ability from ages 79 to 83, where significant associations were reported with the level of support from coworkers and overall support, but not from supervisor support. The multivariate analysis predicting this change in ability again highlighted that support from the specific source – from coworkers in this instance – was more important, accounting for about 2% of the variance in later life cognitive change. Support overall was not predictive of later life cognitive change in the multivariate analysis.

The preceding findings with the LBC1921 suggest that increased supervisor support is advantageous for lifetime cognitive change, whilst greater coworker support is beneficial for later life cognitive change. Self-reports of social support were used and the perception of this may be confounded by an individual's personality. Increased levels of social support have previously been linked to improved health and better cognitive outcomes (Berkman & Syme, 1979; Fratiglioni, Paillard-Borg, & Winblad, 2004). Social support, and the mechanisms proposed for its favourable effect, forms the subject of Chapters 6 and 7 where explanations for the support-health relationship will be introduced and discussed. While potential mechanisms will be detailed in the following chapters, for now, a possible reason for the differential importance of support from coworkers and supervisors at distinct timepoints might be that support from a supervisor is more likely to cease once working life has ended, thus curtailing any continued beneficial effect from acting into old age. The effect of supervisor support would therefore be restricted to changes in cognition observable across the working life. Coworkers, however, may well continue to provide friendship and support for years after retirement; this support may have implications for health and cognitive outcomes in old age. This is only a suggested explanation for the differences observed in the source of support affecting the cognitive outcomes. It is, of course, possible that the level of social support received outwith the working environment is highly related to workplace support, and that it is this which is driving the effects noted. With the assessment of social support from family and friends in the LBC1921 to be described later, it may be possible to investigate this more fully.

5.4.4.2. Physical exertion and hazardous conditions

The other category of occupational characteristics affecting cognition were concerned with the physical nature of the work carried out or the hazards and dangers encountered. The JCQ scales assessing Physical Exertion, Physical Isometric Loads and Hazardous Conditions (and the superordinate scales of Total Physical Hazards and Total Physical Stressors formed from combinations of these), and the level of speech required to be heard had a detrimental effect on cognition across the lifespan. Individuals with lower childhood ability were likely to hold principal occupations which were more physically strenuous and awkward and which brought them into contact with hazardous machinery, materials or environments. These risky working conditions were related to lower ability at age 79, even when childhood ability was controlled. In the multivariate analyses predicting age-79 IQ, 2 indices emerged as important, adjusted for age-11 IQ, sex and education: Hazardous Conditions and voice level at work (accounting for about 2% and 1% of the variance respectively). As with the measures of support above, when the superordinate scales were entered in the analyses they did not emerge as predictors, suggesting it is one of the specific components of the larger scales which is driving their associations with cognition. Increased hazards (consisting of exposure to things being placed/stored dangerously, dirty/badly maintained areas, fire/burns/shocks, dangerous tools/machinery/equipment, and dangerous work methods) and having to talk louder to be heard at work were related to lower cognitive performance in adulthood than would be expected from childhood ability. Only Physical Isometric Loads (the physical awkwardness of work) was related to cognitive change in later life, although it did not contribute in the multivariate analyses. Together, these findings might suggest that a more hazardous working environment reduces an individual's cognitive ability across their working life, but once they are removed from this situation, the negative effect does not continue, other than indirectly through the now lowered level of ability.

It is unclear why the noise level at work may be linked to lifetime cognitive change. The most likely explanation would be that this variable is a marker for a working environment which is generally detrimental to health, rather than there being a direct effect on the cognitive outcomes from having to speak louder. This single item may simply be indexing an aspect of work hazards not covered by the Hazardous Conditions scale. Alternatively, poor hearing in later life (as a consequence of a noisier working environment) could directly affect an individual's performance in the testing session which would therefore underlie the association between cognition and voice level required at work. However, the Moray House Test – which was used to compute the measure of lifetime cognitive change – is a solely paper-and-pencil test completed by the participant. As it does not rely on hearing oral instructions or test items, poor hearing is not a likely explanation for unsuccessful completion of these items.

Of the occupational factors assessed, workplace hazards and dangers were in fact the most important predictors of lifetime cognitive change. Previous research which investigated occupational type often found a link between more manual or blue-collar occupations and dementia, Alzheimer's or cognitive impairment (Smyth et al., 2004; Seidler et al., 2004; Li et al., 2002; Dartigues et al., 1992; Qiu et al., 2003). A potential explanation for this effect has been in terms of increased toxic exposure in these individuals (Seidler et al., 2004; Dartigues et al., 1992; Qiu et al., 2003; Frisoni et al., 1993). However, the Toxic Exposure scale from the JCQ was not related to lifetime cognitive change in the LBC1921 (those with lower ability at ages 11 and 79 reported greater occupational exposure to dangerous chemicals or air pollution for example, however, the latter association was attenuated when adjusted for childhood ability). Increased exposure to toxic materials and substances in more manual occupations may therefore not account for variation in normal cognitive ageing, as has been proposed, but it should also be noted that the Toxic Exposure scale is quite inexact compared with a full epidemiological analysis of workplace exposures.

Thus, the mechanism explaining the effect would need to consider it as a consequence of the *hazardous* nature of the work carried out or the workplace itself, rather than exposure to toxins (although, again, the scale employed to assess this latter aspect may have lacked the required precision): "occupation related hazards may have played a role in the causation of cognitive impairment" (Li et al., 2002, p. 11). This relationship is not simply the result of those of lower initial ability being drawn to more manual occupations with limited mental demands (Seidler et al., 2004), as the associations between hazardous conditions and later ability persisted after the variance attributable to early ability was removed. The specific hazards that might be detrimental to cognitive well-being, or whether this effect acts directly, requires further investigation. Indirect mechanisms can be suggested, including those previously discussed in relation to the mental challenges at work-cognition association, but from the opposite point of view. For example, individuals working in more hazardous conditions may simply do more poorly on psychometric tests as a result of the mismatch between the skills required on their job and those necessary for the completion of cognitive tests (Helmer et al., 2001). Paradoxically, the index of hazards at work may be acting as a surrogate marker for a lack of mental stimulation by elimination, and it is this lack of cognitive engagement which is driving the association. That is, manual workers are not exposed to the cognitive activity which would create reserve, or their reserve is depleted through inactivity (Seidler et al., 2004). Negative lifestyle choices including a poor diet, lack of activity and excessive alcohol consumption may be more prevalent in those with more manual occupations resulting in poorer health and cognitive outcomes (Helmer et al., 2001; Qiu et al., 2003). Or the hazards factor could be an indicator of later illnesses caused by work-related characteristics, with the resultant ill-health in later life accounting for the link with cognitive decline. Individuals employed in manual and hazardous occupations might also lack "cultural "input" throughout the life course" (Frisoni et al., 1993, p. 313). Leisure-time pursuits of a mentally stimulating nature may be important for the preservation of cognitive ability. If these activities are less common in manual workers, perhaps this deficit in mental stimulation in their daily life indirectly causes the hazards-cognition association. Activity participation will be dealt with in detail in Chapters 8 and 9. As stated by Smyth et al. (2004), "more work is needed to carefully disentangle the effects of physical demands of occupations from the environmental exposures with which they are often associated" (p. 502).

5.4.4.3. Household work

The household work items were incorporated (within the work section of the retrospective booklet) in an attempt to include those often overlooked by occupational assessments: generally, those employed mainly part-time, or housewives. However, there was only one association of interest between this assessment and the cognitive outcomes. Those doing a greater amount of household work from 60 to 75 years old performed better on the cognitive measures at age 83. It might be that the increased physical activity associated with this work has lead to a beneficial effect on cognition. Then again, individuals experiencing declines (in their general health, and specifically in their cognitive abilities), may be less able to complete their necessary household tasks. Both explanations would suggest there should be a relationship between household activity and cognitive change from age 79 to 83, however, there was no such link. The lack of an association suggests increased household activity *per se* may not be beneficial for cognitive outcomes. A more detailed activity assessment, which includes participation in sport and exercise across the lifespan, will be discussed in later chapters; this may be a more valid route for investigating the effects of physical activity and exertion on cognitive ageing.

5.5. Strengths and limitations

The assessment of occupational characteristics in the LBC1921 was detailed, covering a wide range of potential influences on ability. The self-report nature allowed participants to record their own, individual experiences rather than applying generic scoring from larger datasets based on job title alone. The latter procedure may serve to reduce bias in reporting across individuals, but it also removes the variance between individuals with the same job title (Bosma et al., 2003a). As many of the previous studies investigated dementia or Alzheimer's disease, proxies were often used to provide the necessary job title information for matching (for example, Smyth et al., 2004). With the LBC1921, participants themselves provided the responses. It is hope this method would be more accurate with respect to the work history details collected. Proxies would be unlikely to be able to complete the more detailed questions of the JCQ, for instance. The current assessment was (necessarily) retrospective which implies recall bias may have influenced the responses. An attempt was made to reduce this, as far as was practicable, by basing the responses only on the principal lifetime occupation (the job held for the longest time) as with many other studies (e.g. Dartigues et al., 1992). Participants should be able to recall details of this with some degree of accuracy. Assessment at a time more proximal to working life would further reduce recall bias, but there would then be the relatively younger age of the cohort to consider, who would have to be followed into old age to allow cognitive ageing to be properly investigated. In future studies, researchers may benefit from taking a complete occupational history from participants, rather than focusing on the principal occupation alone. This might ensure that, for example, details of an occupation that was more mentally complex than that held for the longest period would not be omitted. Due to the age of the LBC1921, the demands of a full history were deemed too great, especially given that they were concurrently being asked about a range of other life experiences and exposures. For current purposes, the longest held occupation was useful and sufficient, as it gives the most appropriate indication of an individual's working life (Dartigues et al., 1992).

Different occupational characteristics may have different cumulative or continuing effects. For example, job complexity was related to cognitive change across the lifespan, and to the level of functioning, but not the change, in later life. Admittedly, the follow-up in old age covered a span of 4 years; with an increased length of time and a greater degree of observed decline, occupational characteristics may have an influence on cognitive ageing. To investigate the differential effects of occupational factors as predictors of the level of, and change in, ability at different ages, it would be informative to have the first cognitive follow-up shortly after retirement, and then repeat assessments over a lengthy period into old age.

The main occupational determinants of cognitive change across the lifespan were related to the hazards of work. This is potentially a cohort effect; it might be that this would not be replicated in younger samples, who may now be experiencing safer working environments than previous generations. A full occupational assessment in a younger group would allow this to be investigated more fully. Furthermore, changes across generations with respect to working women cannot be addressed here. As the cohort are all the same age, it might be that the LBC1921 women who worked were employed in markedly different occupations from women today.

It cannot be determined whether it is the occupational factors assessed, or some unmeasured confounders which are affecting the outcome. If those receiving less support at work, for example, also received lower social support at home, it may be difficult to determine the source of any effect. The effects reported were mostly small and are therefore prone to confounding (such as a person's personality affecting their perception of the social support they received at work). In addition, the number of predictors examined makes type 1 errors a possible explanation for the significant associations discovered. Replication in another sample can begin to deal with this, and a number of the other issues raised above. With the LBC1921 Study, however, an often unmeasured confounder is available: childhood ability was related to a large number of the occupational factors, such that higher ability predicted entry to safer and more mentally complex working environments. The presence of this measure allows its influence to be removed from the associations of occupational characteristics and later cognitive ability. Previous studies lacking an early measure of prior ability may be overestimating the cognitive benefits or costs of workplace factors (such as job complexity) as their estimates are not adjusted for a major determinant of these factors.

5.6. Conclusions

In a response to the NIH review discussed in Chapter 1, one author highlighted that the "importance of "exposures" before age 65 on cognitive...health after age 65 is critically important to understand" (Lyketsos, 2006, p. 86). From the preceding analysis with the LBC1921, it has been suggested that occupational exposures occurring during midlife may well have small but significant impacts on later cognitive vitality. Finding methods of enhancing or reducing the effects of occupational exposure may not be straightforward. Avolio and Waldman (1990) advocated altering cognitive demands at work.

> Appropriate and timely feedback may also provide sufficient reinforcement to keep individuals actively seeking out intellectually stimulating tasks in their jobs, thus potentially facilitating cognitive development over the life span...it is clearly possible that early planned interventions and modifications in occupational experience could produce a more capable work force at older ages (p. 50).

Bosma et al. (2003a) also highlighted the potential cognitive benefits of enriching less mentally stimulating jobs, however, they noted this would have to be carefully controlled so as not to "overload" employees (p. 42). How this would be achieved is not clear. Such modifications may also be unnecessary or ineffective if other occupational characteristics, such as the hazards encountered, are more important with respect to cognitive ageing. Reducing the exposure to such harmful conditions might be theoretically simpler. If harmful exposures are considered modifiable, any associations existing between them and later intellectual function and change must first be clearly specified, assessed and replicated. The suggested harm reduction is based on the assumption that it is a specific characteristic of work itself generating the positive or negative effect. Further research needs to be conducted to ensure that it is not, in fact, some unmeasured (and potentially malleable) lifestyle confounder driving the effect. The next chapters deal with proposed psychosocial determinants of cognitive vitality (Chapters 6 and 7 cover social networks and support, whilst Chapters 8 and 9 will consider activity participation). These factors are candidates for being potential lifestyle confounders of the associations between occupational characteristics and cognitive ageing.

Table 5.1 Intercorrelations among work history variables (N = 339-343)

	1	2	3	4	5
1. Principal occupation years	-				
2. Principal occupation hours/week	-.01	-			
3. Lifetime years worked	.62***	.09	-		
4. Retirement age	.46***	.00	.65***	-	
5. Retirement choice	-.09	-.01	-.22***	-.15**	-

Note. Retirement choice is a dichotomous variable.
$^{**}p < .01$, $^{***}p < .001$

Table 5.2 Intercorrelations among work history variables by gender

	1	2	3	4	5
1. Principal occupation years	-	-.10	.62***	.41***	.02
2. Principal occupation hours/week	-.08	-	-.03	-.15*	-.05
3. Lifetime years worked	.15	.12	-	.58***	-.15*
4. Retirement age	.26**	.29***	.34***	-	-.10
5. Retirement choice	.09	.11	.09	.09	-

Note. Correlations below the diagonal are for men (N = 154-156) and above the diagonal for women (N = 185-187). Retirement choice is a dichotomous variable.

*$p < .05$, **$p < .01$, ***$p < .001$

Table 5.3 Correlations between work history variables and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
Principal occupation years	-.01	-.09	.10	.02	-.14	.05	.05	-.09	.11	.04	-.05	.14	.01	.04	.10
Principal occupation hrs/wk	-.14*	-.06	-.20*	-.19**	-.10	-.28***	-.14*	-.08	-.20**	-.10	-.08	-.12	-.01	-.01	.02
Lifetime years worked	.01	-.01	.06	.06	-.09	-.00	.09	-.09	.11	.03	-.06	.07	-.09	.03	-.07
Retirement age	-.08	.00	-.11	-.07	-.08	-.16*	-.01	-.09	-.05	-.08	-.14	-.10	-.14*	-.11	-.12
Retirement choice	.02	-.04	.08	-.06	-.12	.07	-.06	-.14	.07	-.08	-.13	-.01	-.03	-.04	-.07

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Retirement choice is a dichotomous variable. T = total sample (N = 257-334), M = male (N = 129-152), F = female (N = 128-181).
$*p < .05$, $**p < .01$, $***p < .001$

Table 5.4 Internal consistencies of Job Content Questionnaire scales

	Number of items	Cronbach's alpha
Skill Discretion	6	.70
Decision Authority	3	.76
Psychological Job Demands	5	.61
	9[+]	.70
Coworker Support	4	.64
	6[+]	.74
	7	.74
Supervisor Support	4	.84
	5[+]	.77
	6	.80
Physical Exertion	1	-
	3[+]	.86
Physical Isometric Loads	2	.91
Hazardous Conditions	5	.85
Toxic Exposures	3	.68

Note. Items have been added to the JCQ in subsequent revisions. For each scale, the internal consistency is shown for all possible variants. Only the version marked [+] appears in later analyses.

Table 5.5 Correlations between occupational characteristics and cognition across the lifespan (N = 256-334)

	Age-11 IQ	Age-79 IQ	Cognitive ability age 79	Cognitive ability age 83	Cognitive ability change (79-83)
Skill Discretion	.17**	.19**	.21***	.13*	-.07
Decision Authority	.14*	.13*	.15**	.08	-.07
Decision Latitude	.15**	.16**	.18**	.11	-.08
Psychological Job Demands	-.11	-.13*	-.12*	-.11	-.10
Coworker Support	.04	.09	.09	.14*	.15*
Supervisor Support	.08	.17**	.20***	.22**	.07
Social Support	.09	.17**	.18**	.23***	.14*
Physical Exertion	-.36***	-.39***	-.36***	-.31***	-.07
Physical Isometric Loads	-.29***	-.32***	-.31***	-.33***	-.14*
Hazardous Conditions	-.23***	-.29***	-.24***	-.24***	-.04
Toxic Exposures	-.11*	-.13*	-.12*	-.11	.03
Total Physical Hazards	-.19**	-.23***	-.20***	-.19**	-.01
Total Physical Stressors	-.32***	-.37***	-.32***	-.29***	-.05
Job Complexity	.22***	.26***	.22***	.17**	-.05
Mental Work Demands	.09	.08	.04	.03	-.05

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Decision Latitude = Skill Discretion + Decision Authority; Social Support = Coworker Support + Supervisor Support; Total Physical Hazards = addition of z-scored Hazardous Conditions + z-scored Toxic Exposures; Total Physical Stressors = addition of z-scored Physical Exertion + z-scored Total Physical Hazards. All scales are from the Job Content Questionnaire except Job Complexity and Mental Work Demands.

$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 5.6 Correlations between occupational characteristics and cognition across the lifespan by gender

	Age-11 IQ		Age-79 IQ		Cognitive ability age 79		Cognitive ability age 83		Cognitive ability change (79-83)	
	M	F	M	F	M	F	M	F	M	F
Skill Discretion	.18*	.18*	.11	.22**	.18*	.20**	.13	.14	-.05	-.02
Decision Authority	.20*	.12	.10	.11	.16*	.10	.13	.05	-.03	-.03
Decision Latitude	.21*	.15	.11	.15*	.18*	.15	.14	.09	-.04	-.04
Psychological Job Demands	-.04	-.17*	-.05	-.20**	-.08	-.15*	-.01	-.18*	.05	-.21*
Coworker Support	-.03	.09	-.01	.15*	.09	.10	.10	.19*	.07	.21*
Supervisor Support	-.07	.20*	.09	.23**	.18*	.22**	.20*	.23**	.08	.06
Social Support	-.03	.16*	.08	.22**	.20*	.18*	.21*	.25**	.08	.18
Physical Exertion	-.40***	-.32***	-.45***	-.34***	-.36***	-.36***	-.35***	-.27**	-.07	-.07
Physical Isometric Loads	-.32***	-.26**	-.33***	-.32***	-.33***	-.29***	-.35***	-.32***	-.11	-.16
Hazardous Conditions	-.18*	-.30***	-.27**	-.39***	-.18*	-.37***	-.22*	-.28**	-.07	.03
Toxic Exposures	-.12	-.11	-.21*	-.10	-.14	-.14	-.16*	-.07	-.03	.12
Total Physical Hazards	-.16	-.23**	-.25**	-.28***	-.17*	-.29***	-.20*	-.19*	-.05	.08
Total Physical Stressors	-.30***	-.34***	-.39***	-.38***	-.29***	-.38***	-.31***	-.28**	-.07	-.00
Job Complexity	.28**	.20**	.23**	.25**	.23**	.19*	.21*	.15	-.07	.02
Mental Work Demands	.06	.13	.06	.07	.02	.04	.05	.01	.02	-.10

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Decision Latitude = Skill Discretion + Decision Authority; Social Support = Coworker Support + Supervisor Support; Total Physical Hazards = addition of z-scored Hazardous Conditions + z-scored Toxic Exposures; Total Physical Stressors = addition of z-scored Physical Exertion + z-scored Total Physical Hazards. All scales are from the Job Content Questionnaire except Job Complexity and Mental Work Demands. M = male (N = 116-153), F = female (N = 123-182).
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 5.7 Correlations between household work and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
Household work 20-35	-.04	-.07	-.06	-.08	.00	-.06	-.07	.07	-.11	-.02	-.02	-.02	.05	-.06	.06
Household work 40-55	.02	-.03	.04	.03	.11	.06	.07	.19*	.04	.12	.22*	.04	.08	.09	-.00
Household work 60-75	.00	-.02	.02	.10	.18*	.09	.10	.17*	.09	.14*	.20*	.10	.11	.16	.00
Lifetime household work	-.02	-.05	-.03	-.01	.11	-.00	.02	.17*	-.02	.08	.15	.04	.09	.07	.03

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old.
T = total sample (N = 282-368), M = male (N = 129-152), F = female (N = 153-216).
*$p < .05$, **$p < .01$, ***$p < .001$

Table 5.8 Summary of regression analyses with occupational factors predicting age-79 IQ

A

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.66***	.43	.43***
	Sex	-.10*		
2	Age-11 IQ	.61***	.46	.03***
	Sex	-.13**		
	Hazardous Conditions	-.18***		
3	Age-11 IQ	.61***	.46	.01*
	Sex	-.14**		
	Hazardous Conditions	-.12*		
	Voice level at work	-.11*		
4	Age-11 IQ	.60***	.47	.01*
	Sex	-.13**		
	Hazardous Conditions	-.11*		
	Voice level at work	-.11*		
	Supervisor Support	.09*		

*$p < .05$, **$p < .01$, ***$p < .001$

B

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.58***	.45	.46***
	Sex	-.09		
	Education	.17**		
2	Age-11 IQ	.55***	.47	.02***
	Sex	-.12**		
	Education	.15**		
	Hazardous Conditions	-.16***		
3	Age-11 IQ	.55***	.48	.01*
	Sex	-.12*		
	Education	.15**		
	Hazardous Conditions	-.15**		
	Supervisor Support	.09*		
4	Age-11 IQ	.55***	.48	.01*
	Sex	-.12**		
	Education	.14**		
	Hazardous Conditions	-.11*		
	Supervisor Support	.09*		
	Voice level at work	-.10**		

*$p < .05$, **$p < .01$, ***$p < .001$

Table 5.9 Summary of regression analyses with occupational factors predicting later life cognitive change

A

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.14*	.02	.03*
	Sex	.10		
2	Age-11 IQ	.13*	.04	.02*
	Sex	.10		
	Coworker Support	.13*		

*$p < .05$

B

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.13	.02	.03
	Sex	.10		
	Education	.03		
2	Age-11 IQ	.13	.03	.02*
	Sex	.10		
	Education	.00		
	Coworker Support	.13*		

*$p < .05$

Figure 5.1 Retrospective Self-report mailing flowchart

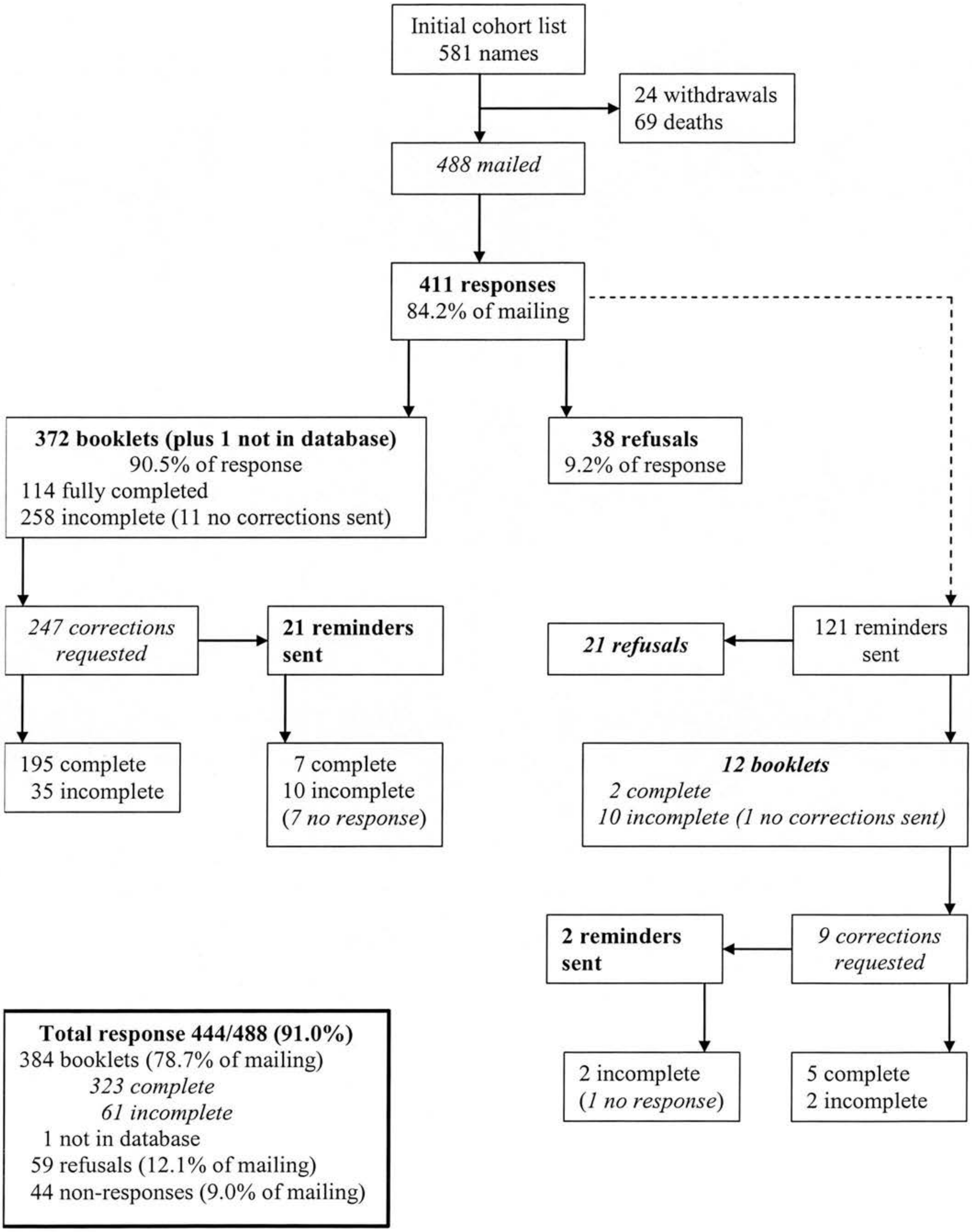


Figure 5.2 Job Complexity scree plot

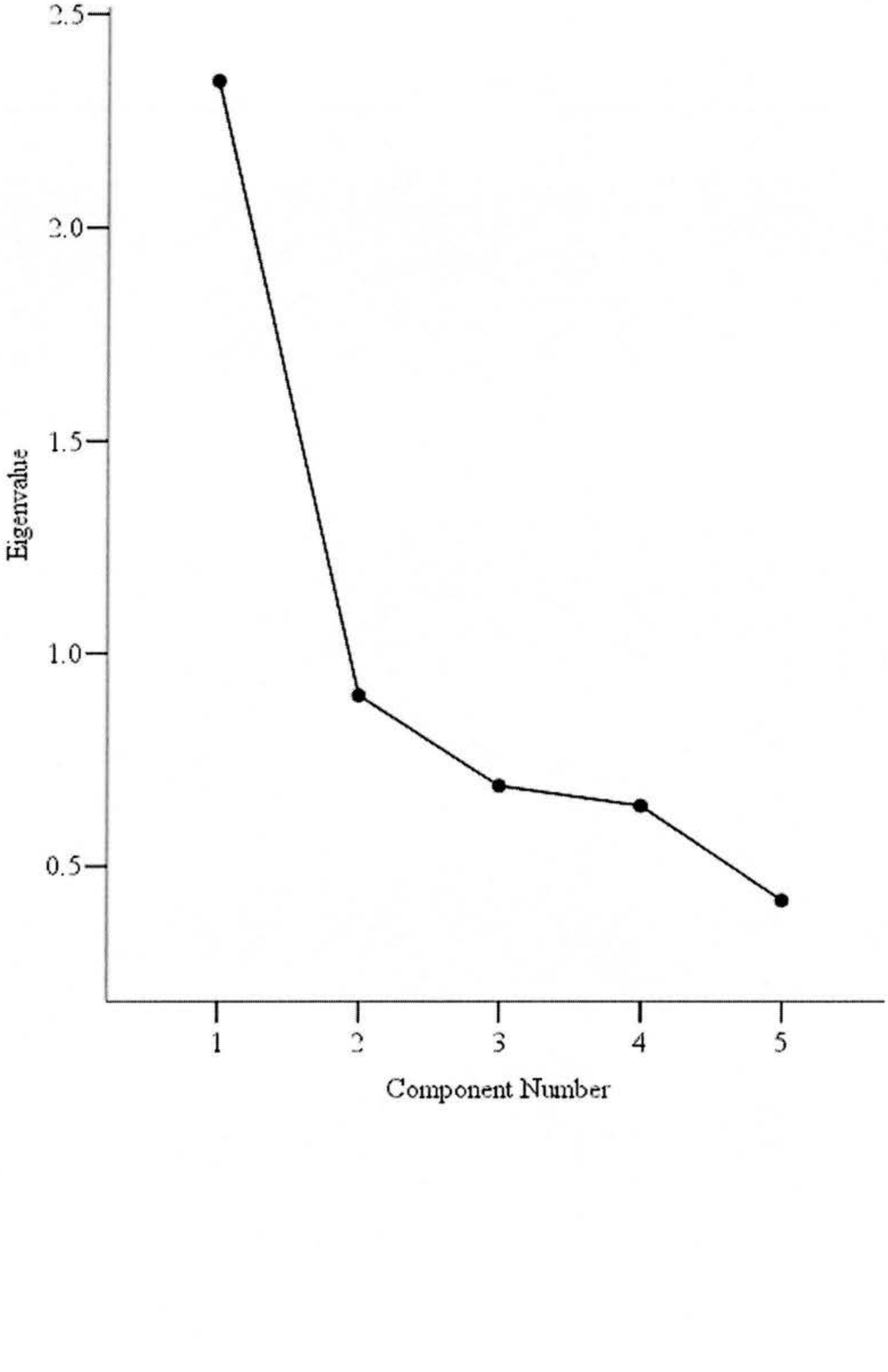
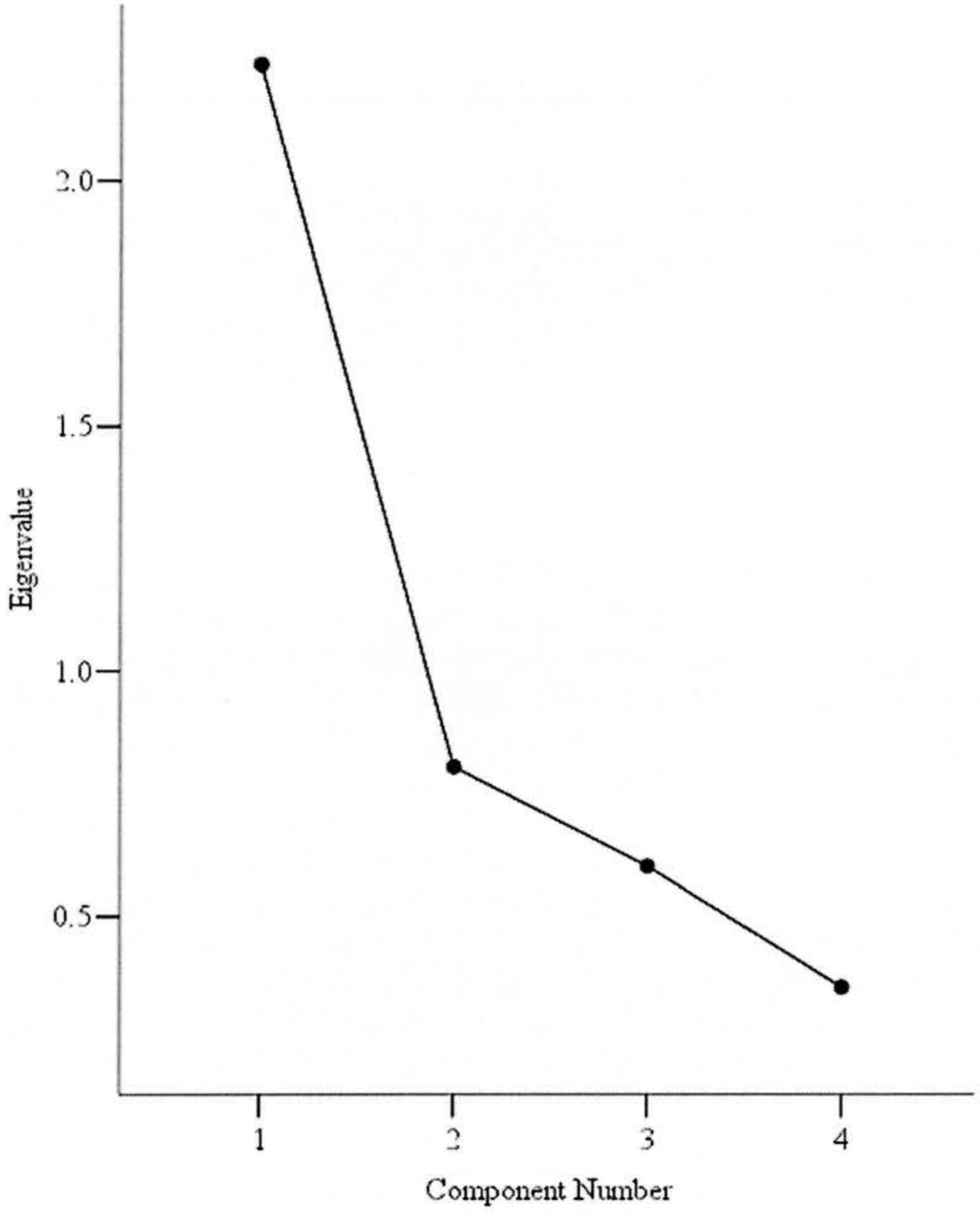


Figure 5.3 Mental Work Demands scree plot



Chapter 6: Social support networks and cognitive ageing

In the preceding chapters, the extant literature relating occupational characteristics to cognitive ageing was reviewed, followed by an investigation of their influence on lifetime cognitive change in the LBC1921. This foregoing analysis indicated the potential importance of certain work-related factors for maintaining cognitive vitality in later life (primarily the deleterious effects of hazardous working conditions, and the benefits of greater support from supervisors and coworkers). Whilst an individual's occupation may be considered a major constituent of their life, there will continue to be a sizeable proportion of the population to whom such occupational considerations are not applicable. Any work-related interventions suggested by this endeavour would therefore not be germane to the population as a whole. There are numerous lifestyle domains which may also be related to cognitive ageing, many of which will be of equal, if not greater, importance to individuals themselves, and that do not suffer the specificity of occupational characteristics. Social relationships, integration within a wider social network, and the social support thus derived, forms one such universal; every individual can be classified according to their degree of contact and interaction with relatives and friends, acquaintances and significant others, from complete isolation to inclusion within a supportive network of relatives and friends. "Social relationships are a ubiquitous part of life, serving important social, psychological, and behavioural functions across the lifespan" (Uchino, Cacioppo, & Kiecolt-Glaser, 1996, p. 488). The beneficial effects of social networks and support initially attracted the curiosity of researchers due to the fact that the level of support received from these many and varied contacts appeared to have significant implications for health, and indeed longevity. Consequently, it is necessary to consider the effects of social support networks on health and mortality at the outset in order to illuminate the more recent literature with respect to their potential impact on cognitive ageing.

6.1. Social support networks and mortality

Interest in the effect of social support on health has been growing steadily since the late 1970s (Cohen & Wills, 1985), with the resultant corpus of research suggesting that "more socially isolated or less socially integrated individuals are less healthy, psychologically and physically, and more likely to die" (House, Landis, & Umberson, 1988, p. 540). Social networks and support may factor into the development of physical and mental disease, and ultimately mortality (Stroebe, 2000; Berkman et al., 1979; Cohen et al., 1985; House, Robbins, & Metzner, 1982). The robustness of the effect suggests there may be important consequences for the future delivery of health services; with increasing numbers of elderly individuals requiring formal geriatric care, there is a great deal of interest in any potential benefits that can be derived from informal networks of community and social ties (Wan, 1982).

6.1.1. Defining social support

Whilst social support has been variously conceptualised and measured (Cohen et al., 1985), a generally accepted definition would cover:

> the existence or availability of people on whom we can rely, people who let us know that they care about, value, and love us (Sarason, Levine, Basham, & Sarason, 1983 p. 127).

Social support, as discussed throughout, refers to support received from informal systems including family, friends, coworkers and contacts within the community or through leisure activities (Cohen et al., 1985; Stroebe, 2000), as opposed to formal systems of care, such as counselling or contact with other health professionals. Within this, there is also a further distinction in the conceptualisation of the nature of the social support being investigated: whether it concerns the physical structure of the network of supportive individuals, or the perceived availability and function of the social support which can be derived from this structure. Structural measures (for example, the number of close friends and relatives an individual can rely on, or their membership of various social groups) attempt to index how embedded an individual is within a network. They generally assess the quantity of social ties through which support can potentially be transmitted. Functional measures look at the role fulfilled by supportive others (whether the support received, if indeed it is received, provides emotional or financial support, for example). Structural and functional assessments may not be strongly related, and the particular aspect of social support considered may determine whether or not effects on health are observed (Wills, 1991; Cohen et al., 1985; Stroebe, 2000).

6.1.2. The Alameda County Study

Social support is one of the resources that an individual can call upon to cope with stressors in their daily life (Stroebe, 2000). A seminal study conducted by Berkman and Syme (1979), based on almost 5000 residents of Alameda County, California, illustrates this point effectively. The participants were all aged between 30 and 69 years old at the baseline examination when they were asked to provide details of their social ties with 4 potential sources of social interaction: marital status, contacts with close friends and relatives (assessed by 3 items), church membership, and participation in both informal and formal associations. Over the 9-year follow-up, 682 participants died. The analysis suggested that mortality was associated with an individual's degree of social connectedness, whether assessed by the presence of the 4 social ties individually or when these were combined into a Social Network Index (produced by the weighted sum of the individual items). In the latter analysis, participants were divided into 4 groupings, from least to most connected. In general, increased social connectedness was associated with decreased mortality over 9 years of follow-up, with age-adjusted relative risks of 2.3 and 2.8 for men and women respectively ($p < .001$). That is, men with the lowest level of social contact were 2.3 times more likely to die during the follow-up than those with the most social contact. However, this result may be a consequence of the individuals with poorer health at baseline becoming more socially withdrawn as a result of their condition(s); such individuals are likely to suffer higher mortality due to their ill-health, rather than a lack of social contact *per se*. And yet, when the analyses were controlled for baseline health status and year of death, the effect of social connectedness on mortality remained significant suggesting this reverse causality was a less likely explanation.

Further control for socioeconomic status, smoking, obesity, alcohol consumption and physical activity also failed to account for the social connectedness-mortality association. In this large, prospective study, the effect appears to be robust insofar that it is independent of a number of potential confounders (Berkman et al., 1979).

6.1.3. Replicating Alameda

Since this influential study in Alameda County, further longitudinal studies have replicated these findings. In the Tecumseh Community Health Study, for example, House and colleagues (1982) collected data concerning a range of social relationships and activities from a sample of almost 3000 individuals who were aged 35-69 years old between 1967 and 1969. Assessments were made of close, intimate relationships (marriage, family and friends), formal organisational involvement (church or voluntary groups), active and social leisure pursuits (going to the cinema or museums, etc.) and passive and solitary leisure interests (watching television, reading, etc.). During the follow-up which lasted between 9 and 12 years, 259 participants died. For men, being married and participating in active, social pursuits was associated with a reduced risk of death, after controlling for age and a number of other potential confounders including coronary heart disease and smoking status: the multiple logistic regression coefficient was -0.614 ($p < .05$) for marital status and ranged from -0.222 to -0.419 ($p < .05$) for the active and social leisure activities (House et al., 1982). The association between activity participation and mortality may not be an effect solely attributable to the social nature of the activities if they are part of a generally healthier lifestyle, for instance [findings related to activity participation or increased social engagement will be described later, and then covered in greater detail in Chapter 8]. By and large, the results for women were weaker and less consistent: being a church member and watching television less frequently were associated with an increased chance of survival [with multiple logistic regression coefficients of -0.134 ($p < .025$) and .190 ($p < .005$) respectively]. Satisfaction with the relationships or activities was not related to mortality in men or women after adjustment for the intensity of the relationship or activity frequency (House et al., 1982).

The results of these 2 large studies indicate the potential importance of social contact for increased longevity. Whilst there was control in both studies for a range of potential confounders, including social class or health status and behaviours for example, it is possible any effect exists as a result of some, as yet, unmeasured factor. Both studies assume, with respect to survival, that there is an accrued benefit derived as a consequence of the *social* nature of contact with others. As mentioned briefly, there is a potential problem demarcating and therefore conceptualising what constitutes the nature of the purely social characteristics of interaction or engagement as distinct from simply being more active generally (with subsequent mental and physical demands), and therefore from where any benefit is being drawn. This is an important point to note as disentangling such links will determine the form of subsequent interventions.

In a recent study of this nature, participants in the Australian Longitudinal Study of Aging, all aged over 70 at baseline, were followed for a decade (Giles, Glonek, Luszcz, & Andrews, 2005). Network assessments were made of the number and frequency of contacts with children, relatives and friends, and the presence of a confidant (and whether or not this was a spouse). Of the 1477 participants assessed at the initial screening, 907 died in the subsequent 10 years. The individuals who survived for the follow-up period had higher baseline total network scores (created by summing the items from each of the network variables); the standardised mean in the total sample was 0.02 (95% CI -0.06 to 0.11), being 0.48 (95% CI 0.34 to 0.61) in those who survived compared with -0.26 (95% CI -0.37 to 0.15) in those who died. When the authors then controlled for a number of potential confounders, including age, sex, residential area, cognitive function, smoking status, self-reported health and the number of morbid conditions, a protective effect remained separately for the friends and confidant networks [RR for the highest network tertile versus the lowest was 0.78 (95% CI 0.65 to 0.92) and 0.83 (95% CI 0.70 to 1.00) respectively]; the effect for the total network score was non-significant [RR for the highest total social network tertile versus the lowest was 0.86 (95% CI 0.72 to 1.03)]. This study highlights the importance of investigating the nature of the contact as it may impact upon the benefits derived, and suggests it is discretionary supports, that is, those chosen by an individual to be part of their network, which appear to have the most sizeable effect on longevity (Giles et al., 2005). Being mindful of potential interventions in the future, this is advantageous as such friendship networks are perhaps more likely to be malleable and modifiable through befriending schemes, for example, than family networks which, by their nature, may be more immutable (Jorm, 2005).

Fratiglioni et al. (2004), reviewing the effect of an active and socially integrated lifestyle on the risk of dementia (based on 7 longitudinal observational studies assessing social networks and cognition), stated that "a large amount of epidemiological data [exists] on the health benefits of social integration and social support" (p. 343). As described above, a number of studies have used all-cause mortality as their outcome – where the most socially withdrawn individuals are shown to experience a 2-4 times greater likelihood of dying – although there is growing evidence linking reduced social support networks to various specific diseases, such as cardiovascular disease (Fratiglioni et al., 2004). It is noted that although the current chapter has concentrated thus far on social networks and survival, the principal outcome of interest in this thesis is the identification of determinants of cognitive ageing. However, the preceding outline highlighted the origins of research into the beneficial effect of social networks which in turn led to their impact upon changes in later life mental ability being investigated. A review of the extant literature in this field follows, after which, the mechanistic explanations proposed to explain the social support networks-health associations will be introduced; these may be applicable to the discussion of any link between the nature of an individual's social network and cognitive change.

6.2. Social support networks and cognitive ageing

In a number of studies conducted to date, social network characteristics, including an individual's number of social ties, or their marital status and the support received from relatives and friends, are predictive of later life mental health outcomes, including cognitive impairment.

6.2.1. Marriage, social networks and dementia

6.2.1.1. The PAQUID Study

As evidenced previously with mortality, marital status may be related to cognitive outcomes. In the French Paquid Study, 2881 individuals were evaluated for dementia over a 5-year follow-up, from a baseline sample of over 3500 all aged over 65 (Helmer et al., 1999). Participants who were married or cohabiting at the outset of the study were at a significantly reduced risk of developing dementia or Alzheimer's disease compared to the participants who had remained single throughout their life. This effect held after controlling for participant's educational level and alcohol consumption, in addition to their living arrangements (alone or with others), activity participation, the number of people in their social network and depression. The fully adjusted relative risk of developing dementia for never married individuals was 2.31 (95% CI 1.14 to 4.68) compared with individuals who were married or cohabiting – single individuals were almost two and a half times as likely to develop dementia across the follow-up period (Helmer et al., 1999). The potential pathways for this effect could take the form of a protective effect for married or cohabiting individuals versus a deleterious effect for non-married individuals. For example, there may be characteristics of the unmarried individuals (personality, behaviours, etc.) which predict both their marital status and eventual dementia prognosis, or perhaps these individuals are less likely to be active and engaged socially, which affects their cognitive ageing trajectory. The latter explanation was dismissed by the authors, however, as controlling for social network and activity variables did not alter the association (Helmer et al., 1999).

6.2.1.2. The Kungsholmen Project

Whilst the Paquid study seems to emphasise the importance of one close, significant relationship for protection against the development of dementia, it should be remembered that there are many other aspects of social networks (including the support derived from these) which can be assessed that may impact upon health and well-being. Fratiglioni and colleagues (2000) noted that, although there was evidence linking social environment to a range of mental disorders, research with dementia, "the most common mental disorder in the elderly" (p. 1315), was limited. In their work with the Kungsholmen Project in Sweden, 1203 participants were assessed when aged over 75 and again approximately 3 years later. All participants were non-institutionalised and dementia free at baseline. At this time, assessments were made of a number of social network factors, including structural aspects (contact with individuals in the network) and the level of satisfaction with, or perceived adequacy of, these contacts. Over the follow-up period, 176 incident cases of dementia were identified. The authors found a higher risk of dementia in those individuals who were unmarried, living alone or with fewer close social ties (friends and relatives). The effect remained significant for living arrangements and close social ties after age, sex, educational level and MMSE at baseline were controlled, both with RR of 1.5 (95% CI 1.0-2.1 and 1.0-2.4 respectively: Fratiglioni, Wang, Ericsson, Maytan, & Winblad, 2000). When combinations of the social network variables were investigated, individuals who were both unmarried and living alone, or who had frequent contact with children but rated this as inadequate (that is, they were not satisfied with the level of social support received), were at the greatest risk of developing dementia [relative risks of 1.9 (95% CI 1.2-3.1) and 2.0 (95% CI 1.2-3.4) respectively]. Thus, the chances of developing dementia were effectively doubled in certain socially isolated individuals. Interestingly, and importantly, the authors note that the risk of dementia was not greater in individuals who reported infrequent contact with their social network as long as this was perceived as being satisfying. Finally, when the individual variables were combined into a single summary score comprising 4 levels (from poor to extensive social networks), those individuals defined as having a poor or limited social network were at a 60% increased risk of developing dementia compared to those with extensive or moderate social networks (controlling for the confounders as before: Fratiglioni et al., 2000).

Again, the endpoint investigated was an all-or-nothing category (dementia diagnosis) rather than the full spectrum of cognitive ageing. It is not clear whether the effect on this dichotomous outcome would generalise to normal cognitive change and decline. In addition, the social network characteristics – including marital status – were only assessed at a single time point, rather than on a series of occasions; "in old age, this is important, because social situations change frequently" (van Gelder et al., 2006, p. 213). Furthermore, the follow-up in the study was limited to 3 years, and it may be that those who later developed dementia had altered social networks at the initial examination as a result of the early stages of the disease process, rather than the reverse. Although baseline cognitive function was used as a covariate in an attempt to control for this, the assessment was limited to a single, general screening tool: the MMSE. The latent mechanisms underpinning the associations are unclear, however, and it has been proposed that:

> social engagement probably challenges people to communicate effectively and to participate in complex interpersonal exchanges. Such a dynamic environment is likely to engender the mobilisation of cognitive capacities, setting in place a "use it or lose it" phenomenon so important to successful ageing (Berkman, 2000, p. 1292).

Berkman (2000) also highlighted the importance of the gradient observed in such results, suggesting, in contrast to Paquid which only investigated marital status, that one close relationship may be insufficient to protect against dementia. There appears to exist a certain substitutability of contacts so that no particular form of contact, for example a spouse, or child, is necessary; their absence alone will not predict dementia prognosis in the presence of other supportive individuals.

The review conducted by Fratiglioni et al. (2004) also confirmed the potentially protective effect of social network factors, with 3 out of 6 studies linking limited social networks with dementia, and a further 2 highlighted the importance of marital status. Yet, as with both Paquid and the Kunsgholmen Project –included in the Fratiglioni et al. (2004) review – the main emphasis has been on the predictors of dementia, and so it is unclear whether the social network characteristics described previously may be determinants of normal, non-pathological cognitive ageing.

6.2.2. Marriage, living arrangements and normal cognitive ageing

A recent study investigated whether marital status and living arrangements over 5 years were related to changes in cognitive function in the following 10-year period (van Gelder et al., 2006). The Finland, Italy, the Netherlands Elderly (FINE) Study was initiated in 1985 and includes men from the 3 named countries who have been followed longitudinally. At the first assessment – when the men were aged about 65 to 84 – information was collected on marital status and living situation, and cognitive function was assessed using the MMSE. This was repeated in 1990 resulting in a sample of just over 1000 men with complete data. Marital status was recorded as married versus unmarried at the 2 occasions, which was further classified to reflect any changes across time: married on both occasions, married then unmarried, and unmarried at both times (there were too few men in the unmarried-married group for analysis). Likewise, living situation was recorded as living alone versus living with others at the 2 assessment points, and as living with others-living with others, living with others-living alone, and living alone-living alone to indicate situational change over the 5 years (there were too few men in the living alone-living with others grouping for analysis).

When a range of potential confounders were adjusted (including age, smoking and baseline cognitive function), mean MMSE in 1990 did not differ across the 3 classifications of marital status or living situation. From 1990 to 2000, men who were married in both 1985 and 1990 showed a mean decline of 1.1 MMSE points (95% CI 0.9-1.4). Those who were married then unmarried declined a further 1.0 point (95% CI 0.1-1.9), and those who were unmarried on both assessments in the preceding 5 years declined by 1.3 points (95% CI 0.5-2.1) more than those married on each occasion (adjusting for the confounders listed above in addition to education, country, alcohol consumption, living situation and a range of medical conditions including stroke, diabetes and cancer: van Gelder et al., 2006). Similar results were recorded for living situation, with those living with others in both 1985 and 1990 declining by 1.1 MMSE points (95% CI 0.8-1.4) over the 10 years of follow-up, those living with others then alone dropped a further 1.1 points (95% CI 0.2-2.0), and those living alone at each occasion declined by 2.7 points more than those living with others on both occasions (95% CI 1.7-3.7).

The FINE Study builds on research concentrating on the prediction of dementia or Alzheimer's by basing cognitive decline on a test of ability scored on a continuum, although this relied solely on the MMSE which the authors admit is a "screening test" (van Gelder et al., 2006, p. 217). Replication with a larger cognitive battery across a number of cognitive domains is suggested. van Gelder et al. (2006) benefit from having 10 years of cognitive follow-up, beginning at the point where the participants' final marital status/living situation was assessed. Most studies have only a single assessment time point which is then used to predict change over the subsequent 3 years or so, leaving reverse causation a very real possibility. However, the FINE Study is limited by the men-only sample; it might be that these social transitions have different effects in women. Nevertheless, the authors concluded that:

> having a partner or living together with others is associated with a smaller cognitive decline. This knowledge may have important implications for public health programs aimed at healthy aging. We should stimulate elderly men to be around other people and not to be alone. Furthermore, caretakers should be aware of the fact that elderly men who are unmarried or who live alone carry a higher risk of cognitive decline (p. 218).

6.2.3. Social engagement and normal cognitive ageing

Whilst the impact of social support networks on normal cognitive ageing is of great interest, assessments of these factors are often confounded by measurements of engagement with others in more formalised social activities, such as going to church or participation in social groups. The domains of social support networks and social engagement may be difficult to disentangle inasmuch as researchers often amalgamate their measurement of these. In a demonstration of this, Hendrie et al. (2006) reported in the NIH review that "two studies found that social engagement and/or support protects against future cognitive decline" (p. 24), highlighting the frequent lack of differentiation. Bassuk and coworkers (1999) defined social engagement as "the maintenance of many social connections and a high level of participation in social activities" (Bassuk, Glass, & Berkman, 1999, p. 165); the former part of this definition certainly appears to deal with the structural aspects of an individual's social network. This aspect, shown previously to influence dementia and mortality, has been relatively under-researched with regards to normal cognitive ageing.

6.2.3.1. Social engagement versus support

Bassuk, Glass and Berkman's (1999) EPESE (Established Population for Epidemiologic Studies of the Elderly) project was based on almost 3000 non-institutionalised adults aged over 65. Cognitive ability was assessed using the 10-item Short Portable Mental Status Questionnaire (SPMSQ), with performance level on this test described as high (9 or 10 out of 10), medium (scores of 7 or 8) or low (scoring from 0 to 6). Social engagement was assessed by several items relating to the presence of a spouse, contact with relatives and friends (both visual contact and communication by mail or telephone), religious attendance, group membership and social activity participation, all of which were combined to give a composite social engagement score. It is clear this indicator of social engagement is composed of both the presence and contact with supportive people within an individual's network, and activity in a specifically social context. Finally, the presence and adequacy of emotional support were each assessed by a single item. Cognitive decline (defined as dropping to a lower cognitive level on the SPMSQ) at 3, 6 and 12 years after the baseline assessment was predicted by an individual's level of social disengagement: "compared with participants who had five or six social ties [the individual items combined into the social engagement score], respondents who had no social ties had approximately twice the odds of experiencing decline by any given follow-up" (Bassuk et al., 1999, p. 169). Even after health status and sociodemographic factors were adjusted, this result held for the composite measure. As with the social networks-mortality associations, however, the social engagement items were not individually predictive of decline. Due to this lack of individual associations, and the combination of actual social participation with network items in the composite measure, it is not clear whether it is increased activity or actual social contact which explains the beneficial effect with respect to cognition. Nevertheless, the substitutability of contacts is again underscored; no one type of contact appears to be important, rather, multiple connections are suggested as essential for cognitive vitality. The least socially engaged individuals were also less likely to receive emotional support. However, when this, and the perceived adequacy of this support were controlled, the association between social engagement and cognitive decline remained (Bassuk et al., 1999). This latter finding might therefore suggest it is not the support derived from the individuals in the social network which underlies the observed effect. There may be something else that is specifically beneficial about the presence of, and contact with, others, or perhaps the effect is due to the social activity component of the combined social engagement score.

Whilst the authors noted that the cognitive assessment was limited (comprising a scale numbering 10 items, scored in such a way that may mean normal cognitive ageing is not being assessed but rather larger, staged decline), and so may not ascertain the more subtle deficits which perhaps a larger battery would, their assessment of the presence and adequacy of support also raises cause for concern. Functional support was assessed simply in the emotional domain (using a total of 2 items) yet the health literature suggests that associations may only be found when functional measures are matched to the outcome (Cohen et al., 1985). In Bassuk et al. (1999), the lack of an association between emotional support and cognitive decline may indicate that this resource was either poorly indexed, or that there is indeed no association. However, individuals aged 70-79 years old reporting a lower frequency of emotional support at baseline were found to have poorer cognitive function (produced from a summary score from 6 cognitive tests) after a 7.5 year follow-up (Seeman, Lusignolo, Albert, & Berkman, 2001). Although the percentage of variance in cognitive function explained by the level of emotional support was around 1%, this was after other known confounders had been controlled for (including age, education and health status). These contradictory findings suggest further work must be done to determine whether emotional support is indeed significantly linked to cognitive decline, independent of structural aspects of the social network or activity participation. It would also be advantageous to assess further domains of social support (such as companionship or instrumental support) which, to date, have been inadequately investigated although they may predict better cognitive outcomes.

There have also been criticisms of previous attempts to characterise the effect of social networks on cognitive change due to low follow-up numbers, examination of cognitive function at 2 relatively proximate occasions, or the reliance on a single measure of cognitive ability (Barnes, Mendes de Leon, Wilson, Bienias, & Evans, 2004). In addition, future work would benefit from a more thorough distinction between the facets of social engagement – assessed in the EPESE project by a number of items covering not only the structural aspects of an individual's network (for example the presence of a spouse and the amount of contact with friends and relatives) but aspects of social activity participation. Research linking social support networks to cognitive decline is a relatively recent area of interest and consequently there are few longitudinal studies addressing these issues (Barnes et al., 2004; Zunzunegui, Alvarado, Del Ser, & Otero, 2003; Beland, Zunzunegui, Alvarado, Otero, & Del Ser, 2005).

6.2.3.2. Networks, contact and integration

A study of an elderly Spanish cohort numbering almost 1000 individuals was an attempt to resolve some of the issues raised by the criticisms of earlier studies. All participants were aged 65 years or over, and were given a test of cognitive ability which included orientation and memory items from the Short Portable Mental Status Questionnaire (SPMSQ), the Barcelona Test and the EPESE short story recall (Zunzunegui et al., 2003). These gave a cognitive score for the baseline examination and 4 years later. Social networks and engagement were assessed using questions derived from the MacArthur Healthy Aging Questionnaire. These resulted in social network variables for having no friends versus one or more, telephone and visual contact with relatives (no contact, once to three times per month or more than three times per month), and having an active role in caring for children [it is not clear whether this is any children, or only their own children, but is defined as a "parenting role providing help to children, playing an important role and being useful" (p. 94)]. Engagement was assessed by 3 items each for children, friends, and relatives, and the total score gave an indication of the participant's self-perceived usefulness to these contacts. Finally, a composite social integration score was created by summing the responses to items about attending religious services, an elderly community centre and association membership (in essence, social activity).

Of the 964 participants with baseline data, 557 were retested 4 years later. Cognitive function at this second examination was positively related to (with multiple regression coefficients in parenthesis; individual *p* values were not reported) monthly visual contact with relatives (0.16, *sd* = 0.06), religious attendance (1.80, *sd* = 0.53), group membership (1.54, *sd* = 0.54), elderly centre attendance (1.17, *sd* = 0.54), and the social integration (activity) index (1.00, *sd* = 0.26), controlling for age, education and, importantly, baseline cognition. Additionally, in women, improved cognition was associated with having one or more friends (1.96, *sd* = 0.70), and engagement with those friends (0.53, *sd* = 0.16: Zunzunegui et al., 2003). In both men and women, a higher social integration index score (a measure of social activity) and more frequent contact with relatives significantly predicted reduced 4-year cognitive decline, as did increased engagement with friends in women. That is, "elderly individuals with poor social connections and social disengagement [were] at increased risk of cognitive decline" (Zunzunegui et al., 2003, p. 97).

Zunzunegui et al. (2003) indexed decline using multiple regressions predicting cognitive function in 1997 controlling for cognitive function in 1993. This effectively gives a continuous measure of cognitive change over the 4 years of follow-up and is perhaps more useful in terms of investigating normal cognitive ageing than categorical groupings. In 1999, a further wave of follow-up was completed in this cohort (Beland et al., 2005). Cognitive change data were available over a 7-year period and 372 individuals participated across all testing occasions. From this analysis the authors concluded

> respondents with higher levels of family ties and social engagement with relatives maintained better cognitive function up until 80 years of age...after 80 the difference diminished. The association between social integration and rate of change in cognitive function appeared when the association with engagement with relatives waned, that is, after 75 years old... Having friends

> was shown to be associated with rate of change in cognitive function for women (p. 326).

Across different social relationships, there was variation in the trajectory of cognitive decline. For older individuals, integration within a community and links to family and friends may both be cognitively protective, with the benefits occurring at different ages. As the relationships between social networks and engagement also differ by gender, future research must investigate fully such potential disparities.

6.2.4. Reviewing the association between social networks and cognition

A recent review suggested that positive aspects of social networks appeared to be generally positively related to better cognitive outcomes in later life (Fratiglioni et al., 2004). However, the authors note the differences apparent across studies in the assessment of social networks (and support when assessed), from simple counts of close contacts to more detailed assessments of social integration. The review identified 7 longitudinal observational studies investigating the association between social networks and cognition, yet only 3 of these (Bassuk et al., 1999; Seeman et al., 2001; Zunzunegui et al., 2003) deal with the actual measurement of social ties or networks – the descriptions of the remaining 4 highlight their reliance on measures of social activity participation (Table 6.1 summarises the review). Bearing this caveat in mind, 5 of the 7 studies reported effects of 'social networks' on cognitive function or decline, which led the authors to conclude there was evidence of a protective effect from social 'lifestyle components' (Fratiglioni et al., 2004). Whilst all the studies controlled for a baseline measure of cognitive function, the earliest 'baseline' assessments were generally around 65 years. When dealing with predictors of cognitive function in old age, however, it is optimal to control for the earliest possible measure of mental ability, because of the known strong association between childhood and late adulthood cognitive function, otherwise it is not possible to exclude the possibility that earlier ability has led to increased or decreased social engagement or integration.

Since Fratiglioni et al.'s (2004) review, a further 2 studies have appeared [in addition to Beland et al.'s (2005) extension of Zunzunegui et al. (2003), highlighted above]: Barnes and colleagues (2004) working on the Chicago Health and Aging Project (CHAP) tested 3899 participants from a baseline sample of 6158 aged 65 years and over; whilst Okabayashi et al. (2004) studied 2200 Japanese individuals aged over 60. The latter study is problematic in dealing with the issues surrounding social support networks and cognitive ageing due to its cross-sectional nature. However, the results are worth examining as emotional support was assessed (a functional measure of social support networks) rather than the more common structural measures. Participants were given a 9-item version of the Short Portable Mental Status Questionnaire (SPMSQ) to index cognitive deficit at one point in time and 6 items assessed emotional support (2 each for spouse, children and others). The sample was split and analysed separately depending on whether the participants had a spouse and children or children only. In those with both types of contact, no relationships were discovered between the support variables and cognition; for individuals without a spouse, less cognitive impairment was observed in those receiving greater support from their children (Okabayashi, Liang, Krause, Akiyama, & Sugisawa, 2004). Whilst causality can clearly not be assigned, the interest of the study is in the differential associations reported from individuals in distinct social networks (those who still have a spouse versus those that do not). Future studies should more adequately distinguish between such groups, as the support received may vary, and originate from numerous sources.

Finally, the CHAP participants were examined a mean of 2.6 times over approximately 5 years (Barnes et al., 2004). A composite cognitive score was computed from performance on the MMSE, immediate and delayed recall from the East Boston Story, and a measure of perceptual speed. Social resources (the term employed by the authors) included assessing network aspects such as the number of children, friends and relatives the participants had at least monthly visual contact with, plus social engagement with four items (including attendance at religious services, or group activity participation). An increased social network was associated with better baseline cognition and less cognitive decline across the follow-up;

cognitive decline was reduced by 39% in an individual with 16 social ties compared to an individual with 1 (Barnes et al., 2004). This result held even after adjustment for education, income and marital status. A greater number of social ties may be beneficial for the health of older individuals; however, it is not possible to state what particular aspect of contact may lead to this effect. Barnes and coworkers performed a simple count of close contacts, but not what role such individuals fulfilled or what support they might provide in the lives of their participants. Although the authors were successful in using more than one cognitive test on more than 2 occasions, the follow-up period averaged just over 5 years, and so is comparable to many of the other studies discussed thus far.

As noted by Fratiglioni et al. (2004), providing a summary of findings is complicated by the varied assessment of social networks, contacts, ties, (dis)engagement, integration and support (and, indeed, the different terminology employed which often describes very similar underlying constructs). van Gelder and colleagues (2006) suggest that being unmarried, living alone, or changing to either of these situations over a 5 year period is detrimental (in men at least) for cognitive health over the subsequent 10 years. Bassuk et al. (1999), Zunzunegui et al. (2003) [and Beland et al. (2005)] and Barnes et al. (2004) suggest that social disengagement (for example, poor social activity participation), reduced social contact or a limited number of social ties might predict later cognitive decline. There is a dearth of studies examining cognitive change and social *support*, although Seeman and coworkers (2001) suggest emotional support, rather than an index of social ties, is predictive of improved cognitive outcomes. The evidence for a protective effect of social network or support factors on cognition therefore requires replication. Moreover, the source of any effect often remains ambiguous, depending largely on the method of assessment employed. Assuming that a beneficial effect does exist, it might be that the mechanisms proposed to account for the link between social support networks and mortality have a role in explaining any association between support networks and cognition also.

6.3. Theoretical explanation

A number of potential mechanisms have been advanced to explain the observed association between health-related outcomes and social support networks. House and coworkers (1982) suggested that a protective effect of social support networks could not simply be the result of diversion from everyday stressors such contact might provide, as their study also reported that an increased risk of death was similarly associated with participation in more passive, solitary activities (which would also provide necessary distraction from these stressors). Contact or interaction with other people may be required to produce the beneficial effect. In a review conducted by Cohen and Wills (1985), 2 alternative hypotheses often used to explain the social support-health association were examined. [Note that social support has rarely been assessed directly in cognitive ageing research, but it is fruitful to consider the mechanisms explaining the social support-health link as it may be the social support derived from the more usually assessed contact with relatives and friends, for example, which produces any positive effect on cognition.] Firstly, social support may act as a buffer against stressful life events and thus reduce exposure to the resultant cumulative pathological effects of stress. In this model, social support would only play a determining role with respect to health and well-being during periods of increased stress. Alternatively, social support may be a constant, more generally available resource, accessed by an individual not just during periods of increased stress, but across time and situations; that is, there would be a main effect of social support on health outcomes but no interaction between stress levels and social support. Receiving more support over time would lead to improved health as a direct result (Cohen et al., 1985).

6.3.1. Support as a stable or buffering resource

In the latter explanation, social support may be seen as a relatively stable experience, derived as a consequence of an individual's level of integration in a network of supportive others, providing them with a role in the community (potentially confounded by indices of social status) which is rewarding socially. This increased integration may be one pathway for preventing the deleterious effects of negative situations by promoting feelings of self-worth, or increasing positive affect, for instance. These effects may act via physiological systems, discussed below, or indirectly via the alteration of the recipient's health behaviours. In the buffering model (Cohen et al., 1985), the effect of social support could operate through similar pathways but rather than providing a continuous beneficial effect, it would only become active in times of challenge. The effect would either occur between the stressor and the potentially deleterious reaction to this, or alternatively increased support may reduce the actual stress reaction. Regardless of where the effect occurs, the consequence would be to lessen the pathological outcome (Cohen et al., 1985). Social support operating in this fashion has been classified into a number of categories: esteem or emotional support, informational support, social companionship and instrumental support. Each of these may be called upon depending on the particular stressor, although in actuality they may not be entirely independent. For social support to successfully buffer the adverse effects of stress, it has been suggested that the support received must match the needs of the situation. As such, informational and esteem support may be applicable to a wide range of stressors, whilst instrumental support (such as monetary aid) and social companionship may show more specificity (Cohen et al., 1985).

6.3.2. Testing the competing models

In their review, Cohen and Wills (1985) observed that the particular model supported by individual studies may be dependent on the nature of the social support network assessment. When structural measures are used (that is, indices that generally count the number of ties or the nature of the social network) a consistent main effect is reported. This only appears to hold true when a number of structural measures are taken together; single network items, such as the number of friends an individual has, generally perform poorly due to their apparent unreliability in adequately assessing social connectedness. Of course, it is entirely possible that this is not a reliability issue but rather that such single items are not valid indicators of the broader construct. Simply having a greater number of social ties may not imply receiving greater support as functional and structural measures generally correlate about .20-.30 (Cohen et al., 1985; Wills, 1991). An exception to this is seen with marital status or the presence of another close, intimate relationship (a confidant for instance), where significant main effects are often reported. The existence of a relationship with such a key individual may indicate the provision of the necessary level of functional support to achieve a positive health outcome. But for this exception, single structural measures may serve as relatively indirect indices of available functional support, whereas composite scores may more successfully assess how anchored an individual is within a larger supportive network (Cohen et al., 1985), perhaps by reducing the error inherent in the assessment procedure.

Empirical support for the stress buffering hypothesis is more often found when specific functional measures are utilised, although this is highly dependent on the particular support function assessed. Cohen and Wills's (1985) *précis* suggested that there is good evidence for a buffering effect (when increased symptoms are apparent in the face of increased stress for those with low support but not those with high support: Wills, 1991) from total functional scores, emotional support and informational support; evidence for a buffering effect of instrumental support is only apparent when the instrumental support offered is matched to the stressor (Cohen et al., 1985).

Cohen and Wills (1985) concluded their review by suggesting that evidence exists for both models proposed to explain the effect of social support on health outcomes, which were not mutually exclusive.

> Evidence for a buffering model is found when the social support measure assesses interpersonal resources that are responsive to the needs elicited by stressful events. Evidence for a main effect model is found when the support measure assesses a person's degree of integration in a large community social network (p. 347-8).

Thus social network integration and functional social support may both be important for general health and well-being (Wills, 1991). The mechanisms by which this beneficial effect occurs could be through the opportunities provided by social relationships to provide engagement and contact with others as an access to necessary resources, or by the modification or promotion of health behaviours by supportive others (Giles et al., 2005). Whatever the specific route, however, the ultimate link to physical disease and mortality must act via biological underpinnings. Pathways linking social networks and support to physiological characteristics are plausible, and have emerged from a number of studies assessing aspects of physiological function and social support (Uchino et al., 1996).

6.3.3. Physiological underpinning

Uchino and colleagues (1996) conducted a major review of studies linking social support to physiological processes of the immune, endocrine and cardiovascular systems. The pathways involved could be many and diverse, and the authors identified 81 studies covering these 3 systems. In general, increased social support was associated with better regulation of the cardiovascular system, with a "small but reliable" mean effect size of .08 (Uchino et al., 1996, p. 490). The review also highlighted the effect of social support on endocrine and immune function. With respect to the endocrine system, 5 of the 6 studies reported found an association between social support and catecholamine level [the catecholamines are epinephrine and norepinephrine which, when secreted, "increase oxygen and heat consumption and activate glucose and fat from storage areas in the body", resulting in "increased heart rate [and] increased myocardial contractility", for example (Uchino et al., 1996, p. 511)]. However, the level of cortisol [which "has a variety of metabolic effects, including increased glucose metabolism and down regulation of immune function" (p. 511)] was not generally associated with social support. Finally, increased social support was associated with improved immune system functioning in 12 out of 19 studies; in the 7 studies with mid to older aged adults, the effect size was .23. Uchino and colleagues (1996) concluded that:

> social support has beneficial effects on physiological processes across different age groups. The net effect of such processes may be to biologically age the individual at a slower rate (Uchino et al., 1996, p. 525).

This has obvious consequences for the development of disease and thus premature mortality. Importantly, as mortality is associated with cognition (Whalley et al., 2001) part of this relationship may be explained by the same physiological mechanisms affecting both outcomes: health and mortality, and cognitive function. Social relationships, networks, integration and support could therefore influence cognitive ageing, itself an integral part of the human ageing process, via shared physiological pathways to those affecting health.

6.4. Social support networks and cognition – possible mechanisms

Social contact may have potentially far reaching consequences for the health and mental well-being of the elderly, but the mechanisms are not fully understood (Barnes et al., 2004). Speculative suggestions have been mooted, including the notion that social networks and support may "delay such an onset [of cognitive symptoms related to dementia] by providing emotional and intellectual stimulation, and practical support" (Fratiglioni et al., 2000, p. 1318). If cognitive ageing is delayed or slowed by the level of social support received through contact and interaction with others, then the physiological pathways underlying this are likely to be shared with those linking social support and health. However, increased support is not the only possible explanatory mechanism. In the study of van Gelder et al. (2006), the protection offered by being married or living with others might be the result of greater mental stimulation in these individuals because of their dealings with other people. Most authors promote a similar idea, with greater social engagement proposed to offer increased opportunities for cognitive challenge; measures of social networks may give an indication of how active an individual is in their social environment requiring the deployment of cognitive operations which therefore promote the use of mental abilities (Barnes et al., 2004; Bassuk et al., 1999). More contacts, and more complex interactions, may result in more complex environments, along similar lines to those proposed by Kohn and Schooler (Schooler et al., 1999; Schooler et al., 2004) for occupational situations. The cognitive reserve hypothesis has also been proposed (Barnes et al., 2004; Zunzunegui et al., 2003;

Fratiglioni et al., 2004; van Gelder et al., 2006) within this mechanistic explanation for the observed associations.

> Good social relations with friends and relatives, throughout the life course and especially in the late life, might produce continued mental stimulation and better cognitive strategies or increase neural growth and synaptic density-the "use-it-or-lose-it" hypothesis-delaying cognitive impairment or protecting against pathological processes (Zunzunegui et al., 2003, p. 98).

It is, of course, also plausible that the reverse is true; those individuals experiencing greater cognitive change in later life may be less able to sustain their social networks (Zunzunegui et al., 2003). Many studies (for example, Barnes et al., 2004; Zunzunegui et al., 2003) have attempted to limit this possibility by controlling for baseline ability or by excluding participants with low scores at baseline, arguing that the effects remain after such controls. However, participants in the EPESE study with lower education and income reported lower social engagement in later life (Bassuk et al., 1999). These factors are often used as crude indicators of prior ability, and so controlling for baseline ability assessed in old age may be insufficient if decline by this stage is already apparent.

Increased social engagement may simply be one indicator of a more active and generally healthy lifestyle, with subsequent benefits for both physical and cognitive well-being (Fratiglioni et al., 2004). Or, perhaps changes in marital status or living situation may precipitate lifestyle changes (such as increased alcohol intake, or less physical activity) which adversely affect cognition (van Gelder et al., 2006). Barnes et al. (2004) and van Gelder et al. (2006) argued that a positive effect of social networks remained after controlling for activity participation in other domains, and so the effect may be more than simply being more active in general or a change in lifestyle pattern. Increased engagement with people in social (and other) activities will be dealt with in greater detail in Chapter 8.

van Gelder and colleagues (2006) further proposed there may be something exceptional about the particular close relationship of being with a spouse or partner that provides cognitive protection. How this effect manifests itself is unclear, although psychosocial pathways may act as mediators of the association. Improved networks increase social engagement, leading to more positive affective states or higher self-esteem, or indeed may directly act to reduce stress and the pathological effects of this (Zunzunegui et al., 2003).

> Social networks affect social and interpersonal behavior. Networks act at the behavioral level through primary pathways, including social engagement and the flow of social support. These microsocial and behavioral processes influence more proximal pathways to cognitive aging, such as depression, direct physiological responses to stress, and life habits that increase the probability of developing health conditions that lead to cognitive decline (Zunzunegui et al., 2003, p. 93).

Feelings of stress or depression may increase due to the loss of a spouse or partner, or no longer living with others, resulting in a rise in the levels of cortisol (van Gelder et al., 2006). Elevated levels of cortisol have been shown to be related to hippocampal atrophy and damage, thus impairing memory (Lupien et al., 1998). However, when depression was controlled in the study of van Gelder and coworkers (2006), the effects of living situation and marital status remained. Other potential physiological pathways could include cardiovascular, endocrine or immune systems (Uchino et al., 1996). Before these mechanisms can be thoroughly addressed, further prospective studies are necessary in order to ascertain causality, an issue that cannot be adequately remedied when only concurrent social support network measurements or short-term follow-ups are available (Cohen et al., 1985).

6.5. Summary and LBC1921 objectives

- Aspects of social networks and support are predictive of health and mortality, and may also determine later life cognitive change.
- The variation in the sources and types of support and network characteristics indexed suggests a full assessment of these factors is warranted.

In their review, Fratiglioni, Paillard-Borg and Winblad (2004) posed certain questions which remain to be answered, including:

> can…premorbid intelligence explain the reported associations?... Might social network act through psychological pathways, such as emotional support, feeling of integration, and meaning in life? (p. 351).

The stability of social support networks over the period of follow-up is also a concern which is rarely addressed, with the study by van Gelder et al. (2006) being a rare exception. There is the possibility that the lifetime impact of social networks could be much greater than that observed over a restricted follow-up period. In a response to the NIH review, it was noted that "the effects of...social networks, interpersonal relationships...before age 65 on cognitive and emotional health in later life require careful consideration" (Lyketsos, 2006, p. 86-87). The importance of cumulative exposure was also raised by Zunzunegui et al. (2003), who questioned whether any effects noted were due to the levels of social networks or integration over a whole lifespan, or a sudden recent change in these levels in later life as suggested by van Gelder et al. (2006). Social networks are, more often than not, assessed at only one time point, with relatively short follow-up periods (although of comparable length to most other cognitive ageing studies). This methodology cannot address the issues of the stability of social networks and support, and the potential importance of cumulative lifetime exposure to supportive networks, which would have serious consequences for any suggested later life interventions (Berkman, 2000).

In this thesis therefore, a number of questions can be addressed. As none of the previous studies controlled for early ability, it is first necessary to determine whether any associations exist between cognitive function in childhood and later social networks and social support. Independently of any associations with childhood ability, do lifetime social network and support factors predict cognitive function in old age (age 79), and later life cognitive change (from age 79 to 83)? If associations with cognitive ageing are observed, it will be possible to examine gender differences in these and whether specific sources or types of support matter more than others.

In an attempt to answer aspects of the issues raised (such as the importance of pre-morbid ability as a determinant of the level of social integration and support, and the potential cumulative benefit of social support across time for successful cognitive ageing), the next chapter details the assessment of social network and support factors in the LBC1921, and relates these to cognitive change across the lifespan.

Table 6.1 Observational longitudinal studies of the association between social network and cognition [Table 1 from Fratiglioni et al. (2004)]

Study, Country	n	Age at baseline (years)	Social networks at baseline	Follow-up (years)	Cognitive assessment	Control factors	Reported associations
Bassuk et al., USA	2812	>65	Social engagement index (marital status, contacts, attendance of church, recreational activities)	3, 6, 12	Global cognitive functioning (Short Portable Mental Status Questionnaire)	Eth, Inc, PMF, Dep, CVD, Smok, Alc, PA, ES	Social disengagement with cognitive decline
Hultsch et al., Canada	250	58-65	Social activities; new-information-processing activities; physical activity	6	Decline in cognitive functioning (memory, comprehension, and speed)	CD, IADL, SH, Med, Pers	No association of social activities with cognition
Seeman et al., USA	1189	70-79	Social ties; emotional support; instrumental support	7.5	Neuropsychological battery (language, memory, conceptualisation, visuospatial ability)	Eth, Inc, CD, Dep, SEB, PA	Emotional support (but not social ties) with better cognitive function
Bosma et al., Netherlands	830	49-81	Physical exercise, mental and social activities	3	Specific tests for memory, verbal fluency; global cognitive test (MMSE)	Cog	Low participation in any activity with cognitive decline
Aartsen et al., Netherlands	2076	55-85	Everyday activity, including social, experiential, and developmental activities	6	Specific tests for memory, fluid intelligence, and speed; global cognitive test (MMSE)	PF	No association of any activity with cognition, but information processing speed with developmental activity

Menec, Canada	1292	67-95	Social, mental, and productive activities; number of leisure activities	6	Combined physical and mental function index	ADL, IADL, Cog, SH, Morb, LS	Greater overall activity, and social and productive activities with better function
Zunzunegui et al., Spain	964	>65	Social relations (social network, social integration, and social engagement)	4	Global cognitive functioning (scale including memory and orientation items)	Dep, BP, PF	Poor social relations, low participation in social activities and social disengagement with cognitive decline

All associations were controlled for age, gender, and education. Eth=ethnicity; Inc=income; CVD=cardiovascular disease; PMF=physical and mental function; dep=depression; smok=smoking; alc=alcohol; PA=physical activities; ES=emotional support; CD=chronic diseases; IADL=instrumental activities of daily living; SH=subjective health; med=medication; pers=personality; SEB=self-efficacy belief; cog=cognitive function; PF=physical function; morb=morbidity; LS=life satisfaction; BP=blood pressure.

Chapter 7: Lifetime social support networks and cognitive ageing in the LBC1921

Social support and network characteristics were assessed at 2 occasions in the LBC1921, when the participants were aged about 80 and 83 years old (Figure 3.1). Self-report measures were used on both occasions. At age 80, the measures were contemporaneous; participants were asked to provide details of their social network and report on the level of social support received at that time. The age-83 assessment was retrospective; participants answered items relating to social networks and support during 3 periods of their life (ages 20-35, 40-55 and 60-75). The information gathered at the age 80 and 83 assessments will be described in detail below, before analysing this in relation to cognitive ageing.

7.1. Retrospective Self-report

7.1.1. Support from others

Section II of the Retrospective Self-report (entitled Support from others) assessed social support and network characteristics in the LBC1921. This was mailed to the cohort as previously described in Chapter 5 [and labelled ***E*** on the LBC1921 Study timeline (Figure 3.1)]. Participants were asked to complete the same series of items for 3 distinct age periods: ages 20-35, 40-55 and 60-75. The age period being assessed was clearly highlighted at the start of each page, and throughout each set of items (shown in Appendix III).

7.1.1.1. Social networks

The structural characteristics of the participant's social network were first assessed (items 1-8). For each age period, participants were required to state how many years they lived alone (maximum 15), if they lived with a spouse or partner at any point (yes/no), and if yes, for how many years (items 1-3 respectively). They were then asked to state the maximum number of children they had living at home during the particular period (item 4), and the number of 'close' friends and relatives they could depend on (item 5). The latter item was adapted from previous research (Seeman & Berkman, 1988; Bassuk et al., 1999; Sherbourne & Stewart, 1991). The presence or absence of a confidant (providing emotional support), and the presence or absence of someone to provide practical support/assistance was then assessed, with the adequacy of the latter item also recorded (items 6-8). These 3 items were adapted from Seeman and Berkman (1988).

7.1.1.2. Social support: level and adequacy

The perceived availability of, and satisfaction with, 6 specified types of social support received were then assessed (items 1.a)-6.b) for each age period). These items were adapted from the Social Support Questionnaire (Short Form: Sarason, Sarason, Shearin, & Pierce, 1987) based on item wordings of Seeman and Berkman (1988). For each item (for example, "How often were there people you could really count on to be dependable when you needed help?"), participants were required to report how frequently people were available to provide the specified type of support on a 5-point scale (from all of the time to none of the time). Participants then stated how satisfied they were with this level of support on a 6-point scale (from very satisfied to very dissatisfied). The 6 social support items for each age period were summed; these will be referred to as Social Support 20-35, Social Support 40-55 and Social Support 60-75. Lifetime Social Support was computed by summing the scores for the 3 age periods. Similarly, scores were computed for Social Support Satisfaction at 20-35, 40-55, 60-75 and the full lifetime (all 3 age periods).

7.1.2. Response

Of the 384 participants [157 (40.9%) men and 227 (59.1%) women] who responded to Section II (Support from others) in the Retrospective Self-report, 94.8% (364) provided fully complete responses, with 5.2% (20) remaining incomplete after corrections and reminders.

7.2. Age-80 Self-report

7.2.1. Procedure

In 2001, the LBC1921 were sent a number of self-report measures as part of a questionnaire booklet, the distribution of which has been described previously (Gow, Whiteman, Pattie, & Deary, 2005a). This is labelled **C** on the LBC1921 Study timeline (Figure 3.1). In summary, the booklet was sent out in September 2001 (with the final return accepted in June 2002) and contained instructions on completion and return of the booklet as well as a contact telephone number should the participants have any queries or difficulties. At the time of mailing, 580 individuals were included on the LBC1921 list; questionnaire booklets were sent to 568 individuals (5 had died and the remainder had not attended the clinic for age-79 Cognitive Testing). This is larger than previous reports of the LBC1921 (Deary et al., 2004b) as it contains participants who were mailed the booklet but who were subsequently excluded, found to be ineligible for the study or did not then attend age-79 Cognitive Testing.

When the booklets were returned (by pre-paid envelope), each questionnaire was checked for omissions. If an item had been missed or had multiple answers, the participant was telephoned to provide corrections. If more than one item was incorrectly completed, a letter was sent to the participant detailing these, and this was again returned by pre-paid envelope. For those who had not completed and returned the questionnaire or corrections 4-5 weeks after mailing, a reminder with another copy of the questionnaire/correction letter was sent out. Over the assessment period, 138 participants were sent reminders: 38 remained as non-responses by the end of the study. In total, 530 responses were received, giving a response rate of 93.3%. Twenty-nine of these responses were refusals, 1 address was unknown and 3 were notifications of death. Questionnaire booklets were therefore received from 497 participants (87.5%), although 28 (5.6%) remained partially completed (27 refused or were not able to complete the corrections requested and 1 participant died). The gender breakdown of the response to the different sections of the age-80 Self-report will be detailed where appropriate in the results.

7.2.1.1. Significant Others Scale (SOS: Power, Champion, & Aris, 1988)

The Significant Others Scale was administered; it is a self-report measure that assesses the availability of, and perceived satisfaction with, the individual's support network. In the current study, 5 potential supports were specified: spouse (husband/wife) or partner, closest brother or sister, other brother or sister, closest son or daughter, and best friend. Participants were required to state how often they received emotional (2 items) and practical (2 items) support from each of these potential supports. For each item they were also asked what their ideal level of support would be. Responses were on a 7-point scale (from never to always). If the participant did not have one of the potential supports (e.g. they were single or their spouse had died) they were asked to cross out that category. When this occurred, the particular significant other was scored as being unavailable to provide support, and thus received the lowest possible score for those items. For each participant, the SOS responses generated the following set of scores:

- whether they had each of the named significant others (yes/no);
- how many significant others they had in total (0-5);
- the perceived level of support received from each significant other;
- their ideal level of support from each significant other;
- a discrepancy measure for each significant other (ideal minus actual support score);
- overall support and discrepancy scores (the total support summed across all the significant others);
- average support and average discrepancy scores (the overall support or discrepancy divided by the number of significant others present in an individual's network; that is, an individual is not penalised if they do no have siblings, for example).

7.2.1.2. Household composition and loneliness

Participants completed details of their age-11 and current (age-80) household composition. They were asked how many people were in their house at age 11, and how many individuals they currently shared their home with, even if they were not related. This gave the total number of people they lived with at ages 11 and 80 (an indicator of their physical contact with others). The information was also used to create a binary variable for living alone at age 80 versus living with others. The participants were then asked 2 specific questions regarding feeling lonely. First, they were asked to answer the following item on a 5-point scale (most of the time to never): "Loneliness can be a serious problem for some people and not for others. At the present moment do you feel lonely?". The second item asked "Do you feel you have people you can talk to when you have problems?", and required a yes/no response.

7.3. Results

7.3.1. Lifetime social network characteristics

When aged between 20 and 35 years old, participants lived alone for a mean of 1.3 years (*sd* = 2.9), although the majority (293 of the 379 individuals who answered this item; 77.3%) never lived alone during this time. A greater number of participants never lived alone between 40 and 55 years old (334 of the 378 who answered this item; 88.4%); the mean number of years lived alone was 0.8 (*sd* = 2.8). However, between 60 and 75 years old, participants lived alone for the greatest number of years (mean = 3.5 years, *sd* = 5.6), although the majority of participants (247 of the 378 who answered this item; 65.3%) never lived alone during this time.

Three hundred and twelve participants (82.3% of the 379 responding) lived with a spouse or partner at some point between the ages of 20 and 35 years old, for a mean of 9.3 years (*sd* = 3.7). Similarly, 89.4% of participants (338 of the 378 responding) did so between 40 and 55 years old, for a mean of 14.3 years (*sd* = 2.5). In the oldest age period (60-75 years old), the proportion of participants living with a spouse or partner at some point was reduced to 78.7% (299 of the 380 responding), for a mean of 13.2 years (*sd* = 3.7).

The highest number of children participants had living in their house ranged from a minimum of 0 in each of the 3 age periods [106 out of 380 participants (27.9%) between 20 and 35 years old; 98 of 378 (25.9%) between 40 and 55 years old; 310 of 380 (81.6%) between 60-75 years old]; the maximum was 7 (1 participant; 0.3%), 10 (2; 0.5%) and 9 children (1; 0.2%) during the 3 age periods respectively. The modal response was 2 children during the first 2 age periods [116 participants (30.5%) and 129 participants (34.1%) respectively] and none in the oldest age period (310, 81.6%).

The number of close friends and relatives recorded by participants ranged from 0 to 50 in the 3 age periods, with means of 9.8 (*sd* = 10.2), 9.3 (*sd* = 10.2) and 8.2 (*sd* = 9.5). [Note for those participants who recorded 'lots', 'many', etc. for this item, a default value of 50 had been entered, as detailed in Appendix VIII.] In all 3 age periods, 96.8% of participants said they had a confidant (any one special person they felt very close and intimate with – someone they shared confidences and feelings with, someone they felt they could depend on): 368 out of 380 at 20-35 years old, 365 out of 377 at 40-55, and 367 out of 379 at 60-75. The majority of participants reported the presence of practical support (someone to help with daily tasks like grocery shopping, house cleaning, cooking, telephoning, or to give a lift somewhere) during each age period: 84.3% (321/381) at 20-35 years old, 88.9% (335/377) at 40-55, and 88.7% (336/379) at 60-75 respectively. Finally, 91.1% (347/381), 91.8% (347/378) and 90.5% (343/379) said this practical support was adequate (they did not require more help in their daily lives than they received) in the 3 age periods respectively.

7.3.2. Lifetime social support and satisfaction

Across the 3 age periods, there was no change in the mean level of social support received. At 20-35 and 40-55 years old, the mean levels were 19.5 ($sd = 4.5$) and 19.7 ($sd = 4.6$) respectively [$t(369) = -1.291, p = .198$]; at 60-75 years old, the mean level was 19.7 ($sd = 4.6$) which did not differ significantly from the level at 40-55 [$t(369) = .091, p = .928$]. Similarly, there was no change across age periods in satisfaction with the level of social support received [20-35 mean = 27.0 ($sd = 4.0$), 40-55 mean = 26.9 ($sd = 4.2$): $t(370) = 1.058, p = .291$; 40-55 mean = 26.9 ($sd = 4.2$), 60-75 mean = 27.1 ($sd = 3.8$): $t(371) = -1.350, p = .178$].

7.3.3. Age-80 Significant Others Scale (SOS)

The Significant Other Scale (SOS) was completed by 488 individuals [205 (42.0%) men and 283 (58.0%) women]. Of this number, 220 (45.1%) were married (had a spouse) at the time of the mailing, 265 (54.3%) had a close sibling, and 137 (28.1%) had another sibling. The majority of participants had a close child (394; 80.7%) with a similar percentage recording that they had a best friend (399; 81.8%). Overall, most participants listed 2 or 3 significant others [147 (30.1%) and 137 (28.1%) participants respectively], giving a mean of 2.9 ($sd = 1.2$).

7.3.4. Age-80 household composition and loneliness

The total number of individuals living in participants' households ranged from 2 to 15 at age 11 [mean = 5.4 ($sd = 1.9$)], and from 1 to 5 at age 80 [mean = 1.6 ($sd = 0.6$)]. Two hundred and thirty six individuals (48.3% of the 489 who recorded their living arrangements) were living alone at age 80. Of the 490 participants who answered the separate item on feeling lonely, 208 (42.4%) reported never feeling lonely at present. A further 135 (27.6%) and 107 (21.8%) said they seldom or only occasionally felt lonely respectively; 34 participants (6.9%) reported being lonely quite often and 6 (1.2%) reported feeling lonely most of the time. Women reported being more lonely than men [3.8 ($sd = 1.0$) versus 4.3 ($sd = 0.9$), where a lower value indicates greater loneliness; $t(472.0) = 5.864, p < .001$]. Those who were living alone at age 80 reported greater feelings of loneliness [mean = 3.6 (1.0) versus 4.5 (0.8), the lower score indicating greater loneliness; $t(427.1) = -11.395, p < .001$].

7.3.5. Social network and support associations with cognition

7.3.5.1. Living alone versus with a spouse/partner across the lifespan

The associations between the lifetime social network characteristics described above and the measures of cognition from across the lifespan were examined (Table 7.1). All associations were small and mostly non-significant with some exceptions. Living with a spouse/partner at any time between 20 and 35 years old was negatively associated with age-83 cognitive ability ($r = -.12, p = .049$). Those who lived with a spouse or partner at any time during this period performed more poorly on the cognitive tests at age 83 [the standardised age-83 cognitive ability score was -.02 in this group versus .30; $t(284) = 1.973, p = .049$]. When examined separately by gender (Table 7.2), this relationship was only found in women ($r = -.17, p = .038$); women who had lived with a spouse/partner at any time between 20 and 35 years old were significantly less cognitively able at age 83 [their standardised age-83 cognitive ability score was -.05 versus .41; $t(152) = 2.088, p = .038$]. Furthermore in women, living with a spouse or partner at any time between 20-35 and 40-55 years old was related to lower cognitive ability at age 79 [$r = -.15$ ($p = .027$) and -.18 ($p = .010$) respectively], and living with a spouse or partner during the 60-75 years old age period was related to lower age-83 cognitive ability ($r = -.16, p = .042$: Table 7.2). This association may be confounded by social class differences in age at marriage, however, an alternative explanation concerning the relationship between IQ and marital status will be considered in the discussion.

Additionally, the *number of years* lived with a spouse/partner between 20 and 35 years old was negatively associated with cognitive ability level across the lifespan in the full sample (Table 7.1: $r = -.14$ to $-.26$). Those who lived with a spouse/partner for longer during this period scored lower on the cognitive tests at ages 11, 79 and 83. The association between the number of years lived with a spouse/partner between 20 and 35 years old and age-79 IQ was slightly attenuated after adjustment for age-11 IQ, but remained significant [$r = -.19$ ($p = .001$) from $-.24$ ($p < .001$)]. In women, the length of time lived with a spouse or partner during the 20-35 years old age period was negatively related to ability across the lifespan [Table 7.2: age-11 IQ $r = -.19$ ($p = .017$); age-79 IQ $r = -.24$ ($p = .002$); age-79 cognitive ability $r = -.28$ ($p < .001$); age-83 cognitive ability $r = -.29$ ($p = .001$)]; whereas living alone for longer between 20 and 35 years old was associated with a more positive cognitive change from age 79 to 83 ($r = .18, p = .030$). Overall, women who were married younger or cohabiting longer had lower ability at age 11 and in later life. In men, only the number of years lived with a spouse or partner between 20 and 35 years old was associated with poorer cognitive ability at age 79 ($r = -.18, p = .045$).

7.3.5.2. Children living at home across the lifespan

In the full sample, there were no significant associations between the number of children living at home during any of the age periods and cognitive function assessed across the lifespan (Table 7.1). When analysed separately by gender (Table 7.2), men who reported having a greater number of children at home between 40 and 55 years old had higher cognitive ability at age 79 ($r = .19, p = .017$). For women, having a greater number of children in the home at 60-75 years old was associated with poorer mental ability at age 79, whether MHT-based IQ or the composite of the 3 cognitive tests completed (for both, $r = -.16, p < .05$). When age-11 IQ was adjusted, the association between the number of children in the home at 60-75 years old and age-79 IQ was increased to $-.20$ ($p = .005$).

7.3.5.3. Close friend and relatives across the lifespan

Having a greater number of close friends and/or relatives in any of the 3 age periods was negatively associated with cognitive ability level assessed across the lifespan (Table 7.1: $r = -.17$ to $-.25$); participants who reported a higher number of close contacts in young, middle or late adulthood had poorer mental ability at ages 11, 79 and 83. When the associations between the number of close friends/relatives and age-79 IQ were adjusted for age-11 IQ, the relationship held in all 3 age periods [r = -.15 (p = .007) for 20-35 years old, -.14 (p = .012) for 40-55 years old and -.14 (p = .011) for 60-75 years old].

Women who were less able at age 11 reported having a greater number of close friends and/or relatives during the 3 age periods assessed (Table 7.2: r = -.22 to -.27); in men, the correlation of age-11 IQ was only significant with the number of close friends/relatives reported for 40 to 55 years old (r = -.17, p = .047). The correlations between the number of close friends/relatives during the 3 age periods and age-79 IQ were similar in men and women (Table 7.2: r = -.22 to -.26), however the associations were attenuated in women when age-11 IQ was controlled (r = -.06 to -.10, *ns*). In men, after adjusting for age-11 IQ, the negative associations between the number of close friends/relatives remained in each age period [r = -.21 (p = .012) at 20-35 years old, -.20 (p = .021) at 40-55 years old, and -.26 (p = .002) at 60-75 years old].

7.3.5.4. Presence of emotional and practical support across the lifespan

The presence (or absence) of a confidant providing emotional support during the 3 age periods was not related to cognition assessed across the lifespan, either in the total sample (Table 7.1) or separately in men and women (Table 7.2). However, when age-11 IQ was adjusted, the association between the presence of a confidant at 60-75 years old and age-79 IQ became significant in the full sample (r = -.12, p = .023). Thus, participants who reported not having a confidant (providing emotional support) when aged 60-75 years old had poorer mental ability in late adulthood, independent of their level of childhood ability. It should be noted that this item had a highly uneven distribution – only 3.2% of participants reported not having a confidant.

The presence (or absence) of someone to provide practical support during the 3 age periods was not associated with mental ability in the full sample (Table 7.1). However, in women, those reporting the presence of practical support at 20-35 years old had higher age-79 IQ ($r = .14$, $p = .047$: Table 7.2); this association was attenuated after controlling for age-11 IQ ($r = .11$, $p = .141$). In men, the presence of someone providing practical support at 20-35 years old was negatively related to cognitive change from age 79 to 83 ($r = -.20$, $p = .024$); those men who reported having someone to count on when they needed extra help in their daily tasks in young adulthood showed greater decline in later life [-.14 versus .43; $t(129) = 2.290$, $p = .024$].

Finally, inadequate practical support between 60 and 75 years old (needing more help in daily tasks than was available) was associated with poorer IQ at ages 11 and 79, and composite cognitive ability at age 79 in the full sample [$r = -.16$ ($p = .003$), -.13 ($p = .010$) and -.11 ($p = .042$) respectively: Table 7.1]. The association between age-79 IQ and the adequacy of practical support was attenuated when age-11 IQ was controlled ($r = -.04$, $p = .524$). When analysed separately by gender (Table 7.2), inadequate practical support between 60 and 75 years old was associated with poorer childhood cognitive function in both men and women [$r = -23$ ($p = .008$) and -.14 ($p = .049$) respectively]. Those who required more help in later life had significantly lower childhood ability; for men, mean age-11 IQ was 87.2 ($sd = 10.4$) for those requiring extra help versus 101.5 ($sd = 14.7$) [$t(137) = 2.699$, $p = .008$], and for women, mean age-11 IQ was 95.9 ($sd = 15.8$) versus 101.8 ($sd = 13.7$) [$t(195) = 1.978$, $p = .049$].

7.3.5.5. Social support and satisfaction across the lifespan

The associations between the level of, and satisfaction with, social support at each age period and cognition are shown in Table 7.3. Individuals reporting having received higher levels of social support at 20-35 and 60-75 years old had higher ability in childhood [$r = .11$ ($p = .039$) and .11 ($p = .049$) respectively]. The measure of lifetime social support (created by summing the level of social support at each of the 3 age periods) was also associated with age-11 IQ ($r = .13, p = .018$). A similar pattern of associations is observed for age-79 IQ [$r = .11$ ($p = .038$) with Social Support 20-35; $r = .12$ ($p = .025$) with Social Support 60-75; $r = .12$ ($p = .020$) with Lifetime Social Support]. Adjusting for age-11 IQ attenuated the latter associations with age-79 IQ [$r = .05$ ($p = .404$), .06 ($p = .294$) and .05 ($p = .382$) respectively]. When analysed separately by gender, the aforementioned associations between IQ and social support were only significant in women (Table 7.3: ranging from .14 to .18, $p < .05$). Again, however, adjusting for age-11 IQ attenuated the age-79 IQ-social support associations ($r = .05$-.09, *ns*). Concerning the perceived adequacy of the social support received, both age-11 and age-79 IQ were associated with Social Support Satisfaction 20-35, Social Support Satisfaction 40-55 and Lifetime Social Support Satisfaction (ranging from $r = .11$ to .13, $p < .05$); the associations between satisfaction with the level of social support and age-79 IQ were attenuated when age-11 IQ was controlled ($r = .03$-.05, *ns*). When the sample was split by gender, the correlation between Social Support Satisfaction 20-35 and age-79 IQ was only significant in women ($r = .14, p = .038$), which was attenuated when age-11 IQ was controlled: $r = .07, p = .321$); whereas the correlation between Social Support Satisfaction 40-55 and age-11 IQ was only significant in men ($r = .20, p = .022$). Overall, these results suggest that while there exist relationships between the level of social support received across the lifespan, and the perceived adequacy of this, and mental ability in childhood and old age, there is no direct effect of these social support factors on later mental function independently of prior ability. There were no significant associations between any of the social support (level of, or satisfaction with) measures and the level or change in cognitive ability from 79 to 83 years old (Table 7.3).

The correlational results presented thus far have been based upon the social network and support factors indexed retrospectively when the LBC1921 were aged about 83 years old. This assessment asked participants to reflect back on different periods throughout their lives. In the associations which follow, the social network and support variables are those which were collected for when the cohort were aged 80.

7.3.5.6. Age-80 Significant Others Scale (SOS)

The number of significant others participants reported having at age 80, the overall level of social support received at age 80, the discrepancy between this and the participant's ideal level of social support, and the average level of social support received (the overall support received divided by the number of significant others providing it) were not significantly related to any of the cognitive measures (Table 7.4). There was a small association between the average discrepancy in the level of social support received at age 80 (ideal level minus actual) and cognitive ability at age 79 ($r = .11, p = .023$); this suggests that those reporting more inadequate support (a higher discrepancy between actual and ideal social support) performed cognitively better in later life. When the sample was split by gender (Table 7.4), in men, greater overall social support received at age 80 was associated with higher cognitive ability at age 83 ($r = .17, p = .049$), whilst higher age-11 IQ was associated with a greater discrepancy between the average level of social support received and the ideal level ($r = .15, p = .043$). There were no significant associations between the level or perceived adequacy of social support in women.

When the *presence* of each of the significant others at age 80 was looked at individually (Table 7.5), simply having a spouse was positively related to age-79 IQ ($r = .10, p = .032$), such that those with a spouse had a significantly higher age-79 IQ [mean = 102.5 (13.6) versus 99.6 (14.9); $t(464) = -2.145, p = .032$]. This association remained after adjusting for age-11 IQ ($r = .13, p = .010$). Participants who were married at age 80 had higher cognitive function at age 79, independent of their level of prior ability. This initially appears to contradict the retrospective data reported previously, and will be discussed in greater detail later. Having another sibling was negatively associated with age-11 IQ ($r = -.11, p = .030$): mean age-11 IQ was 97.9 (15.5) in those with another sibling compared with 101.4 (14.3) in those without [$t(422) = 2.182, p = .030$]. When examined in men and women separately (Tables 7.6 and 7.7), the presence of a best friend in men was associated with less cognitive decline from age 79 to 83 [mean cognitive ability change from age 79 to 83 = .03 (.86) for those with a best friend versus -.39 (.89) for those without; $t(130) = -2.237$,

$p = .027$]; the presence of a closest child in women was negatively associated with cognitive ability at age 79 [mean cognitive ability age 79 = -.05 (.97) for those with a closest child versus .24 (.88) for those without; $t(265) = 2.205$, $p = .028$].

The associations between the level of support received from each significant other and the cognitive measures were then investigated (Table 7.5). When analysing data for levels of spousal support, those without a spouse were excluded. Exclusions were made in the same manner for the closest and other sibling, closest child and best friend respectively. Those who received increased support from another sibling (not their closest) had higher age-79 IQ ($r = .20$, $p = .023$), however, this association was attenuated when age-11 IQ was controlled ($r = .15$, $p = .117$). Conversely, participants receiving higher levels of support from their closest child had lower IQ at ages 11 and 79 ($r = -.12$ and -.10 respectively, $p < .05$). Again, however, the latter association was attenuated after adjustment for age-11 IQ ($r = -.03$, $p = .533$).

For each significant other present (again excluding those who did not list the specified significant other), it was also possible to calculate a discrepancy measure: the ideal level of support minus actual support received. The associations with these discrepancy measures and cognition are also shown in Table 7.5. A greater discrepancy between the actual and ideal support received from the closest child and best friend was related to increased age-11 and age-79 IQ ($r = .10$ to .15, $p < .05$), whilst the discrepancy in support from another sibling was negatively associated with age-79 IQ ($r = -.20$, $p = .019$). None of the associations between the measures of discrepancy and age-79 IQ remained significant after age-11 IQ was adjusted. Thus, whilst increased later mental ability is associated with dissatisfaction in the level of support received from a close child or best friend, and a greater satisfaction with the support from another sibling was related to better cognitive function in later life, these associations were not independent of childhood ability.

The associations between the level of support received from each significant other (and the discrepancy measure) and cognition are shown separately for men and women in Tables 7.6 and 7.7. For men who listed a closest sibling, receiving greater support from this individual was associated with better cognitive ability at age 83 ($r = .28$, $p = .019$). There was an association in men with another sibling between the level of support received from this individual and age-79 IQ ($r = .27$, $p = .042$), and the discrepancy between the ideal and actual level of support ($r = -.27$, $p = .041$). That is, men with another sibling (in addition to their closest sibling) were cognitively more able at age 79 when this sibling provided increased support and this support more closely matched their ideal level. When age-11 IQ was controlled, the former association was attenuated ($r = .21$, $p = .159$) although the latter was not ($r = -.35$, $p = .015$). For men with a best friend, increased age-11 IQ was associated with a greater discrepancy between the ideal and actual level of support received from this individual ($r = .18$, $p = .035$). In men with a closest child, less support from this individual and a greater discrepancy between the ideal and actual level was associated with higher childhood ability [$r = -.22$ ($p = .004$) and .20 ($p = .010$) respectively]. In women, an increased level of support from a closest child was related to poorer cognitive ability at ages 79 and 83 [$r = -.14$ ($p = .041$) and -.18 ($p = .011$) respectively]. Furthermore, a greater discrepancy between the ideal and actual level of support from this individual was associated with increased age-79 IQ, and cognitive ability at ages 79 and 83 [$r = .21$ ($p = .002$), .18 ($p = .011$) and .21 ($p = .021$) respectively]. The association between this discrepancy and age-79 IQ remained after age-11 IQ was controlled ($r = .22$, $p = .004$).

7.3.6. Household composition, living alone and loneliness

The number of people in the house at age 11 [this information was collected alongside the social network and support factors at age 80] was negatively related to both age-11 and age-79 IQ ($r = -.19$ and -.17 respectively, $p < .001$: Table 7.4); the latter association was no longer significant after age-11 IQ was adjusted ($r = -.07$, $p = .178$). [The relationships were similar in men and women (Table 7.4), although, as in the full sample, the age-79 IQ associations were attenuated after controlling for age-11 IQ: $r = -.13$ ($p = .089$) and -.01 ($p = .932$) respectively.] A greater number of people in the house at age 11 was also associated with poorer cognitive ability at ages 79 and 83 [$r = -.10$ ($p = .036$) and -.12 ($p = .045$) respectively], but there was no association with later life cognitive change ($r = -.09$, $p = .132$). However, the number of people in the house at age 80 was positively related to age-79 IQ ($r = .10$, $p = .035$); adjustment for age-11 IQ did not attenuate this association ($r = .12$, $p = .017$).

Living with others at age 80 (versus living alone; this variable was created from the information on number of people in the house at age 80) was positively related to age-79 IQ (Table 7.4: $r = .11$, $p = .023$). This association remained after age-11 IQ was adjusted ($r = .13$, $p = .006$). Those living alone rather than with others had significantly lower age-79 IQ [mean = 99.4 (14.9) versus 102.4 (13.7), $t(465) = -2.273$, $p = .023$]. The association between living alone and age-79 IQ was not significant when the sample was split by gender, and living alone at age 80 was not related to the composite measure of cognitive ability (or change) at ages 79 and 83 (Table 7.4). Increased loneliness (shown by a lower score on the feeling alone item) was related to lower mental ability at age 79 [whether assessed as age-79 IQ ($r = .18$, $p < .001$) or composite cognitive ability from the 3 tests delivered at age 79 ($r = .14$, $p = .003$): Table 7.4]. The association between loneliness and age-79 IQ remained after adjusting for age-11 IQ ($r = .24$, $p < .001$). The associations between cognitive ability and loneliness were only significant for women (Table 7.4), however, when age-11 IQ was controlled, the age-79 IQ-loneliness association was significant for both men ($r = .15$, $p = .048$) and women ($r = .24$, $p < .001$). Taken together, these results suggest that both living with others in old age (versus living alone) and not feeling lonely are associated with increased cognitive ability in old age, independently of the level of ability in childhood.

7.4. Regression analyses

The preceding results have examined the univariate associations between social network and support variables and cognitive outcomes. The final stage of analysis will use significant correlations to guide the selection of variables in regression analyses. Firstly, the social network/support predictors of age-79 IQ will be sought. [As in Chapter 5, standardised β are reported throughout.]

7.4.1. Predicting age-79 IQ

The social network/support factors which remained associated with age-79 IQ when age-11 IQ was adjusted may account for changes in cognition across the lifespan. These were the variables which were therefore selected for further analysis. A hierarchical regression was conducted with age-79 IQ as the dependent variable. Age-11 IQ and sex were entered as independent variables in block 1. In the 2nd block, the following variables were entered in a stepwise fashion: the numbers of years with a spouse at 20-35 years old, the number of close friends/relatives at 20-35, 40-55 and 60-75 years old, the presence of a confidant at 60-75 years old, the presence of a spouse at age 80, living alone at age 80 and loneliness at age 80.

Age-11 IQ ($\beta = .64, p < .001$) and sex ($\beta = -.12, p = .013$) accounted for about 41% of the variance in age-79 IQ in model 1 (Table 7.8). The number of years lived with a spouse from age 20 to 35 years old entered in the next model, accounting for 2% of the variance in age-79 IQ. The number of close friends or relatives (60-75 years old) accounted for 1% of the variance in the final model. Individuals who were alone for longer between 20 and 35 years old, and who reported having fewer close friend/relatives in old age, had improved cognitive function at age 79, independent of childhood ability.

Regressions were also performed separately for men and women. In men, age-11 IQ explained about 38% of the variance in age-79 IQ ($\beta = .64, p < .001$). The number of close friends/relatives in each of the 3 age periods and the level of loneliness at age 80 were entered stepwise in the 2nd block; none of these factors significantly accounted for variance in age-79 IQ. In men with another sibling (in addition to their closest sibling, recorded in the Significant Others Scale), there was also an association between the discrepancy in the ideal versus actual level of social support received from their other sibling and age-79 IQ (partialling out age-11 IQ). The regression was therefore rerun in this subgroup, including this social support discrepancy measure in block 2. Age-11 IQ accounted for 51% of the variance in age-79 IQ in this analysis ($\beta = .72, p < .001$), however, again, none of the social network or support variables made a significant contribution to the prediction of age-79 IQ.

In women, the number of children in the household from 60 to 75 years old and loneliness at age 80 were entered in the 2nd block of the regression analysis. Age-11 IQ accounted for 47% of the variance in age-79 IQ. Loneliness was the only other variable which entered the model, contributing a further 2% to the variance explained in age-79 IQ (Table 7.9 – *A*). In those women who had a closest child at age 80 (from the Significant Others Scale), there was an association between age-79 IQ and the discrepancy in the level of support (ideal minus actual) from this individual, independent of age-11 IQ. The analysis was therefore rerun in this subsample of women, with the discrepancy measure also included in the 2nd block. Age-11 IQ accounted for 45% of the variance in age-79 IQ, and the discrepancy in support from the closest child and loneliness at age 80 contributed a further 3% and 1% respectively (Table 7.9 – *B*). Therefore, in men, the social network or support factors assessed here did not predict later cognitive function independently of childhood ability. However, in women, those who had poorer cognitive function at age 79 (controlling for childhood ability) reported increased feelings of loneliness at age 80.

7.4.2. Predicting later life cognitive change

Regression analyses were also conducted with cognitive change from age 79 to 83 as the dependent variable. However, in the full sample, there were no significant associations between any of the social support factors or social network characteristics – whether assessed retrospectively or at age 80 – and cognitive change in later life. Regressions were therefore only conducted separately by gender. For men, age-11 IQ was entered in the 1st block, followed stepwise by those variables with significant associations to the outcome in block 2 (presence of practical support 20-35, presence of a best friend at age 80). Table 7.10 summarises this analysis. In the 1st model, age-11 IQ did not significantly contribute to variance in cognitive change from age 79 to 83 years old. The presence of practical support at 20 to 35 years old and the presence of a best friend at age 80 entered the next 2 models, each accounting for about 3% of the variance in later life cognitive change. Men who reported having someone to provide practical support in early adulthood experienced greater cognitive decline in later life, whereas those with a best friend in old age showed less cognitive decline.

In women, only the number of years lived alone from 20 to 35 years old was entered stepwise in the 2nd block after age-11 IQ was entered in the 1st block. Age-11 IQ accounted for about 7% of the variance in later life cognitive change (Table 7.11). The number of years lived alone between 20 and 35 years old entered in the next model, contributing a further 3% to the variance explained. Women who lived alone for a greater number of years in young adulthood experienced less cognitive decline from 79 to 83 years old.

7.5. Discussion

Participants in the Lothian Birth Cohort 1921 Study answered a range of questions about their social networks and the level of social support they received. The former items included marital status or counts of close friends and relatives, for example, whilst the latter asked participants to rate how much support they received (and how satisfied they were with this level of support) of various types or from different contacts. Assessments were conducted both retrospectively and contemporaneously to index these factors throughout the lifespan and in old age. The relationships between lifetime social network and support factors and cognitive ability were examined. Of particular interest were those factors predicting age-79 IQ (when age-11 IQ was controlled) and cognitive change in later life (from 79 to 83 years old).

7.5.1. Summary of results

Childhood mental ability was related to a number of the social network and support characteristics. For example, higher ability in youth was associated with (correlation coefficients are shown in parenthesis) sharing a house with fewer people at age 11 (-.19), living with a spouse/partner for a fewer number of years between 20 and 35 years old (-.14), having fewer close friends/relatives across the lifespan (-.18 to -.22), feeling the level of practical support received at 60-75 years old was inadequate (-.16), receiving an increased level of social support at ages 20-35, 60-75 and across the lifespan (.11 to .13), and greater satisfaction with the level of support received at ages 20-35, 40-55 and across the lifespan (.12 to .13). After childhood ability was adjusted, certain social network and support factors remained associated with increased IQ at age 79, including living with a spouse/partner for a fewer number of years between 20 and 35 years old, having fewer close friends/relatives at 20-35, 40-55 and 60-75 years old, the presence of a confidant at 60-75 years old, the presence of a spouse at age 80, not living alone at age 80, and reduced loneliness at age 80. However, in the regression analyses predicting later life IQ (controlling age-11 IQ and sex) the significant predictors entering the model were the number of years lived with a spouse in young adulthood and the number of close friends and relatives in old age, each explaining about 1-2% of the variance.

There were no significant associations between later life cognitive change (from age 79 to 83) and any of the social network and support factors in the full sample. Regression analyses (controlling for age-11 IQ) were therefore only conducted separately by gender. In men, the presence of practical support in young adulthood was detrimental to later life cognitive change whereas the presence of a best friend at age 80 was beneficial (each factor accounted for about 3% of the variance). In women, living alone for a greater number of years in young adulthood was favourable with respect to later life cognitive change, explaining about 3% of the variance.

7.5.2. Social networks and cognition

As discussed in Chapter 6, the assessment of social network and support characteristics is often broadly defined by whether structural or functional aspects are being considered. For example, the number of close friends and relatives an individual can rely on would be described as structural. Such items index the presence of social ties from which support could potentially be derived. On the other hand, functional measures assess the type of support received (emotional or practical support, for example). The particular form of network or support items used might determine what associations are reported with health or cognitive outcomes (Wills, 1991; Cohen et al., 1985; Stroebe, 2000). Both types of item (structural and functional) were used with the LBC1921, and the relationships observed with cognitive change across the lifespan will now be discussed.

7.5.2.1. Household composition in childhood

Although a number of interesting associations were reported between social network characteristics and cognition, it would appear that some of these factors may not have been indexing the level of contact with, or support from, other individuals. Firstly, living with a greater number of people at age 11 was negatively associated with childhood and later adulthood mental ability (although the latter association was attenuated to non-significance when adjusted for early ability). The association between childhood ability and occupancy rate (a measure of the average number of individuals per room, closely related to the number of individuals in the household) was reported from the SMS1947 data. Those living in more crowded conditions scored lower on the MHT when aged 11 (Scottish Council for Research in Education, 1953). Children from homes with 1 individual or fewer per room scored an average of 47.26 (out of 76 on the MHT) compared with 30.26 for those living in households where there were 3 or more persons per room. It would be suggested that a more overcrowded home in childhood might be a marker of socioeconomic status or deprivation. The researchers concluded,

> though, therefore, we cannot ascribe the lower tests scores of children living in crowded homes to overcrowding *per se*, it is fairly clear that the social conditions, of which overcrowding is one factor, are reflected in the child's performance in the intelligence test (Scottish Council for Research in Education, 1953, p. 43).

For the individuals of the SMS1947, and the LBC1921, living with more people in childhood is unfavorable with respect to cognition, perhaps as a consequence of the link between overcrowding and social class.

Furthermore, when asked at age 80 about the presence of a range of significant others, individuals who reported having another sibling (in addition to their closest sibling, that is, they were part of a larger family) scored lower at age 11. This item appears to be a very rough proxy for family size, which was also associated with lower MHT scores in the SMS1947 (Scottish Council for Research in Education, 1953). Family size and overcrowding are closely related, and both are influenced by parental social class. It is therefore likely that lower social class and increased deprivation, or other associated detrimental environmental factors, explain the relationship between family size, household composition and childhood ability, rather than there being a direct link. As childhood household composition and family size (indexed by having another sibling in this instance) appear to be markers of childhood circumstances rather than the presence of social networks or support, they will not be discussed further.

7.5.2.2. Marital status across the lifespan

Perhaps one of the most robust findings to have emerged from social network research (and discussed in Chapter 6) concerns the protective effect of being married for later cognitive function (Helmer et al., 1999; Fratiglioni et al., 2000; van Gelder et al., 2006). When marital status was retrospectively assessed across the lifespan in the LBC1921, simply being married versus unmarried in the 3 age periods was, on the whole, unrelated to cognitive function in the full sample (other than a small negative association between being married in young adulthood and cognitive ability at age 83). However, women who reported being married in any of the 3 age periods had poorer cognitive function in later life. Interestingly, there were also negative associations (significant for women) between the number of years lived with a spouse or partner in young adulthood and cognitive function assessed at the various points across the lifespan (although this factor did not account for variance in the regression analyses). That is, not only does there appear to be no protective effect of being married at different ages, but in women, the opposite is true: *unmarried* women are at a cognitive advantage. Research linking the SMS1932 to the Midspan studies (discussed in Chapter 2) might help to explain this finding (Taylor et al., 2005b). In this linkage analysis, a higher score on the MHT at age 11 was associated with a greater likelihood of being unmarried by midlife for women; for each standard deviation increase in childhood IQ, the OR of being married versus unmarried was 0.42 (95% CI = 0.27-0.64). This relationship is replicated in the current analysis with the LBC1921 as women with higher ability were married for fewer years in young adulthood (assuming, of course, that this suggests these women are marrying later, or perhaps, not at all). Taylor et al. (2005) proposed that "women who spent longer in education and focused on furthering a career during early adulthood, delayed getting married, with some never marrying" (p. 1627). In addition, the LBC1921 women who lived alone for longer in young adulthood (suggesting they were unmarried) showed less cognitive decline in later life. This factor accounted for about 3% of the variance in later life cognitive change when childhood ability was adjusted. Together these findings suggest that marital status assessed across the lifespan may not simply be assessing the presence or absence of a close, emotionally supportive other. In effect, and for women in particular, marital status is a reflection of a range of psychosocial characteristics (in this instance mental ability, but also perhaps socioeconomic status); these predictors of marital status may confound any cognitive benefit derived from being married.

Conversely, the presence of a spouse at age 80 *was* positively related to cognitive function at age 79, independently of childhood ability (in the full sample, but not separately for men and women). Being married in old age is therefore associated with a relative improvement in cognitive function across the lifespan, although marital status at age 80 was not a significant predictor in the regression analyses. This is in agreement with the studies reviewed in Chapter 6 (Helmer et al., 1999; Fratiglioni et al., 2000; van Gelder et al., 2006), however, there was no continued positive effect of being married on cognitive change from age 79 to 83. It is possible that due to the relatively short-term follow-up of the LBC1921 in old age, the cognitive decline observed is not of a sufficient magnitude for an effect of martial status to be apparent.

It is interesting to note the apparent changing pattern of the marriage-cognition association across the lifespan. The discrepant associations reported could have arisen as a result of chance due to the number of correlations conducted. Replication in further samples is required to counter the possibility of type 1 errors underlying the correlations. For both men and women, higher ability in youth predicts higher ability in old age (Deary et al., 2004b). In men, higher childhood ability is associated with being married by midlife whereas in women, this would predict a greater likelihood of being unmarried (Taylor et al., 2005b). If marriage is protective of cognitive function in old age, then for men, higher childhood ability predicts not only a better cognitive outcome, but a state (marriage) which is also beneficial. The effect of early ability and marital status would thus operate in the same direction. However, for women, the (assumed) cognitive protection of being married would be confounded by the tendency for those women of lower initial ability to marry. In later life, the cognitive protection offered by marriage may be increasingly important, and might therefore account for the results reported by other researchers (Helmer et al., 1999; Fratiglioni et al., 2000; van Gelder et al., 2006). Indeed, "the cognitive stimulation of a partner or other person may protect the brain from deterioration. Furthermore, the loss of a partner could cause changes in lifestyle (such as changes in smoking, drinking, and dietary habits) or even stress and depression" (van Gelder et al., 2006, p. 213). This has not been shown in the LBC1921 as marital status did not account for variance in later life ability in the multivariate analysis. And yet, the relationship between marriage and cognitive decline in later life is potentially confounded by assortative mating – the tendency of spouses or partners to be alike on certain characteristics. It has long been known that married couples are similar with respect to intelligence (Jones, 1929). As intelligence is predictive of survival, those of lower ability are at an increased risk greater cognitive decline *and* of being unmarried in later life (that is, their similarly low ability spouse has died). The link between marriage and decline would therefore be secondary to assortative mating by IQ and the IQ-survival effect.

7.5.2.3. Presence of supportive others

In the social support literature, it is often reported that single social network measures do not adequately index the level of any social support received and are therefore rarely related to health outcomes (Cohen et al., 1985) – the exception to this being the presence of a spouse. This one individual is often seen as being able to provide all the necessary emotional support required to predict better health outcomes. Across previous studies it has been consistently shown that married individuals have an increased chance of survival, with single men being at the greatest risk of mortality (House et al., 1988). However, some researchers have argued that there exists a certain, though not complete, substitutability of social contacts with only a serious lack of supportive individuals leading to a greater risk of death (House et al., 1982; Berkman et al., 1979). This suggests that the required emotional support for better health need not come from a spouse, but indeed the presence of a confidant (who may or may not be the spouse) could fulfill this role (Giles et al., 2005). In the LBC1921, the presence of a confidant between 60 and 75 years old was associated with better cognitive function in later life, independent of childhood ability, although the presence of this individual did not significantly account for variance in age-79 IQ in the multivariate analysis.

At age 80, the items used to assess social networks and support in the LBC1921 differed from those of the retrospective assessment, but in the Significant Others Scale, participants were able to record having a best friend. This individual might be analogous to a confidant. Although there were no associations between the presence of this individual and cognitive ability in the full sample, men who reported having a best friend at age 80 declined less from 79 to 83 years old. Importantly, the presence of this individual accounted for about 3% of the variance in later life cognitive change in the regression analysis in men, controlling for childhood ability. Having a best friend appears to be cognitively beneficial, possibly as a result of the level of support derived from this person. The importance of friends in protecting against cognitive decline was reported by Zunzunegui et al. (2003), although they found the effect in women rather than men. And yet, it is also possible that those who have a best friend who is still alive are of higher socioeconomic status or are healthier, or that individuals who have experienced a degree of cognitive decline are less able to maintain close social contacts as a result. The absence of a best friend might therefore be a consequence, rather than a cause, of later life cognitive decline. Although controlling for childhood ability reduces the chance of this alternative explanation, it is not possible to rule it out entirely with the data currently available.

Interestingly, the only other factor which predicted later life cognitive decline in men was the presence of practical support between 20 and 35 years old (there was no association in the full sample or separately for women). This item assessed the availability of someone able to offer assistance or practical support in day-to-day tasks, rather than naming a specific individual who might provide this support. Men who reported being able to call on this practical support in young adulthood showed greater cognitive decline from 79 to 83 years old (accounting for about 3% of the variance). The reason for this is unclear as it is predicted that greater support should be protective of cognitive ability, not deleterious. However, it is possible that the men requiring extra help in young adulthood would be those who were generally less healthy or less cognitively able, although there was no association between childhood ability and the presence of practical support. Some unmeasured confounder might be accounting for this association, as it is difficult to interpret given the hypothesised direction of the support-cognition relationship. As considered previously, the result could be a chance finding owing to type I error. This is a limitation throughout the current analysis with the LBC1921 due to the number of correlations conducted. With the retrospective nature of the assessment, response biases and misinterpretation of the items is a very real possibility.

7.5.2.4. Living situation in later life

Household composition in later life was positively related to age-79 IQ in the LBC1921, controlling for childhood ability; living with a greater number of people in later life was related to a more positive change in cognitive function across the lifespan. When this variable was recoded as living alone versus living with others at age 80, the effect remained. It could be suggested that no additional cognitive benefit is accrued from living with 2 or more individuals, but rather any protective effect is simply the result of the living with others rather than living alone dichotomy. Each extra person sharing the household may not provide additional social contact or support over and above the advantage of not being alone. This finding is in agreement with previous literature, whereby living alone was a risk factor for cognitive decline or dementia (Fratiglioni et al., 2000; van Gelder et al., 2006). Living alone might be a marker for a lack of cognitive stimulation from other individuals or a reduction in social support, leading to poorer mental health outcomes. It is also possible that a transition to being alone has led to adverse lifestyle changes or increased depression which are driving the association (van Gelder et al., 2006). Regardless of any hypothesised pathways, however, it is important to note that living alone versus with others did not enter the regression predicting age-79 IQ, nor was living situation related to later life cognitive change. Continued follow-up with the cohort will help to determine whether living situation is associated with further cognitive change in the LBC1921, or whether transitions from one situation to another are predictive of decline, as in van Gelder et al. (2006).

7.5.2.5. Children, friends and relatives

Assessing the number of children in the home and the number of close friends and relatives across the lifespan was an attempt to index contact with others and the size of an individual's social network at different points. Regarding the number of children, there were no consistent findings with respect to cognitive ageing. However, those reporting having a larger number of close friend/relatives during the 3 age periods performed more poorly at each cognitive assessment, and the number of close friends/relatives between 60 and 75 years old accounted for about 1% of the variance in age-79 IQ, controlling for childhood ability. (In men, although the associations with age-79 IQ held after adjustment for childhood ability, these factors did not account for variance in the multivariate analyses.) Might this association suggest that those of lower ability in childhood have more friends, and somehow this increased social network is detrimental to later cognition? An effect of the actual size of a person's social network is rarely reported as individual measures of networks (such as the number of friends) may be poor indicators of increased social integration; an increased number of ties might not be related to actually receiving more support (Cohen et al., 1985; Wills, 1991). [For example, Berkman et al. (1979) found no association between mortality and 3 individual items indexing social contact with friends and relatives (for example, "How many close friends do you have?"); however, when these were combined into a composite index, participants who reported more frequent contact with a larger number of friends and relatives at baseline were at a significantly reduced risk of dying.] Furthermore, no study suggested there might be an adverse effect. The negative relationship reported here might be a consequence of the assessment method. Questions about social networks are likely to be difficult to complete retrospectively as they refer to aspects of an individual's life which are, by their nature, less concrete than say, occupational characteristics. Reflecting on such factors will be more complex as a result, suggesting the retrospective items may be poor indicators of that which they were intended to assess. Indeed, individuals of lower ability may be more likely to misinterpret the questions, or misreport their number of close contacts. Both early and current cognitive ability appear to have confounded answering this item retrospectively.

A similar measure indexed contemporaneously at age 80 may not have suffered such limitations. In completing the Significant Others Scale, participants were asked to report the level of support received from 5 different individuals (for example their spouse, or a best friend). The number of significant others for which information was provided was taken as a basic indicator of the number of close, significant others in an individual's network. This was not associated to any of the cognitive ability measures. This accords with the previous literature reporting that the absolute size of a person's network is neither beneficial nor detrimental for health outcomes (Cohen et al., 1985). Although not comparable to the retrospective items, it might also suggest that such questions are best answered specifically about certain individuals (rather than asking the participant to count all 'close' significant others) and in reference to the current point in time.

7.5.3. Social support and cognition

7.5.3.1. Lifetime social support and satisfaction

The associations with markers of *social networks* were varied as has been discussed in relation to research examining health-related outcomes (Cohen et al., 1985). However, the perceived level of *social support* at various ages was also assessed in the LBC1921, which is less often assessed in cognitive ageing research (Seeman et al., 2001; Okabayashi et al., 2004). Those with higher ability in childhood reported receiving an increased level of social support across the lifespan. Increased support was also related to higher ability in later life, however, this relationship was attenuated to non-significance after adjusting for childhood ability. This suggests that the association between greater support received across the lifetime and later cognitive functioning is due to those who begin with higher ability receiving more social support. Similar results were obtained from the measures of satisfaction with the level of support received. Studies investigating social support and cognitive ageing have never controlled for ability measured many decades before the social support assessment and so it is not clear whether the link between social support and cognition would hold in these cases. It is very possible, however, that retrospectively assessed social support is not a valid indicator of the actual level of social support received (likewise for social support satisfaction) and may be seriously confounded by current ability or indeed, the current level of social support received and the adequacy of this. The retrospective assessment required participants to consider 3 distinct points in their past. Those who were less able or were experiencing greater cognitive change at the time of the retrospective assessment may have been unable to do this. Furthermore, as mentioned previously, the intangible nature of social support may make it complicated to report on, particularly over 15 year periods across a lifetime.

7.5.3.2. Social support in later life

The lack of associations between the level of, and satisfaction with, social support may not be entirely due to the retrospective nature of the assessment. The overall level and adequacy of social support assessed in later life was not associated with any of the cognitive measures. This is in accordance with Bassuk et al. (1999) who found no association between emotional support and 3, 6 and 12-year cognitive decline, however, Seeman et al. (2001) did report a beneficial effect of emotional support over a 7.5 year follow-up. Both studies focused on emotional support, whereas the LBC1921 completed items covering both emotional and practical support. The level of emotional support received might be adequately assessed by the presence of a significant close contact (such as a spouse or confidant) as discussed above. In men, however, a greater overall level of support received at age 80 was associated with higher cognitive ability at age 83, although there was no association between social support and later life cognitive change. It is difficult to interpret this as indicating a cognitive benefit of greater support due to a lack of other supporting evidence. As such, a positive effect of social support on cognitive ageing is not apparent.

7.5.4. Loneliness

Although not specifically assessing the structure of an individual's social network, or the actual level of social support received, the level of loneliness experienced by an individual may indicate both an inadequate network and a lack of support. In the LBC1921, increased feelings of loneliness at age 80 were related to poorer cognitive function in old age, controlling for childhood ability. That is, individuals who showed more negative cognitive change across the lifespan were lonelier in later life. If increased feelings of loneliness are a valid indicator of a reduced network of supportive others, then perhaps this single item adequately assesses the level of support an individual receives and the degree to which they are satisfied with this. Therefore it would not be feeling lonely *per se* which is cognitively disadvantageous, but rather it is the inherent lack of social support, contact or integration within a wider social network which is driving the effect. In women, the level of loneliness experienced at age 80 accounted for about 2% of the variance in age-79 IQ after childhood ability was controlled. Berkman (2000) suggested "being alone is what is risky, not living alone" (p. 1292). However, it is also possible that those who are experiencing cognitive decline are less able to appropriately gauge how lonely they are, or that they have chosen to remove themselves from social situations or have been left socially isolated due to this decline (Berkman, 2000). In this explanation, loneliness would be a consequence rather than cause of cognitive decline. Loneliness was not related to later life cognitive change, and it was only assessed at one point in time (when the participants were aged 80). This important point requires further investigation before it would be possible to determine which causal pathway takes precedence. Moreover, it is necessary to consider whether the detrimental effect of feeling lonely (if that is the causal direction) occurs later in life, or whether there is a cumulative effect across the lifespan. This latter issue would have implications for any suggested interventions (Berkman, 2000).

7.6. Potential mechanisms

It is challenging to discuss potential mechanisms because the factors accounting for variance in the final regression analyses were, perhaps, not all valid indicators of social networks or support. For example, in the full sample, increased age-79 IQ (adjusted for age-11 IQ) was predicted by living alone for longer in young adulthood and having fewer friends and relatives in late adulthood. The former association is likely to have been confounded by higher ability women delaying marriage or remaining unmarried, whereas the latter question may have been difficult to answer retrospectively, resulting in differences in the appropriate completion of this item across ability level. For women [there were no social network or support factors accounting for variance in age-79 IQ in men], loneliness was the only factor accounting for additional variance in age-79 IQ. If the causal pathway is from increased loneliness to poorer cognitive function, then it may be that loneliness is an indicator of poor social integration and/or a lack of social support. This in turn might affect cognition due to a lack of cognitive stimulation and challenge from other individuals or a reduction in the complexity of an individual's social environment (Berkman, 2000). Alternatively, "social circumstances such as social isolation may have pervasive health consequences…social factors may influence host resistance and affect vulnerability to disease in general" (Berkman et al., 1979, p. 203).

Due to the lack of associations between cognitive change in old age and the social network and support characteristics, regression analyses could only be conducted separately by gender. In women, living alone for longer in young adulthood predicted less cognitive decline. However, as mentioned above, this is likely to be confounded by the relationship between marital status and cognitive ability in women. For men, the presence of practical support in young adulthood and the absence of a best friend at age 80 contributed to decline in cognition from 79 to 83 years old. The effect of the former factor is problematical to explain in the context of increased support enhancing cognition; it is likely responses to this item have been confounded by current ability level or decline. The beneficial effect of having a best friend, however, can be explained in similar terms to the loneliness findings above. Having a close friend, a confidant, may provide both social support and cognitive stimulation that partly maintains cognitive vitality in later life. The physiological pathways by which such effect might act were discussed in Chapter 6.

7.7. Strengths and limitations

In the assessment of social network and support factors in the LBC1921, a number of issues were addressed. Firstly, the source of support was investigated as Okabayashi et al. (2004) suggested social networks may vary by those with or without a spouse, for example. Investigating the source of support is rarely attempted, and in the current thesis a reason for this is highlighted: splitting the sample by those with or without a particular supportive other often results in reduced numbers in specific groups (those participants with another sibling, for instance) with a resultant lack of power to detect any effect. The current assessment was also an attempt to rate social support factors across the lifespan. This raised a number of problems and might suggest that reporting about past levels of support is of limited validity. It may not be possible to recall with any degree of certainty the level of support received in distinct periods of time, in this case each covering a span of 15 years. The retrospective assessment may have been subject to recall biases, or those of higher ability being better able to complete the items. The contemporaneous assessment conducted at age 80 should have lessened these problems, however, this occurred after the cognitive assessment at age 79, making causal conclusions difficult. Furthermore, social network characteristics are often combined into summary indices which was not attempted in the current analysis. This might explain both the lack of associations or those in opposing directions to that which would be expected. As in the occupational analysis (Chapter 5), with so many associations conducted, type 1 errors may account for the significant correlations reported. Replication in another sample, or over an extended period of time, is necessary to determine whether the suggested relationships hold and are important, or are artefactual and spurious.

The analyses were considered on the whole sample, and also separately by gender in case there were differential effects of social networks and support in men and women. This suggested that none of the indices contributed to variance in age-79 IQ in men. It is possible that there are other measures of social networks or support not covered in the current assessment which might play a role in cognitive ageing research. There were no associations in the full sample between the social support network factors and later life cognitive change. The relatively short 4-year follow-up in old age may mean the cognitive decline observed is not of a sufficient magnitude for effects of social support to be noticeable. If the impact of social network and support characteristics is small, a longer follow-up might be required to detect this. A number of the issues discussed could be examined with a further wave of cognitive testing which would extend the follow-up time and perhaps the degree of decline observed. It might then be fruitful to concentrate on the predictive power of the social network and support factors assessed at age 80, and those retrospectively assessed for the oldest age period only (as these may have greater validity than those referring to earlier points in the lifespan).

In the current assessment, a primary aim was to separate measures of social networks and support from those of social engagement within the context of activity participation. This was a major confound in many of the studies discussed in the previous chapter. By keeping these domains separate it was hoped it would be easier to determine the source of any beneficial effect on cognitive ageing. The limited significant associations with specific indices of social networks and support reported currently might suggest that it is rather social engagement which is behind the previous findings. This point will be returned to in the subsequent 2 chapters.

7.8. Conclusions

Even with the limitations discussed, a number of interesting findings relating social support to cognitive benefits in old age have been reported. Those of greatest interest primarily concern reduced loneliness or the presence of a close friend as being protective of cognition. The pathways by which these effect might operate are varied, and "social networks may be protective because of the social engagement and satisfaction they provide" (Berkman, 2000, p. 1291). It is important that the associations reported currently are replicated in further samples, such that interventions might be suggested. These would have the goal of reducing loneliness and social integration in the most vulnerable elderly individuals by a variety of means, including befriending projects for example. Other interventions aimed at enhancing social interaction might, by their nature, include increasing activity participation that has a particular social component. As discussed, social activity participation was often a confounder of the previously reported associations between support and cognitive ability. Activity participation, in itself, is a major topic in cognitive ageing research, and is the subject of the next chapter.

Table 7.1 Correlations between lifetime social network characteristics and cognition across the lifespan

		Age-11 IQ	Age-79 IQ	Cognitive ability age 79	Cognitive ability age 83	Cognitive ability change (79-83)
Number of years lived alone	20-35	-.09	-.01	.04	.04	.09
	40-55	-.02	-.04	.01	.01	.04
	60-75	-.04	-.03	-.02	.03	.05
Lived with spouse/partner	20-35	-.02	-.06	-.09	-.12*	-.05
	40-55	-.03	-.04	-.09	-.10	-.04
	60-75	.01	-.00	-.02	-.08	-.05
Years lived with spouse/ partner	20-35	-.14*	-.24***	-.26***	-.24***	.00
	40-55	-.02	.02	.02	-.02	-.07
	60-75	.04	.08	.06	.05	-.01
Number of children at home	20-35	-.02	-.02	-.04	-.04	-.10
	40-55	-.00	.03	.00	.01	-.07
	60-75	-.01	-.07	-.07	-.00	.01
Number of 'close' friends/relatives	20-35	-.18**	-.23***	-.20***	-.17**	-.01
	40-55	-.22***	-.25***	-.20***	-.16**	-.03
	60-75	-.18**	-.22***	-.17**	-.18**	-.05
Presence of confidant	20-35	.01	-.02	-.03	-.05	.01
	40-55	.05	-.03	-.07	-.01	.07
	60-75	.04	-.07	-.08	-.04	.06
Presence of practical support	20-35	.02	.06	.05	.05	-.02
	40-55	.00	-.00	-.03	-.03	-.03
	60-75	.07	.05	-.03	-.00	.00
Adequacy of practical support	20-35	-.06	-.09	-.06	-.06	-.05
	40-55	-.10	-.07	-.09	-.07	.00
	60-75	-.16**	-.13*	-.11*	-.08	-.01

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Lived with spouse/partner, presence of confidant, presence of practical support and adequacy of practical support are dichotomous variables. N = 229-369.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 7.2 Correlations between lifetime social network characteristics and cognition across the lifespan by gender

		Age-11 IQ		Age-79 IQ		Cognitive ability age 79		Cognitive ability age 83		Cognitive ability change (79-83)	
		M	F	M	F	M	F	M	F	M	F
Number of years lived alone	20-35	-.07	-.11	.01	-.09	.05	-.00	.08	.01	.08	.18*
	40-55	-.03	-.03	-.05	-.02	-.10	.05	-.10	.04	-.02	.03
	60-75	-.06	-.05	-.02	.02	-.07	.05	-.05	.06	.06	-.01
Lived with spouse/partner	20-35	.02	-.04	.04	-.13	-.02	-.15*	-.04	-.17*	.01	-.07
	40-55	.09	-.07	.14	-.13	.05	-.18*	.04	-.16	-.01	-.03
	60-75	.15	-.04	.12	-.10	.10	-.11	.12	-.16*	.05	-.04
Years lived with spouse/ partner	20-35	-.09	-.19*	-.17	-.24**	-.18*	-.28***	-.19	-.29**	-.01	-.02
	40-55	.02	-.04	.08	-.04	.12	-.05	.12	-.10	.02	-.10
	60-75	-.12	.11	-.08	.08	.03	.01	-.03	.06	-.15	.11
Number of children at home	20-35	-.00	-.03	.01	-.02	.05	-.07	-.03	-.05	-.08	-.14
	40-55	.08	-.04	.15	-.06	.19*	-.11	.15	-.08	-.05	-.05
	60-75	-.01	-.02	.07	-.16*	.08	-.16*	.11	-.07	.08	-.00
Number of 'close' friends/relatives	20-35	-.13	-.22**	-.25**	-.22**	-.15	-.22**	-.13	-.20*	-.03	-.01
	40-55	-.17*	-.26***	-.26**	-.25***	-.15	-.22**	-.13	-.19*	-.08	.01
	60-75	-.04	-.27***	-.22**	-.23**	-.14	-.18**	-.12	-.22**	-.07	-.04
Presence of confidant	20-35	-.03	.07	-.01	.01	-.02	-.01	-.08	[a]	-.03	[a]
	40-55	.09	.02	.03	-.07	-.01	-.12	.04	-.05	.08	.06
	60-75	.03	.05	-.08	-.06	-.04	-.10	-.05	-.04	-.01	.11
Presence of practical support	20-35	-.07	.09	-.11	.14*	-.04	.09	-.09	.15	-.20*	.10
	40-55	-.15	.08	-.11	.03	-.11	-.01	-.04	-.03	-.04	.00
	60-75	.02	.10	-.03	.06	-.03	-.05	.07	-.04	.10	-.02
Adequacy of practical support	20-35	.01	-.10	-.05	-.09	-.06	-.04	-.00	-.08	.08	-.13
	40-55	-.06	-.13	.02	-.09	-.03	-.11	.03	-.11	.05	-.05
	60-75	-.23**	-.14*	-.10	-.13	-.13	-.08	-.10	-.08	.00	-.03

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Lived with spouse/partner, presence of confidant, presence of practical support and adequacy of practical support are dichotomous variables. [a] Cannot be computed because at least one of the variables is constant. M = male (N = 110-153), F = female (N = 109-216).

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 7.3 Correlations between lifetime level of social support, support satisfaction and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
Social Support 20-35	.11*	.05	.16*	.11*	.00	.18**	.04	-.00	.06	.04	-.01	.08	.03	-.06	.09
Social Support 40-55	.11	.08	.13	.10	.05	.11	.04	.00	.05	.04	.06	.03	-.01	.02	-.00
Social Support 60-75	.11*	.06	.15*	.12*	.04	.14*	.07	.03	.07	.04	.07	.01	-.03	.03	-.05
Lifetime Social Support	.13*	.08	.17*	.12*	.05	.16*	.06	.01	.07	.05	.05	.04	-.00	.01	.00
Social Support Satisfaction 20-35	.12*	.11	.13	.12*	.03	.14*	.05	-.02	.08	.03	-.03	.06	.04	-.04	.09
Social Support Satisfaction 40-55	.13*	.20*	.11	.11*	.10	.10	.05	.02	.05	.04	.06	.03	-.02	-.03	-.01
Social Support Satisfaction 60-75	.10	.14	.09	.09	.08	.08	.04	.05	.02	.03	.06	.01	-.01	-.04	.02
Lifetime Social Support Satisfaction	.13*	.17	.12	.11*	.08	.11	.05	.02	.05	.03	.03	.03	-.00	-.04	.03

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. T = total sample (N = 275-363), M = male (N = 126-149), F = female (N = 149-214).
*$p < .05$, **$p < .01$

Table 7.4 Correlations between age-80 social support factors, household composition, loneliness and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
No. of significant others age 80	-.05	-.05	-.03	.00	-.01	-.01	.03	.10	-.05	.02	.14	-.09	-.03	.04	-.06
Overall Support age 80	-.04	-.05	.01	.03	.00	.03	.04	.11	-.05	.04	.17*	-.07	.01	.06	.00
Overall Support Discrepancy age 80	.04	.13	-.04	.01	.02	.01	.05	.07	.03	-.00	.00	-.01	-.08	-.07	-.08
Average Support age 80	.05	-.01	.11	.08	.04	.10	.03	.08	-.01	.03	.13	-.03	.09	.07	.09
Average Support Discrepancy age 80	.07	.15*	-.01	.04	.01	.06	.11*	.11	.11	.04	-.01	.07	-.04	-.07	-.03
People in house age 11	-.19***	-.16*	-.22**	-.17***	-.20**	-.15**	-.10*	-.14	-.07	-.12*	-.14	-.10	-.09	.00	-.15
People in house age 80	.02	.05	.04	.10*	.08	.09	.08	.13	.03	.03	.15	-.05	-.05	.02	-.06
Alone at age 80	.01	.02	.05	.11*	.06	.11	.08	.10	.04	.02	.10	-.05	-.02	.02	-.02
Loneliness age 80	-.00	-.05	.08	.18**	.09	.22**	.14**	.12	.13*	.07	.07	.06	.00	.02	.01

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old.
Overall/Average Support Discrepancy = the difference between the ideal and actual level of overall/average support received. Alone at age 80 is a dichotomous variable. T = total sample (N = 293-469), M = male (N = 132-198), F = female (N = 161-270).
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 7.5 Correlations between individual significant others factors and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	Present	A	D	Present	A	D	Present	A	D	Present	A	D	Present	A	D
Spouse	.01	-.12	.10	.10*	-.03	.04	.06	.07	-.07	.03	.08	-.11	.01	.01	-.05
Closest sibling	-.02	.08	-.04	.01	.07	-.06	.07	.05	-.01	.06	.12	-.02	-.06	.09	-.09
Other sibling	-.11*	.13	-.12	-.06	.20*	-.20*	-.01	.08	-.08	-.03	.14	-.07	-.05	.13	-.11
Closest child	-.01	-.12*	.15**	-.01	-.10*	.13*	-.04	-.10*	.17**	-.05	-.08	.10	-.07	.07	.02
Best friend	-.00	.02	.12*	-.05	.06	.10*	-.04	.02	.07	.02	.05	-.00	.10	.06	-.07

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old.

Present = correlations with the presence or absence of the named significant other and the outcome (N = 293-466); A = correlations between the actual level of social support received from the named significant other and the outcome, excluding those participants without this significant other; D = correlations between the discrepancy in the ideal and actual level of support received from the named significant other and the outcome, excluding those participants without this significant other. Correlations between the actual level of social support or the discrepancy measure from each significant other and cognition were based on the following numbers: spouse N = 137-205, closest sibling. N = 162-256, other sibling N = 80-133, closest child N = 241-376 and best friend N = 241-384.

*$p < .05$, **$p < .01$

Table 7.6 Correlations between individual significant others factors and cognition across the lifespan in men

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	Present	A	D	Present	A	D	Present	A	D	Present	A	D	Present	A	D
Spouse	.04	-.15	.16	.04	-.11	.11	.05	-.03	.03	.06	-.05	.02	.03	-.00	-.02
Closest sibling	-.05	.06	.05	.01	.03	-.01	.08	.12	.00	.07	.28*	-.06	-.07	.04	-.04
Other sibling	-.13	.22	-.02	-.07	.27*	-.27*	.08	.18	-.19	.10	.11	-.17	-.01	.02	-.08
Closest child	.09	-.22**	.20*	.09	-.09	.05	.11	-.06	.17*	.11	.02	.01	-.02	.11	-.05
Best friend	-.04	-.04	.18*	-.09	-.02	.16	-.03	-.00	.06	.05	.03	-.03	.19*	.01	-.09

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old.
Present = correlations with the presence or absence of the named significant other and the outcome (N = 132-197); A = correlations between the actual level of social support received from the named significant other and the outcome, excluding those participants without this significant other; D = correlations between the discrepancy in the ideal and actual level of support received from the named significant other and the outcome, excluding those participants without this significant other. Correlations between the actual level of social support or the discrepancy measure from each significant other and cognition were based on the following numbers: spouse N = 94-139, closest sibling N = 69-108, other sibling N = 33-56, closest child N = 119-174 and best friend N = 106-157.
$*p < .05$, $**p < .01$

Table 7.7 Correlations between individual significant others factors and cognition across the lifespan in women

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	Present	A	D	Present	A	D	Present	A	D	Present	A	D	Present	A	D
Spouse	.07	-.01	-.08	.11	.09	-.08	.04	.19	-.19	-.00	.22	-.26	.05	.08	-.13
Closest sibling	-.00	.09	-.11	.01	.12	-.10	.07	.01	-.02	.05	-.00	.00	-.06	.11	-.12
Other sibling	-.09	.09	-.20	-.06	.12	-.15	-.08	-.02	-.00	-.12	.16	-.05	-.07	.20	-.13
Closest child	-.06	-.02	.08	-.08	-.11	.21**	-.13*	-.14*	.18*	-.15	-.18*	.21*	-.08	.03	.09
Best friend	.02	.07	.07	-.00	.11	.07	-.04	.04	.08	-.01	.07	.01	.02	.09	-.06

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old.

Present = correlations with the presence or absence of the named significant other and the outcome (N = 161-269); A = correlations between the actual level of social support received from the named significant other and the outcome, excluding those participants without this significant other; D = correlations between the discrepancy in the ideal and actual level of support received from the named significant other and the outcome, excluding those participants without this significant other. Correlations between the actual level of social support or the discrepancy measure from each significant other and cognition were based on the following numbers: spouse N = 43-66, closest sibling N = 93-148, other sibling N = 47-77, closest child N = 122-202 and best friend N = 135-227.

*$p < .05$, **$p < .01$

Table 7.8 Summary of regression analysis with social network/support factors predicting age-79 IQ

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.64***	.41	.42***
	Sex	-.12*		
2	Age-11 IQ	.62***	.43	.02**
	Sex	-.08		
	Years lived with spouse/partner 20-35	-.15**		
3	Age-11 IQ	.60***	.44	.01*
	Sex	-.08		
	Years lived with spouse/partner 20-35	-.14**		
	Number of close friends/relatives 60-75	-.10*		

*$p < .05$, **$p < .01$, ***$p < .001$

Table 7.9 Summary of regression analyses with social network/support factors predicting age-79 IQ in women

A: All women

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.68***	.47	.47***
2	Age-11 IQ	.68***	.49	.03**
	Loneliness age 80	.17*		

**p < .01, ***p < .001

B: Women listing a closest child in the Significant Other Scale

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.67***	.45	.45***
2	Age-11 IQ	.66***	.48	.04**
	Closest child support discrepancy	.19**		
3	Age-11 IQ	.65***	.49	.02*
	Closest child support discrepancy	.20**		
	Loneliness age 80	.13*		

Note. Closest child support discrepancy = the difference between the ideal and actual level of support received from the closest child.
*p < .05, **p < .01, ***p < .001

Table 7.10 Summary of regression analysis with social network/support factors predicting later life cognitive change in men

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.05	-.01	.00
2	Age-11 IQ	.04	.03	.05*
	Presence of practical support 20-35	-.21*		
3	Age-11 IQ	.06	.06	.04*
	Presence of practical support 20-35	-.23*		
	Best friend age 80	.19*		

Note. Presence of practical support 20-35 and best friend are dichotomous variables (the presence versus absence of practical support or best friend respectively).
*$p < .05$

Table 7.11 Summary of regression analysis with social network/support factors predicting later life cognitive change in women

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.27**	.07	.07**
2	Age-11 IQ	.29***	.10	.04*
	Number of years lived alone 20-35	.20*		

*$p < .05$, **$p < .01$, ***$p < .001$

Chapter 8: Activity participation and cognitive ageing

When discussing the assessment of social support networks for their potentially protective effect against cognitive decline (Chapters 6 and 7), it was alluded to that the measures often employed for this purpose were either supplemented by, or included indices of, involvement and participation in a variety of social activities (attending church or being a member of a social group, for example). If the assessment of social activity participation and social support networks are confounded in this way, it may be difficult to ascertain from where any beneficial effect on cognition is derived: is it a consequence of the social support received from other persons also participating in these activities; is it the actual active engagement on the part of the participating individual which confers the advantage; or, indeed, do both aspects, either directly or indirectly, independently influence successful cognitive ageing (by the same or alternative physiological pathways)? Moreover, leisure pursuits assessed within the social domain are but one aspect of an individual's potential activity participation. Areas of activity and engagement which may be similarly predictive of cognitive ageing include those of a physical (covering sports and exercise) and intellectual or mental nature (for example, reading or doing puzzles). The relationship between activity participation within these 3 specified domains and cognitive ageing will be discussed in the current chapter. Fratiglioni and colleagues (2004) noted:

> for all three lifestyle components (social, mental, and physical), a beneficial effect on cognition and a preventative effect against dementia are suggested (Fratiglioni et al., 2004, p. 343).

Whilst their systematic review is a valuable *précis* of the activity-cognitive ageing literature, the lack of detail concerning assessment procedures and effect sizes means that a more detailed description is required. In this chapter, the summary provided by Fratiglioni et al. (2004) will be presented, supplemented by information about selected studies from the review. Additional papers which have since been published will also be considered. Potential mechanisms to explain the association between activity participation (in the social, physical and intellectual domains) and cognitive ageing will then be introduced.

8.1. An active and socially integrated lifestyle

It has long been proposed that maintaining an active and engaged lifestyle will have a noticeable, positive impact upon later cognitive functioning. Indeed:

> the most interesting issue raised by the NCEHP [National Institutes of Health Cognitive and Emotional Health Project] report is the consistent signal suggesting the protective importance of social engagement, and activity, especially physical activity, to the maintenance of cognitive...health in late life (Lyketsos, 2006, p. 87).

Investigating this central premise has become a keystone in cognitive ageing research, with numerous research teams attempting to establish unequivocally whether or not increased activity and engagement is protective of cognitive ability in late adulthood. This determined focus is based on the principle that activity participation is potentially modifiable (Anstey & Christensen, 2000). If exercise promotes cognitive health, this finding could be transformed into interventions for the increasingly elderly population.

8.1.1. Environmental complexity

Schooler's (1984) environmental complexity hypothesis states that more complex environments (defined partly in the current context by increased participation in a number of activities) lead to a greater degree and variety of stimulation, as a result of the many and varied leisure pursuits followed, in which an increased level of more involved decision-making is required. It would follow that individuals

> who engage in activities that make significant demands on their cognitive skills will show greater maintenance or improvement in their abilities...different patterns of participation in everyday activities may be associated with different trajectories of cognitive change in later life (Hultsch, Hertzog, Small, & Dixon, 1999, p. 247).

Although this hypothesis may be more appropriate for, and particularly relevant to, activities of a specifically cognitive nature, it is possible that any activity might contribute to increased environmental complexity and involve some form of mental stimulation (for example, in the planning stages or when carrying out). Of course, it is likely that there exist multiple pathways which may not necessarily confer advantages via environmental complexity, including benefits derived from improved social support networks or physical fitness (for specifically social and physical activities respectively). Such mechanisms are not mutually exclusive.

8.1.2. Reviewing the field

Fratiglioni et al. (2004) reviewed 15 longitudinal studies investigating the effects of lifestyle factors on normal cognitive ageing. [Cross-sectional studies were not reviewed. Nevertheless, such studies have in general suggested that increased activity participation – whether in the social, intellectual or physical domain – is related to better cognitive performance (Hultsch et al., 1999). In the current chapter, analyses arising from cross-sectional studies will only be discussed on occasions when their methodology merits specific mention or if the findings have potential applicability to the LBC1921 Study.]. The 15 studies were grouped according to whether they assessed social networks, physical activity or non-physical activity (although a number of studies assessed activities across more than one domain, and were therefore included in each appropriate grouping).

8.1.3. Social networks

Fratiglioni and colleagues (2004) classified 7 studies under the *social network* heading (listed in Table 6.1; see also Chapter 6); however, on looking at the descriptions of these, 6 ostensibly examine social activity participation either in addition to, or apparently instead of, social support networks (Fratiglioni et al., 2004). [Note that the remaining study (Seeman et al., 2001) was purely concerned with emotional support – discussed in Chapter 6 – and did not assess social activity.] Half of the identified studies provided evidence in favour of a link between cognitive decline and decreased social activity participation or social disengagement: two of these studies reported an association between reduced frequency of participation in social activities and cognitive decline, and displayed this relationship where social activities were included in a composite social engagement index (Bassuk et al., 1999;

Zunzunegui et al., 2003: to illustrate, the latter study will be described below including an indication of the effect size). A further study reported an association between improved functioning and increased social activity (Menec, 2003). Briefly, in this study, 'function' was a dichotomous variable which comprised both mental (presence/absence of cognitive impairment assessed by 10 questions) and physical aspects (observer perceived physical difficulties, activities of daily living and instrumental activities of daily living). Increased overall activity at baseline – when the cohort were aged 67-95 years old – predicted better function 6 years later (OR = 0.93, $p < .05$). When the activities were analysed separately, participation in 2 specific social activities (church-related activities and mass activities, such as bingo or attending a community club) was associated with better function (OR = .71 and .59 respectively, $p < .01$). Unfortunately, due to the composite nature of the function measure, which was "more heavily weighted toward physical than cognitive function" (Menec, 2003, p. 78), it is not clear how important these social activities might be to cognitive vitality over a 6-year period in later life. The remaining 2 studies included in the review revealed no relationship between social activity and cognitive function.

Fratiglioni and colleagues (2004) therefore suggested that there exists evidence for a beneficial effect of improved social *networks* on cognitive function (Fratiglioni et al., 2004). Their conclusion, however, highlights the fact that the boundaries between social activity and social support networks are often blurred by the nature of assessing them, with researchers investigating social support often including basic measures of social activity participation in their indices. Nevertheless, it is possible to keep the assessment of these domains distinct, and furthermore, such a distinction is advantageous as it may assist in identifying the origin of any favourable effect on cognition. Attempts have been made to index social networks and engagement separately. To consider this in more detail, 2 studies will be highlighted.

8.1.3.1. Social activity versus networks or support

Zunzunegui et al. (2003) and Barnes et al. (2004) both used distinct measures of these constructs. Social engagement or integration was assessed by participation in 3 or 4 activities respectively, with examples of these being religious attendance, group or activity participation, and a part-time or full-time job. The social network assessment generally consisted of an index of contact with relatives and friends and cognition was assessed by a short test battery. From Zunzunegui et al. (2003), cognitive ability (controlled for a baseline level measured 4 years previously) was related to their social integration index, with a regression coefficient of 0.87. That is, increased social integration (group membership or attending religious services, for example) predicted a higher level of cognitive function assessed 4 years later (independently of baseline cognition). The effect of social integration on ability was greater than the effects of the indices of monthly contact with relatives and engagement with friends, which are more closely related to standard measures of social networks and support than activity. The regression coefficients of these factors in the same analysis were both less than 0.2, which suggests they account for a smaller proportion of the variance in later ability than social integration (Zunzunegui et al., 2003). From this analysis, social activities appear to be more beneficial to cognition than social interaction, although, in this study at least, both factors produced independent effects on cognitive change. By separately assessing and analysing these constructs, Zunzunegui and coworkers (2003) were able to investigate the effect of social activity on ability, uncontaminated by the simultaneous measurement of social support in the same index. Whilst this distinction in assessment is useful to ascertain independent effects, it does not necessarily indicate that discrete underlying constructs exist.

In the second highlighted study (Barnes et al., 2004), social networks and engagement were positively related to baseline cognitive function (at around 74 years old). Importantly for the current discussion, both also predicted reduced cognitive decline over the subsequent 5 years. Comparing participants in the 10^{th} and 90^{th} percentile on the social network and engagement measures, cognitive decline was reduced by 39% and 91% for those with increased social networks and engagement respectively (Barnes et al., 2004). Are these values indicative of increased social activity being more important for maintaining cognitive vitality in old age compared with better social networks? Possibly; however, unlike the Zunzunegui et al. (2003) study, these indices were not entered simultaneously into the same analysis. As such, it is not possible to make firm assertions. Further research directed toward the separate assessment of the social network and activity constructs followed by their simultaneous analysis in predicting cognitive change would be advantageous. This type of analysis may allow the subject to be examined more clearly, yet it is also possible that a different approach is needed, particularly one which concerns the potentially shared conceptual basis of both social support networks and activity.

8.1.3.2. Pathways from social activity to cognition

If the continued investigation of social activity and cognitive ageing concurs with the conclusions set forth in the Fratiglioni et al. (2004) review – that increased activity in this domain reduces later life cognitive decline – then it is necessary to consider the pathways by which this effect could operate. A beneficial effect could operate via a number of mechanisms. Higher levels of social activity could alter the course of cognitive ageing as a consequence of the increased levels of social support received from an individual's subsequently more extensive social networks (Zunzunegui et al., 2003); the protective pathways from social support to cognition were discussed in Chapter 6. Alternatively, or indeed additionally, increased social activity throughout life and in old age may increase an individual's level of mental stimulation and engagement with their environment, suggesting that it is the specifically cognitive aspect of the activities which accounts for their protective effect (Barnes et al., 2004; Zunzunegui et al., 2003); social activities "may be markers of cognitive activity that take place in a social context, rather than an individual context" (Barnes et al., 2004, p. 2325). Thus, any observed cognitive benefit of social activity may be a consequence of the derived social support, the associated mental engagement, both of these pathways, or, of course, from some further factor which also influences social activity participation and cognitive ageing.

8.1.4. Physical activity

Eight of the studies identified by Fratiglioni et al. (2004) examined the link between physical activity and cognition; all but one reported an association between increased physical activity participation and better cognitive function or less cognitive decline (Table 8.1). Contrast this with an earlier review investigating various predictors of cognitive change (including education and health) which suggested extant findings with respect to activity were contradictory (Anstey et al., 2000). This earlier review, however, identified only 4 studies which assessed activity and cognitive change, 3 of which subsequently appeared in the later Fratiglioni et al. (2004) review, whilst the fourth was based on a subsample drawn from one of the other listed studies. As such, the later review may be seen as more comprehensive, although the authors of this observed that the range of assessment procedures made detailed cross-study comparisons difficult. For example, 3 studies rated physical participation by the intensity of the activity, whilst in another, participants were simply grouped as physically active or inactive (Fratiglioni et al., 2004). This variation across studies is perhaps unavoidable as different researchers may wish to investigate diverse aspects of physical activity participation. Nevertheless, the authors concluded that increased exercise or daily physical activity has a beneficial effect for later cognitive outcomes. Anstey and Christensen (2000) cautioned, saying "that the effect of physical activity on cognitive change is very small and only detected in large samples" (p. 170), a caveat they admitted was based on the then rather limited evidence.

8.1.4.1. Women and walking

As mentioned, the lack of methodological consistency makes interpretation of the results difficult. Furthermore, if one is to consider potential interventions based on such findings, it would be necessary to determine the form, duration and importantly the intensity of exercise which would provide the greatest benefit to the elderly population with respect to cognitive function. As walking is the most common exercise taken by older individuals (World Health Organization, 1998), a beneficial effect of this simple, low-cost workout would potentially be among the most straightforward to influence. One of the studies covered by the review did investigate walking behaviour and cognitive function, which reported that in a sample of women, walking behaviour was related to 8-year cognitive change (Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001). This was based on a sample of 9800 white women who were assessed at a baseline examination between 1986 and 1988. Cognitive function was assessed (at baseline, and then after an interval of 6 and 8 years) using a modified version of the MMSE, with cognitive decline being defined as a decrease of 3 or more points at follow-up. Nine hundred and fifty participants scoring below 23 (out of 26) at baseline were excluded. In addition, exclusion of participants lost to follow-up or those with physical impairments at baseline resulted in a final sample of almost 6000 aged around 70 years old. The participants were asked to report their average daily physical activity as the number of blocks walked and flights of stairs climbed. Additionally, an index of 33 physical activities was completed for weekly participation in the preceding year, the data from which was converted into energy expended (kilocalories) per week (Yaffe et al., 2001).

Over an average follow-up period of 7.5 years, 20% of the sample were categorised as having declined cognitively. However, women in the highest quartile of number of blocks walked were 37% less likely to show decline compared to those in the lowest quartile (OR = 0.63, 0.53-0.76). Similarly, those in the highest quartile of total energy expenditure were at a 35% reduced risk of cognitive decline (Yaffe et al., 2001). Adjusting for potential confounders of this association (age, education, health, depression, smoking status, history of disease, etc.) did not greatly alter the results (for blocks walked the OR was 0.66, 0.54-0.82, and for total energy expenditure the OR was 0.74, 0.60-0.90). The authors concluded that "women with higher levels of physical activity remained at lower risk for cognitive decline" (Yaffe et al., 2001, p. 1705). Similar results were reported whether cognitive change was classified as decline versus no decline, as above, or analysed as a percentage change continuous variable. Yaffe et al. (2001) suggested their findings were consistent with a protective effect on cognition from both moderate and strenuous physical activity.

Weuve and colleagues (2004) similarly focused on physical activity participation in a sample of almost 20,000 women aged over 70 years old. Data were available for participation in a range of physical activities assessed as part of a larger survey before the cognitive aspect of the study was introduced. This physical information was converted to average metabolic equivalent values, taken from about 5 self-reports over a period of 8 to 15 years. Six tests of mental ability were delivered via a telephone interview, and cognitive change data was available over 1.8 years in 16,466 participants. When activity was divided into quintiles, the most active groups performed significantly better on the cognitive measures (with OR ranging from 0.28 to 0.95); "although the absolute differences in score may appear small, the mean differences we found across quintiles of physical activity were equivalent to the mean differences we observed for women 2 to 3 years apart in age" (Weuve et al., 2004, p. 1457). When walking behaviour was analysed separately in those women who had not participated in vigorous activity, similar trends were discovered between increased energy expenditure and better cognitive function. As did Yaffe et al. (2001) before them, the authors highlighted the importance of this finding, suggesting that physical activity need not be vigorous to be cognitively beneficial; "walking the equivalent of at least 1.5 hours per week at a 21-30 min/mile pace was also associated with better cognitive performance" (p. 1459).

Although both studies boast impressive sample sizes, they also display a number of weaknesses. The cognitive assessments in the Weuve et al. (2004) study were conducted over the telephone and the follow-up period was less than 2 years. However, their physical activity data was collected on numerous occasions before the cognitive waves began, which may allow greater confidence in any causal theorising. Yaffe et al. (2001) may have had a follow-up period of 6 to 8 years, but relied solely on a modified MMSE – a single, general test of cognition. Furthermore, both studies were based on wholly female cohorts which may limit the generalisability of the findings. Patterns of activity may differ across men and women, or any physiological effects may be different. Nevertheless, a finding that a simple and cheap activity such as walking can influence the course of cognitive decline would be ultimately important; further work is therefore required to determine the level at which physical activity leads to cognitive benefits in more diverse samples, particularly those including elderly men.

8.1.4.2. Physical activity in men

A study of almost 300 men from Finland, Italy and the Netherlands may assist in this (van Gelder et al., 2004). Baseline MMSE performance (assessed around age 74) and the 10-year change in MMSE were not related to the duration of physical activity measured at baseline. However, *intensity* of this baseline physical activity was related to both the initial level of, and change in, MMSE scores. Participation in activities of at least medium-low intensity led to a significant reduction in cognitive decline. Furthermore, changes in activity participation over the 10-year follow-up were associated with cognitive change, such that reduced activity predicted cognitive decline, although the causal direction of this latter finding cannot be attributed (van Gelder et al., 2004).

8.1.4.3. Underlying mechanisms

van Gelder et al. (2004) suggested that if there does exist a pathway from increased physical activity to reduced cognitive decline in later life as suggested above, the latent mechanism may not be entirely understood, "although it may be related to a healthy lifestyle, a reduction in cardiovascular risk factors, or a direct effect on neurons" (Yaffe et al., 2001, p. 1708). Similar pathways were proposed by the NIH review. Increased physical activity may reduce the prevalence of vascular risk factors (such as hypertension) and decrease the risk of vascular disease (including coronary heart disease). As vascular disease has been linked to cognitive decline and Alzheimer's, increased physical activity may therefore have a beneficial effect on later life cognitive outcomes via a reduction in vascular risk factors and disease (Hendrie et al., 2006).

There may also be a direct effect of physical activity on brain physiology (van Gelder et al., 2004; Yaffe et al., 2001; Fratiglioni et al., 2004; Hendrie et al., 2006; Dishman et al., 2006): "voluntary physical activity…can favorably influence brain plasticity by facilitating neurogenerative, neuroadaptive, and neuroprotective processes" (Dishman et al., 2006, p.345). Exercise can lead to development and adaptation in the central nervous system, which has implications for cognitive ageing and suggests "neurogenesis could provide another pathway by which physical activity could protect against cognitive decline and dementia" (Hendrie et al., 2006, p. 24).

Physical activity may therefore lead to improved cognitive function via better health and a lower burden of disease, with subsequent consequences for healthier brain function, or act as a marker for a generally healthy lifestyle with the associated reduction in illness and infirmity, or there may be a direct effect on the brain. These are amongst the most commonly cited pathways linking increased sport and exercise participation to reduced cognitive decline. It is also possible that increased social support or stimulation derived from greater participation in physical activities underlies the effect; the potential explanatory pathways for this route have been discussed previously (Chapter 6). Finally, it may be the cognitive engagement associated with physical activity participation which explains the beneficial outcome. Combinations of these pathways are possible as they are not mutually exclusive.

8.1.5. Mental activity

Finally in the Fratiglioni et al. (2004) review, 6 studies which examined the link between cognitive outcomes and involvement in "non-physical leisure activities" were summarised. [The review actually records 7 studies under this heading, however, one study and a 5-year extension of it were both counted in the total number.] The assessment of non-physical leisure activities generally encompasses pursuits thought to stimulate an individual cognitively, specifically requiring mental, as opposed to social or physical, engagement. Remaining mentally engaged is often seen as the most important activity with respect to the preservation of intellectual ability into old age, frequently expressed as part of the 'use it or lose it' hypothesis (Kramer et al., 2004). In general, increased participation in intellectual or mental activities was related to the maintenance of cognitive function, or reduced cognitive decline; only one study failed to report such an association (the studies are listed in Table 8.2).

8.1.6. Active lifestyle = preserved mind?

8.1.6.1. Variations in cognitive assessment

Within the relatively small number of studies reviewed by Fratiglioni and colleagues (2004), there was marked variation in the methods employed to assess cognitive function, ranging from single measures of global cognitive function (often assessed by a short scale) to extensive test batteries, comprising assessments across a number of cognitive domains. Any discrepancies in the results reported may be partly attributable to the composition of the cognitive test batteries, with individual measures varying greatly in their sensitivity and reliability. Anstey and Christensen (2000) suggest that cognitive measures with pronounced floor – and likewise, ceiling – effects will be ineffective as markers of cognitive decline. A larger test battery would therefore be preferable in cognitive ageing studies as a limited, single test may be ineffective, and insufficient to detect change, particularly given the differential rate of decline across abilities, time and individuals. A failure to sample across a range of ability domains may mean that decline is undetected not because it has not has occurred, but rather because the measures likely to detect change with increasing age have been omitted from the test battery. If the changes in intellectual ability as a result of cognitive ageing are imprecisely indexed, then consequently, *predicting* such changes becomes increasingly difficult and discrepant findings may be reported (Anstey et al., 2000; Fratiglioni et al., 2004). Moreover, 6 of the 15 studies identified in the review by Fratiglioni and coworkers (2004) examined the association between activities and cognitive decline, whilst the majority (9 studies) dealt with the level of cognitive function a number of years after the baseline assessment.

One area of widespread commonality, however, was with the period between the initial screening and the follow-up examination; for most of the studies, this was about 6 to 7 years, although one study did have a follow-up of under 3 years whilst another covered a span of over 40 (Fratiglioni et al., 2004). Just as a larger cognitive test battery is preferable for the detection of cognitive change, so correspondingly a longer period before repeat cognitive testing is advantageous as it is likely that cognitive changes will be more evident; the length of this follow-up period may be a crucial factor in the effectiveness of assessing rates of cognitive ageing. To understand the centrality of this, consider that the age range in cross-sectional studies is on average about 25 years, whilst longitudinal follow-ups can cover as few as 2 years. Assuming that:

> age changes and age differences are of a similar size and the relationship between cognitive change and age is linear, then the expected effect sizes in longitudinal studies are roughly a proportion of the follow-up interval to the age range in a cross-sectional study. For example, if age explains 30% of the variance in a cross-sectional study with an age range of 30 years, then this would translate to age changes of 1% per year in a longitudinal study (Anstey et al., 2000, p. 164).

Thus a study with a reduced test-retest interval will be in a weaker position to detect cognitive change. As a direct consequence, such a study will also suffer from a diminished capacity to reveal any effect of activity participation on cognitive ageing. A longer follow-up alone may not entirely ameliorate this problem; with increased time between test sessions, sample attrition is potentially greater (Anstey et al., 2000).

8.1.6.2. Assessing activity participation

In assessing activity participation, the most common method of enquiry is self-report; for example, participants are asked to record their frequency of participation in specific activities or types of activity. As noted by Fratiglioni et al. (2004), this activity assessment, in a similar fashion to the measurement of cognitive ability, can differ substantially across studies. Results are therefore not always comparable. Whereas some studies count the number of different activities an individual participates in, others may seek estimates of the actual amount of time spent on activity participation (within a specified timeframe). Consequently, in the review by Fratiglioni et al. (2004) "generalisations [were] made about broad categories [of activity]" (p. 345), as effects on cognitive ability and change attributable to particular activities were not identifiable.

8.2. Beyond Fratiglioni et al. (2004)

Due to the importance attached to intellectual activity for maintaining cognitive vitality, a more detailed description than that provided by Fratiglioni et al. (2004) follows. Activity assessments carried out in 2 major longitudinal studies will be highlighted, which include activities from the cognitive, as well as social and physical domains. This account may begin to specify mental stimulation as an overriding protective factor, with respect to activity participation and cognitive ageing.

8.2.1. The Seattle Longitudinal Study

Although the Seattle Longitudinal Study (SLS: Schaie, 2005a) is a major longitudinal enquiry into the determinants of cognitive ageing, including lifestyle characteristics, it was not included in the Fratiglioni et al. (2004) review. The Life Content Inventory (LCI) has been used to evaluate the micro-environment of the SLS participants which includes an assessment of their involvement in a variety of activities. Initially, the LCI was delivered via structured interviews to 140 SLS participants who had completed the first 3 study cycles, aged between 40 and 70 years old at the time of the interview (after the 3rd wave of the study). Parts of the LCI were retrospective, so that lifestyle was assessed not only concurrently, but also for the period around the second wave of cognitive testing (11 years before the LCI interview). An initial analysis of the LCI identified 8 clusters: homemaker activities, level of social status, subjective dissatisfaction with life status, disengagement, semi-engagement, noisy environment, dimension of family solidarity, and maintenance of acculturation (Gribbin, Schaie, & Parham, 1980). Specific clusters are of particular interest to the current discussion, given that they incorporate aspects of activity participation.

Unfortunately, however, due to the method of analysis employed, it is not possible to isolate a specific effect of an active lifestyle on cognitive ageing. For example, Disengagement deals with aspects of activity (or the lack thereof) such as "high number of passive activities" and "few past and present hours spent reading", but it also considers other, non-activity participant characteristics including "relatively more advanced age". The association reported between Disengagement and poorer cognitive function could be the result of a lack of activity, or perhaps it was in fact simply a direct consequence of increased age. Similarly, the items assessed retrospectively were not separated from contemporaneous items in the analysis. Determining whether there exist critical periods for activity participation (linked with the stability of lifetime activity patterns) with respect to cognitive ageing is an important area of research. Furthermore, the LCI assessment occurred after the measurement of cognitive function, and so it would be more correctly stated that an individual's mental ability predicts the level of certain clusters.

Since the aforementioned analyses, the LCI was revised and converted to a self-report questionnaire, administered in this format from 1977 onwards; 1376 participants completed the LCI at this wave, 779 of whom also completed it in 1984. Rather than analysing all the LCI items together as before, the SLS researchers chose to separately factor analyse the 30 activities included, which led to 17 being categorised as follows (with an example of the type of activity defining each factor): Fitness Activities (physical fitness), Educational Activities (self-improvement), Social Activities (visiting others), Communicative Activities (daydreaming and reminiscing), Solitary Activities (solitary games or hobbies) and Household Activities (cooking: Schaie, 2005a). As the details of this analysis in the latest update of the Seattle Longitudinal Study (Schaie, 2005a) have been incorrectly reported (Schaie, 2005b), it is necessary to examine previous editions (Schaie, 1996) to ascertain the correct factor loadings. [In Schaie (2005a), 'participant in sports' has been listed as loading onto the Educational Activity factor, rather than Fitness; likewise, 'handicrafts' loads onto Fitness rather than Solitary, and 'discussion and talking' loads onto Solitary rather than Communication.] From an initial list of 30 activities, it is unfortunate that only 17 are used to describe these 6 factors (most of which are therefore described by only 2 or 3 items each). As the results are summarised (Schaie, 1996; Schaie, 2005a) from an unpublished doctoral dissertation, it is not clear what items have failed to meet the criteria for inclusion, or what those criteria might be. It does not appear to be a simple statistical cut-off based on the magnitude of factor loadings, as 4 items load below .30 (the lowest loading being .194), often used as the minimum item loading needed to define a factor. No indication of the internal consistencies of the scored factors is given; with few items describing each, it is possible, though indeed not certain, these may fall below generally accepted levels.

Bearing in mind these caveats, the greatest associations between activity and cognitive ability were seen with Educational and Communication Activities (with associations ranging from .19 to .37). These factors are defined by what might be considered more intellectually demanding pursuits, including "writing correspondence" or "cultural activities" for example, as opposed to items of a more physical or social nature. Whilst this might indicate that mental activity is particularly protective of cognitive function, of course, it is also possible that more able individuals simply initiate participation in these more intellectual interests. The cross-sectional nature of this reported SLS analysis does not favour one causal explanation over another.

The 6 activity factors were also included in a further factor analysis with the other LCI items, producing a single Leisure factor (again, no measure of internal consistency was recorded). One of the other factors produced in this analysis was labelled Intellectual Environment and was defined by 4 items: books in home, art objects in home, magazines read and educational courses taken (Schaie, 2005a). These items essentially define a mental engagement factor although it is not clear why such activities were not included in the preceding analyses of the leisure activity items. In the final cluster analysis (conducted alongside the other LCI factors produced, including Work Characteristics and Social Status, for example), two participant clusters were identified as generally performing significantly higher on particular cognitive abilities. Both clusters were defined in part by increased Intellectual Environment scores. In the 3 clusters performing poorly on the cognitive tests, Intellectual Environment scores were generally lower (Schaie, 2005a).

Again, this latter analysis relates lifestyle and mental ability factors both assessed contemporaneously; indices of cognitive change are not used. The Seattle Longitudinal Study would be ideally suited to analyse longitudinal changes in intellectual function as predicted by activity participation. This dataset has not yet been reported, although the description highlights many of the problems encountered in analysing activity participation data, especially when this is collected after the cognitive assessments have occurred (Schaie, 2005a). Consequently, any conclusions about activity participation and cognitive ageing arising from the SLS are based on the earlier LCI findings, with a substantially reduced sample size compared to that which is presently available. Schaie (2005a) summarised those earlier findings as follows:

> risk of cognitive decline is lower for persons with substantial involvement in activities typically available in complex and intellectually stimulating environments. Such activities include extensive reading, travel, attendance at cultural events, pursuit of continuing education activities, and participation in clubs and professional associations (Schaie, 2005a, p. 421).

Whilst it is true this increased engagement characterised the most successfully ageing individuals, such a forthright conclusion is perhaps premature; for example, indicators of socioeconomic status also define these participants, thus confounding the associations. *Independent* effects of increased activity participation have not been reported.

8.2.2. The Victoria Longitudinal Study

The belief that an engaged lifestyle may protect against cognitive decline in later life has perhaps been more effectively scrutinised in the Victoria Longitudinal Study (VLS), another major study of ageing. If "different patterns of participation in everyday activities [are] associated with different trajectories of cognitive change in later life", then a thorough consideration of such engagement is both warranted and necessary (Hultsch et al., 1999). The VLS follows a similar methodology and procedure to the SLS in that a cohort is recruited and then examined at regular 3-year intervals, with new participant recruitment occurring every 6 years. The results from the first 3 waves of testing from the initial cohort are currently presented; this originally numbered 487 individuals aged 55-86 years old, falling to 335 at the first follow-up and 250 at the second. At each wave, participants were given 9 tests of cognitive function, covering memory, verbal ability and processing speed.

In order to assess their "level of engagement with the environment" (p. 248), participants completed an activity lifestyle questionnaire, recording their frequency of participation in 70 activities over the preceding year using a 9-point scale (from never to daily). Sixty-four activities were then classified into the following groupings (with examples of the activities in brackets): physical (jogging), self-maintenance (preparing a meal), social (visiting friends), hobbies and home maintenance (playing musical instrument), passive information processing (listening to the radio) and novel information processing (learning a language). It is important to note that unlike the SLS, these groupings do not appear to be based on a data reduction analysis of the questionnaire responses, but rather the classifications of the research team, and so may not actually reflect latent activity patterns or dimensions (although a previous analysis also identified 6 factors from 66 of the 70 items: Hultsch, Hammer, & Small, 1993). Nevertheless, the VLS assessment is possibly a broader representation due to the inclusion of almost 4 times as many activities defining each category. In general, those participants defined as young-old (aged 55-70) were more involved in terms of physical, self-maintenance, hobbies and novel information processing activities compared to the old-old (71-86). These cross-sectional trends were replicated longitudinally, with declines apparent over a 6-year period in the same activity domains (for example, the mean novel information processing score decreased from 71.96 (16.11) at time 1 to 68.67 (16.10) at time 3; $F(1, 232) = 21.35$, $p < .001$: Hultsch et al., 1999). Neither self-maintenance nor passive information processing activities had strong associations with the other activity domains or the cognitive measures, and so were excluded from further analyses. An Active Lifestyle factor was defined by the remaining activity categories (the physical, social and hobbies groupings), whilst novel information processing remained as a separate latent variable. This latter variable showed the largest cross-sectional association with the 9 cognitive tests (ranging from .26 to -.45). Might it be that activities requiring novel information processing, such as playing bridge or learning a language, are therefore the most important form of activity protecting against cognitive decline? In the final longitudinal analyses reported, Hultsch and co-workers (1999) sought the answer.

Two hundred and fourteen participants had full cognitive and activity data available. The results revealed that "there were relatively few significant relationships of cognitive change to either initial status or to latent change in...activity" (Hultsch et al., 1999, p. 256). In the subsequent modelling analysis, no significant pathways were retained between Activity Lifestyle and any of the cognitive variables. However, Novel Information Processing and the 6-year change in this both maintained significant paths to working memory (.21 and .37 respectively). The researchers also specified a further model which included a general cognitive change factor; cognitive decline was directly linked to a change in novel information processing activities. This work suggests that those participating in intellectually engaging activities, and who continue to do so across time, are less likely to show cognitive decline. And yet, even when participants are followed longitudinally, as is the case with the VLS, the nature of causation remains a prime concern. The "cross-sectional relationships may indicate simply that brighter and more educationally advantaged people are more likely to participate in intellectually demanding pursuits" (Hultsch et al., 1999, p. 260). Cognition and activity participation were measured in midlife, or indeed later; perhaps lifetime levels and changes in activity are of greater importance to mental vitality in old age.

8.2.3. Engaging the mind

Mentally stimulating activities might exert a direct influence on the brain, resulting in a reduction or delay in the onset of age-related cognitive decline. From the opposite pole, a lack of intellectual challenge via reduced activity may be damaging. Hultsch et al. (1999) summarised this "disuse" scenario as

> one way to characterize the impact of favorable experiences or conditions on cognitive performance in later adulthood. This view attempts to account for age changes in cognitive performance in terms of changes in the nature of activities performed by people across the life span. Essentially, it is suggested that changes in activity patterns result in disuse and consequent atrophy of cognitive processes and skills. The view is often captured in the adage "use it or lose it"" (p. 245).

This account is most often cited to explain the observed link between mental activities and cognitive ageing (Fratiglioni et al., 2004). Use or disuse of mental abilities could lead to structural or functional changes in the brain. With an engagement model, however, the nature of causality is difficult to tease out particularly as participation in cognitively demanding activities is likely to be determined by prior cognitive ability (Hultsch et al., 1999). If intellectual engagement via increased activity is observed to be cognitively protective in the LBC1921, the proposed mechanisms, and potential criticisms of these, will be considered in more detail.

8.3. A lifetime of activity

Throughout the foregoing discussion, the design of the highlighted studies follows a similar pattern: baseline examination when participants have entered late adulthood, including cognitive and activity assessment; cognitive follow-up some years later (often between 2 and 10 years); investigation of whether cognitive change over study period is predicted by baseline activity levels. It is rare, though not entirely unprecedented, for studies to consider whether there is a link between declining activity participation and cognitive ageing over the same period (refer to the VLS above), which could potentially indicate that external factors such as general health are the determinant of declines in both domains, as opposed to activity participation affecting cognition.

In the previous discussion and assessment of other lifestyle factors, the importance of a lifetime approach has been highlighted (Chapters 4-7). Wilson and colleagues (2003), however, noted that most studies assess activity in later life, and cognitive decline from that point onwards. Few studies have attempted to get an indication of lifetime participation in activities that may be important for later functioning. The general over-reliance on a single time point analysis of activity participation makes it impossible to determine whether it is the level of this in later life which is important, or whether *lifetime* participation may be crucial. Lifelong activity participation may be an indicator of the use of an individual's mental abilities in their day-to-day living (Friedland et al., 2001). To address this issue, it would be necessary for studies to assess activity and cognition in mid-adulthood, for example, and then follow the participants over an extended period of time into old age when cognitive change should be observable. Studies of this nature are atypical, and even where such data exist, as with the SLS, the analysis of these is not currently available. The second option would be to retrospectively assess activity participation at some baseline examination, and determine how changes in activity levels throughout life are related to later participation, and whether the lifetime level of, or change in, activity is related to mental ability and later cognitive change. A few studies have recently attempted this (in terms of predicting both normal and pathological cognitive ageing) by employing a variety of methods.

8.3.1. Lifetime activity and Alzheimer's

One approach has been to use a case-control design, as in a study with 193 Alzheimer's patients (where surrogates provided the required activity information) and 358 age and gender-matched controls (Friedland et al., 2001). Participation in 26 activities (which were not listed) was assessed first as ever or never, and then further where appropriate as the average hours per month spent on these between the ages 20-39 and 40-59 years old. The authors noted that data for the teenage years were collected but were hampered by missing values, highlighting one of the major perceived difficulties in dealing with retrospective assessment. The 26 activities were categorised as passive, intellectual and physical based on previous work (Hultsch et al., 1993). In each of these groupings, the data gathered were used to create measures of diversity ("sum of the total number of activities participated in at least once per month per category, divided by the total number of activities making up an activity category"), intensity ("sum of the total hours per month devoted to each activity type") and percentage intensity ("percent of total activity hours per month devoted to each activity category": Friedland et al., 2001, p. 3441).

The odds ratio for having Alzheimer's disease was 3.85 (2.65-5.58) for those who performed fewer than the mean number of activities, after adjustment for age, sex and education. Alzheimer's patients also participated in a lower diversity of activities throughout life, with OR of 2.51 (95% CI = 1.75-3.59) for low passive diversity, 2.43 (95% CI = 1.66-3.54) for low intellectual diversity and 2.67 (95% CI = 1.85-3.85) for low physical diversity. Concerning intensity, control participants were more active (in terms of time spent on activity participation) for intellectual activities in both early (20-39 years old) and mid-adulthood (40-59 years old); no differences were observed for intensity in the passive or physical domains. Finally, in order to investigate the effect of a change in activity during the lifespan, the effect of midlife intellectual activity participation on Alzheimer's status was investigated, when sociodemographic factors and importantly, early adult intellectual activity participation were controlled. The probability of developing Alzheimer's was significantly greater for those showing a reduction in intellectual activity participation between early and mid-adulthood. The authors concluded "patients with AD are less active in midlife (early and middle adulthood) in terms of intellectual, passive, and physical activities" (Friedland et al., 2001, p. 3444). The methodology employed in this study is intriguing, covering a range of activities during specified points in the lifespan. However, as it deals with a pathological condition, it is not clear whether activity participation across the lifespan will also be predictive of normal cognitive ageing.

8.3.2. Lifetime activity and normal cognitive ageing

8.3.2.1. Early life physical activity

There are few studies reporting the relationship between activity across the lifespan and normal cognitive ageing; studies of this nature may, however, be influential if they suggest that it may be necessary for activity interventions to occur at a young age to partially protect against future adverse cognitive changes (Dik, Deeg, Visser, & Jonker, 2003). Dik and colleagues (2003) distinguished themselves as the first to investigate early life physical activity and cognitive decline. Participants were members of the Longitudinal Aging Study Amsterdam, aged between 55 and 85 years old at baseline (N = 3107). Follow-ups occurred after 3 and 6 years, and individuals aged over 62 were given further cognitive assessments. Physical activity information was collected at the 3-year follow-up from 1385 participants (when those with MMSE scores less than 24 and those no longer participating by the 6-year follow-up were excluded, the final sample size was 985). Cognitive function was assessed by 2 measures: the MMSE to assess general cognitive ability and a letter substitution task to assess information processing speed.

To evaluate early life physical activity, participants were asked if, between 15 and 25 years old, "they had participated in sports or other physical activity that caused them to sweat or that made them exhausted" (Dik et al., 2003, p. 644). Responses were categorised as no regular activity (never or sometimes participate), low (under 1-2 hours each week), moderate (between 3 and 9 hours each week) or high (10 hours or over each week). Baseline MMSE scores were not significantly different across the 4 activity groups, however, the most and least active groups had the lowest information processing speed. Analysis of the longitudinal data revealed that "low physically active subjects scored on average 0.38 points higher on MMSE compared with inactive subjects (= reference group) during 6 years follow-up" (Dik et al., 2003, p. 646). When age and verbal intelligence were controlled, this was no longer significant. For information processing speed, in the fully adjusted model (controlling for age, sex, verbal intelligence, and a range of other confounders), the low activity group performed significantly better than the non-physically active (reference) group. When analysed separately by gender, the associations between information processing speed and activity were significant for men, but not women. Importantly, the "cognition-by-time interactions were not significant, suggesting that early life physical activity was not associated with the rate of decline during 6-year follow-up, but with the level of cognitive functioning" (Dik et al., 2003, 649). The authors therefore suggested that early rather than current activity is more important for later life cognitive function; any beneficial effect, of physical activity in this case, is apparent from early adulthood.

Retrospective assessment methods are useful in that they can index aspects of an individual's life – that may impact upon later cognitive change – during time points preceding the first examination. Such methods are not without their problems, most notably recall bias. Low MMSE scorers were excluded from the Dik et al. (2003) analysis in order to address this issue, however, it is likely that protocol would only be a partial remedy. Whilst this initial investigation did boast an impressive sample size, the limited cognitive battery is a potential weakness, restricting the extent to which the findings may be generalised to other cognitive domains. Moreover, Dik and colleagues' (2003) assessment of physical activity did not differentiate between leisure time pursuits and those associated with occupational demands. This apparent failure to distinguish across these forms of activity may explain the reduced information processing scores in the high activity group, likely to be confounded by social class (although socioeconomic status was entered in the analysis). The assessment was also solely concerned with high intensity physical activity and so it remains unclear whether less intense physical exercise (including walking), or social and intellectual pursuits from early adulthood, might determine later cognitive function and change. The authors acknowledge this and the need for further, more detailed physical activity assessments based on more than a single self-report item. Finally, when deciding what periods to assess retrospectively and for how long, it is important to consider the lifespan context and developmental changes that may be occurring at these ages. Dik et al. (2003) assessed a 10-year period from 15 to 25 years of age; this covers the transition from childhood to young adulthood during which there may have been major life changes for the participants (leaving school, starting work, etc.) with related consequences for their activity participation. Further retrospective assessments periodically throughout the lifespan would have been advantageous, additionally addressing the issue of whether critical periods exist for activity participation to have a beneficial effect on cognition, and when these might be.

8.3.2.2. Lifetime cognitive activity

As mentioned above, Dik et al. (2003) concentrated on the retrospective assessment of physical activity, but it is meaningful to investigate the effects of lifetime participation in cognitively engaging pursuits. Indeed, "it seems likely that cumulative experience in cognitively demanding activities across the life span is related to cognitive reserve" (Wilson, Barnes, & Bennett, 2003, p. 635). Wilson and colleagues therefore constructed a measure of lifetime participation in cognitive activities, which was delivered to 141 individuals (after 18 were excluded due to possible dementia) aged about 84 years old. Participants were members of the Memory and Aging Project, a longitudinal study of Alzheimer's disease based in Chicago. The activity assessment included 25 items chosen to represent common cognitive activities with reduced physical or social components (such as visit library or write letter), split over 5 ages: 6, 12, 18 and 40 years old, and at the time of the examination. For each item, a 5-point scale (from every day or about every day to once a year or less) was used to record individual patterns of activity participation. Cognitive ability was assessed in an hour-long test session, in which 18 ability measures were delivered (although the MMSE was used solely for cohort description) covering 5 domains of cognitive function: episodic memory, semantic memory, working memory, perceptual speed and visuospatial ability.

The cognitive activity items had a high Cronbach's alpha (.88) and so a composite measure was created by summing the individual items which approximated a normal distribution. Education was associated with this composite measure of cognitive activity, although it only accounted for about 6% of the variance. Importantly though, "if lifetime cognitive activity contributes to cognitive reserve, it should be related to level of cognitive function in old age" (Wilson et al., 2003, p. 639). Three of the five domains of cognitive ability were related to lifetime cognitive activity (perceptual speed, visuospatial ability and semantic memory, but not episodic or working memory) after adjustment for age and sex, and continued to be so when education was also controlled. The coefficients from the linear regressions ranged from 0.3 to 0.5 in predicting the mental test scores (where these has been standardised previously: mean = 0, standard deviation just under 1), suggesting that higher lifetime cognitive activity predicts better cognitive functioning in later life. This conclusion would be more persuasive if the association continues to hold after adjustment for prior cognition. As it stands, it is not possible to determine whether lifetime cognitive activity – as assessed by Wilson et al. (2003) – is anything other than a marker for higher ability in childhood.

Nevertheless, unlike many of the studies discussed previously, Wilson et al. (2003) managed to test a broad range of cognitive abilities, although perhaps with a reduced sample size as a result. Their procedure does also suggest that older individuals (in this case with an average age of almost 84) are able to complete a retrospective measure of lifetime activity participation. With planned annual follow-ups of this cohort, it will be possible to determine not only whether increased participation in cognitive activities predicts an increased level of later life functioning (assuming this relationship is not attenuated by prior ability), but also reduced cognitive decline from this point onwards. It would also be interesting to determine whether cognitive activity at a particular age during the lifespan was more important than at other times, rather than using a composite lifetime marker of cognitive engagement; this could have been examined with the data currently available to Wilson et al. (2003).

8.3.2.3. Archival activity and ability information

Whilst retrospective data collection is clearly not as accurate as contemporaneous activity assessment, in many situations, it will be the only viable method of assessing the domain of lifetime activity participation (Friedland et al., 2001). A few studies are able to circumvent this, however, as there do exist – on rare occasions – archival databases containing relevant information, which can then be followed up at a later point. One such study was included in the Fratiglioni et al. (2004) review, which possessed activity information recorded in midlife from World War II recruits (Pushkar et al., 1995). Cognitive ability was also assessed at this time, and 326 veterans were given the same tests about 40 years later (the follow-up is known as the Veterans Study). In terms of changes in verbal intelligence across this period, increased activity was said to be protective. Hultsch and colleagues (1999) – the research team who conducted the Victoria Longitudinal Study, discussed previously – went on to reanalyse this data. They were principally concerned that Pushkar et al. (1995) had created a lifestyle factor which included not only aspects of intellectual engagement, but also of socioeconomic indicators. Hultsch et al. (1999) similarly criticise the work of Schaie and others, as detailed above, for including markers of socioeconomic status in their lifestyle factors. When reanalysed separately, intellectual activity was not related to the cognitive measures (at baseline or follow-up) but socioeconomic status predicted the change in verbal intelligence across 40 years. Such indicators should, they argue, be kept separate as they may have independent effects on cognition and activity participation. It is vital that these are investigated simultaneously but individually, to ascertain whether any beneficial effects with respect to cognitive ageing are derived from an individual's social background, or their level of activity independent of this (Hultsch et al., 1999).

However, the Veterans Study researchers suggested that differences in study designs and methodologies between their study and the Victoria Longitudinal Study may explain the disparity in the initially reported results (Pushkar et al., 1999). The veteran's data was archival, and covered a span of around 40 years (from the ages of 25 to 65), whilst the VLS covers only 6 years. In addition, the Veterans Study is described as comprising a more heterogeneous sample in which potentially beneficial effects of lifestyle are more observable, and who completed tests of both verbal and nonverbal abilities (the VLS concentrated on the assessment of verbal abilities). Nonetheless, the authors did find some common ground, stating:

> we agree with Hultsch and colleagues that early abilities are the major determinants of later life abilities. However, we believe engaged lifestyles have significant but small causal effects on verbal performance across the adult life span. In actuality, we believe that the hypothesis that decreases in intellectual activities increase cognitive decline and the hypothesis that decreases in cognitive abilities lead to a decrease in intellectually challenging activities are probably true in different circumstances occurring in late life (Pushkar et al., 1999, p. 526).

The VLS researchers counter by suggesting that insufficient attention has been paid to the possibility that cognitive decline may influence engagement, as opposed to vice versa, and that many studies have too readily accepted the use it or lose it assumption. Analysis and reanalysis based on extant datasets may be inadequate for this purpose, such that new designs specifically comparing the engagement hypothesis to alternative explanations are required (Hertzog, Hultsch, & Dixon, 1999). That is, it might be argued that intervention, rather than observation, would be the most fruitful method of inquiry.

In one final, recent study, researchers were also fortunate to assess early activity participation and pre-morbid ability by accessing school records from the mid-1940s (Fritsch et al., 2005). In this study (the Cleveland Longitudinal Aging Studies of Students: CLASS), the participants had all graduated from the same high school between 1944 and 1946. Nine hundred and twenty alumni were identified and invited to participate in the study from a potential 1,904. In total, 663 participants were interviewed by telephone, being assessed for their immediate and delayed recall of a paragraph (Logical Memory). The Modified Telephone Interview for Cognitive Status was used to screen for cognitive impairment, with scores below pre-specified cut-off values indicating further investigation was warranted. In cases where the participant was not able to be interviewed (due to ill-health or death, for example), proxies were interviewed, being asked to answer 16 questions (a reduced version of the Informant Questionnaire on Cognitive Decline in the Elderly) about the participant's cognitive functioning over the last 10 years. When cognitive impairment was indicated by the initial screening – either by self or proxy report – proxies were further interviewed by telephone to determine dementia status (using the Dementia Questionnaire).

High school data held about the participants was accessed to provide a measure of childhood mental ability and activity participation. Yearbooks which included lists of the activities each individual participated in each year were used to index school activity participation, whilst scores were available from the Otis Self-Administering Test of Mental Ability which assesses a range of cognitive functions, and provides a composite score (mean = 100, *sd* = 12: Fritsch et al., 2005). The final sample used in the analysis numbered 396 individuals, with participants being excluded for various reasons such as missing activity data, or having completed an alternate IQ test at school. Childhood IQ was assessed at a mean age of about 15 years old, and the mean score of this sample was 112.7 (11.2). The group participated in an average of 2 activities per year when at high school, which had a small association with childhood IQ ($r = .2$, $p < .001$). The late adulthood assessment was conducted at a mean age of 74.8 years old, when 370 participants were classified as cognitively normal, 12 as suffering mild-cognitive impairment (MCI) and 14 had dementia (Fritsch et al., 2005).

In logistic regression analyses, both childhood IQ and activity level [recoded as low (up to 2 activities per year) or high (> 2 activities)] predicted dementia/MCI status, with odds ratios of .51 and .32 respectively (95% CI = 0.32-0.79 and 0.12-0.84 respectively), controlling for sex and education.

> The risk of having dementia/MCI is half as great for persons who are one standard deviation above the mean [on the IQ test] than for persons who are at the mean…[and] about one-third as great for persons who participated in

> an average of two or more activities per year than for persons who participated in fewer (Fritsch et al., 2005, p. 1193).

When MCI and dementia status were investigated separately, IQ remained a significant negative predictor, however, activity level was no longer significant at conventional statistical levels. This latter finding may be a result of the reduction in sample size by splitting the cognitively impaired group into types.

The results of this study suggest that independently of prior ability, sex and education, objectively assessed activity levels from childhood can impact upon later cognitive status around 60 years later. This is a surprising finding given the crude measures used to assess childhood activity and adult cognition. As with the Veterans Study, the truly retrospective activity measure is not confounded by participant biases in recall. There are, however, a number of shortcomings in this study which may limit the immediate impact of these findings. Age was not entered into the analytical models (due to the reduced range). It would have been worthwhile to do so as there will exist some potentially important variation, both in the age at which the participants were tested as children and as adults. Cognitive impairment (seen in a small proportion of the sample) was based on a telephone evaluation. A greater spectrum of ability measures delivered in a face-to-face clinical examination would have allowed the investigators to determine whether childhood activity participation predicted later functioning in normal, as well as pathological, cognitive ageing. Similarly, whilst the method for gathering activity participation information was innovative, there were no details of, or distinction between, the types of activities listed. As the authors discuss, only pursuits within school were listed, and no attempt was made to collect information about other interests "because of concerns over recall bias" (Fritsch et al., 2005, p. 1195).

Whilst there is a paucity of studies, the tantalising speculative results in the extant literature suggest that collecting data from earlier points in the lifespan (in addition to contemporaneous assessment) may be a fertile avenue for future cognitive ageing research, whether retrospectively, or as part of a planned long-term follow-up (although this latter design would clearly take many decades to bear fruit). Engagement may have different effects throughout the adult lifespan, and "the benefits of an engaged lifestyle for basic cognitive mechanics may only be realized prior to old age" (Hertzog et al., 1999, p. 532). Retrospective assessments of activity have the potential to tackle this issue, and their deployment within the LBC1921 can be a major, early part of this work.

8.3.3. Early ability, midlife activity and cognitive change

There is, however, a longitudinal study which has not had to rely on retrospective activity reports, has followed individuals over time, and for these individuals, has records of mental ability in childhood (Richards, Hardy, & Wadsworth, 2003). The Medical Research Council National Survey of Health and Development (also referred to as the British 1946 birth cohort) began with a sample of over 5000 children from England, Scotland and Wales born in March 1946 (Wadsworth, 1991). Although included in the Fratiglioni et al. (2004) review, it appears to be rarely considered in discussions of cognitive ageing as the cohort were aged only 53 years old at the follow-up detailed below. Due to the presence of early life mental ability data, this study has produced certain key findings which address issues central to the debate on whether activity participation is cognitively beneficial.

When the participants were 36 years old, an assessment of physical and spare-time leisure activity participation was conducted. Physical activity was recorded as none versus some (from responses to a list of 25 types of sport and exercise), whilst participation (yes/no) in 7 spare-time activities (such as chess, bridge or similar games) was summed and coded as participation in none, 1, 2 or greater than 3 activities. Similar measures of participation were taken when the cohort were aged 43. At this time (and again at 53 years old), cognitive function (memory) was assessed by the recall of a 15-word list from 3 attempts. One thousand nine hundred and nineteen participants had full data for analysis (Richards et al., 2003).

Both physical activity and spare-time activity were related to better memory at age 43. With respect to physical activity, the regression coefficient predicting memory score was 0.58 (95% CI = 0.10-1.06) adjusting for sex, education, social class, health status and, importantly, childhood IQ (a measure of general cognitive ability was available for these individuals, assessed when they were 15 years old). The coefficient for spare-time activities was 1.38 (95% CI = 0.84-1.93).

> Thus for a given baseline IQ score (at 15 years), and after controlling for sex, education, social class and health status, those who engaged in physical exercise at 36 years scored on average half a point more on the memory test at 43 years than those who did no physical exercise. Similarly, those who engaged in spare-time activity scored on average 1.4 points more (Richards et al., 2003, p. 789).

Richards et al. (2003) repeated their analysis, this time predicting memory at 53 years old and controlling for memory at age 43 (in addition to the other confounders). Physical activity at 36 years old, but not spare-time activity, predicted a reduced rate of decline in memory from age 43 to 53, with regression coefficients of 0.44 (95% CI 0.01-0.87) and 0.06 (95% CI = -0.47-0.55) respectively. The analysis further suggested that being physically active at 36 years old offered minimal protection against decline if participants were physically inactive at 43. Physical activity appeared to offer a cumulative beneficial effect, "with those engaged at both occasions having an average decline 1.01 points slower than those engaged at neither age" (Richards et al., 2003, p. 790).

The results suggest that, independent of childhood ability, active leisure-time is beneficial for the *level* of memory function, whilst physical activity prevents *decline* in memory function over 10 years. By being able to adjust for childhood ability, the results are unlikely to be a consequence of reverse causality – those of higher ability being more active. Interestingly, the analysis by Richards et al. (2003) suggests that individuals must remain active (physically) to continue reaping the cognitive rewards. The British 1946 birth cohort is able to combine a number of necessary components in the study of activity participation and cognitive change: a measure of childhood cognition which must be controlled to remove the confounding effect of higher ability on increased activity participation; indices of activity participation (from the physical and non-physical domains) reported from midlife; measures of the level of, and 10-year change in, cognition. It must be noted that the single measure of cognition in adulthood covers only one domain: memory. The cohort are also young, and so it may need several more waves of testing before the predictors of later life cognitive ageing can be investigated. And yet, the relatively young age of the cohort does highlight an important issue for other researchers in the area. Most studies begin with individuals when aged about 60, 70 or older; however, by their 50s, the participants in the current study had already experienced cognitive changes related to their activity participation. Whilst not a study of cognitive ageing *per se* (yet), the British 1946 birth cohort has shown the presence of a protective effect of increased activity participation with respect to the level of, and change in, memory function in midlife, independent of prior function. This latter point is rarely achievable, as highlighted by the preceding discussion. It is now important to examine whether this beneficial effect would hold for an elderly group, and if, as with Richards et al. (2003), the protection offered continues only for as long as active participation.

8.4. Causal connections

In most of the studies reported above, the results were adjusted for age, gender and education, in addition to baseline cognitive ability on average about 6-7 years prior to the follow-up examination (Fratiglioni et al., 2004). Even if associations remain between activity and mental ability after adjustment for these confounders (asserted by the Fratiglioni et al. (2004) review, among others, concluding that greater activity participation in the 3 domains reviewed was advantageous with respect to cognitive outcomes), it is necessary to assert 3 possible alternative explanations for this observation, before accepting that activity participation affects cognition:

activity participation may be mediated by, or the consequence of, a higher level of prior ability (from a point in the lifespan earlier than the baseline examination);

activity participation may be a marker for a generally healthier lifestyle, with the latter driving the association to better mental outcomes;

finally, reduced activity participation may be a marker for the onset of dementia, or indeed cognitive ageing (Fratiglioni et al., 2004).

Studies have attempted to discount these rival explanations by respectively controlling for baseline cognitive status, health status, or excluding those participants who later develop dementia. The activity-cognition associations are essentially still present after such re-analyses, nevertheless, the authors point out that no studies controlled the greatest potential confounder – "the premorbid cognitive capability of an individual to engage in certain activities" (Fratiglioni et al., 2004, p. 348). [The results of Richards et al. (2003) were included in this review and did control for pre-morbid ability, but are perhaps being overlooked due to the age of the cohort. Fritsch et al. (2005) have since used a prior measure of ability, however, their outcome was in the prediction of severe cognitive impairment rather than normal cognitive ageing.] Controlling for a baseline measure may be insufficient to truly investigate cognitive ageing if the follow-up occurs in mid to late adulthood, when a degree of decline may already have occurred. This would obscure any potential link between activity participation and cognition. It is clear that the LBC1921 Study – in which a valid measure of early ability exists – is ideally suited to the investigation of the effect of activity participation on normal cognitive ageing in an elderly group, independent of pre-morbid cognitive ability. This analysis would be among the first of its kind, and undoubtedly particularly significant in this field of research.

8.5. Summary and LBC1921 objectives

> The studies of leisure activities, despite simplistic categorization, have been able to demonstrate some significant relationships between daily activity and cognitive aging. These studies seem to support the "use it, or lose it" approach to cognitive aging, but further longitudinal research is needed to determine the nature of the causal relationship between the activities and maintained intellectual performance (Schaie & O'Hanlon, 1990, p. 58).

Support for the engagement hypothesis is, however, by no means universal, with Hertzog and co-workers (1999) suggesting that current evidence is ambiguous and in need of clarification. Whilst, the aforementioned studies offer "an initial step toward the analysis of cognitive functioning as related to environmental factors…[they also] lay important groundwork for additional research" (Schaie, Nguyen, Willis, Dutta, & Yue, 2001). To illustrate the contentious points in need of clarification in future investigations, again consider the conclusion to the Fratiglioni et al. (2004) review (previously used to highlight important, outstanding issues discussed in relation to social support networks and cognitive ageing).

> Can...premorbid intelligence explain the reported associations? Is it important to maintain an active lifestyle during the whole life span or only old age? Can a change in lifestyle play a major part?... Is the cognitive stimulation the common factor for all investigated lifestyles? Which is the most relevant component: physical, cognitive, or social? How do they interact? (p. 351).

Researchers utilising retrospective methods have begun attempting to elucidate some of these issues, including the fact that "risk for cognitive impairments later in life may be greater in those with low IQ in adolescence...but it also appears that an active lifestyle, as indicated by participation in extracurricular activities in high school, can independently reduce the risk" (Fritsch et al., 2005, p. 1195).

The current research with the LBC1921 will thus address these issues, namely:

- Is mental ability in childhood related to activity participation throughout the lifespan across the social, physical and intellectual domains?
- Is mental ability in childhood related to activity participation in old age?
- Independently of childhood mental ability, does lifetime activity participation affect the level of ability in later life (at ages 79 and 83)?
- Does lifetime activity participation predict later life cognitive change (age 79-83)?
- Does activity participation in old age predict later life cognitive change (age 79-83)?

If associations are discovered between activity and cognition,

- Is one domain (social, physical or mental) of greater importance?
- Increased activity at what point in the lifespan produces the greatest benefit?

The following chapter will detail the methods used to assess activity participation, both retrospectively and contemporaneously, in the LBC1921. Following this, each issue will be dealt with in turn.

Table 8.1 Observational longitudinal studies of associations between physical activity and cognition [Table 3 from Fratiglioni et al. (2004)]

Study, Country	n	Age at baseline (years)	Lifestyle measure	Follow-up (years)	Cognitive assessment	Control factors	Reported associations
Albert et al., USA	1011	70-79	Physical activity	2-3	Neuropsychological battery (language, memory, conceptualisation, visuo-spatial ability)	Eth, Inc, CD, dep, PF, SN, ES	Strenuous physical activity with preservation of cognitive function
Caremelli et al., USA	566	65-86	Self reported physical activity	6	Decline in short-term memory, verbal fluency, and visuospatial ability	SRH	Low physical activity with cognitive decline
Hultsch et al., Canada	250	55-86	Social activities; new-information-processing activities; physical activity	6	Decline in cognitive functioning (memory, comprehension, and speed)	CD, IADL, SH, med, pers	No association of physical activity with cognition
Yaffe et al., USA	5925	>65	Physical activities of low, medium, or high intensity	6-8	Decline in a global cognitive measure (MMSE)	Morb, PF, smok, oestr	Moderate and strenuous physical activity with a decreased cognitive decline
Schuit et al., Netherlands	347	Mean=74.6	Daily time of physical activity (medium or high intensity)	3	Decline in a global cognitive measure (MMSE)	PMF, dep, SH, SRH, smok, alc	Low daily physical activity with higher cognitive decline, only in people with APOE e4

Ho et al., China	2030	>70	Self reported physical activity (yes vs no)	3	Global cognitive test (MMSE)	PMF, dep	No exercise with cognitive impairment
Bosma et al., Netherlands	830	49-81	Physical exercise, mental and social activities (hours per week)	3	Specific tests for memory, and verbal fluency; global cognitive test (MMSE)	cog	All three activities with lower cognitive decline, but also higher cognition with higher activity
Richards et al., UK	1919	36	Spare-time activity (high social and mental component); physical exercise	7	Verbal memory performance	SES, IQ, SH, dep	Spare-time activity and physical exercise with better memory performance in midlife

All associations were controlled for age, gender, and education. Eth=ethnicity; Inc=income; dep=depression; ES=emotional support; CD=chronic diseases; SRH-self-reported health; IADL=instrumental activities of daily living; SH=subjective health; med=medication use; pers=personality; PF=physical function; morb=morbidity; smok=smoking; oestr=oestrogen; cog=cognition; SN=social network; PMF=physical and mental function; alc=alcohol.

Table 8.2 Observational longitudinal studies of the association between non-physical leisure activities and cognition [Table 2 from Fratiglioni et al. (2004)]

Study, Country	n	Age at baseline (years)	Non-physical activities	Follow-up (years)	Cognitive assessment	Control factors	Reported associations
Gold et al., Canada	316 men	64.7 (mean at follow-up)	Engaged lifestyle (SES, locus of control and intellectual activities)	40	Intelligence (verbal, nonverbal, mechanical tasks)	SRH, pers, paternal SES	Engaged lifestyle with maintenance of verbal intelligence
Hultsch et al., Canada	250	55-86	Social activities; new-information-processing activities; physical activity	6	Decline in cognitive functioning (memory, comprehension, and speed)	CD, IADL, SH, med, pers	Intellectually challenging activities with lower probability of cognitive decline, but also higher cognition with higher activity
Bosma et al., Netherlands	830	49-81	Physical exercise, mental and social activities (hours per week)	3	Specific tests for memory and verbal fluency; global cognitive test (MMSE)	Cog	All three activities with lower probability of cognitive decline, but also higher cognition with higher activity
Aartsen et al., Netherlands	2076	55-85	Everyday activity, including social, experiential, and developmental activities	6	Specific tests for memory, fluid intelligence, and speed; global cognitive test (MMSE)	PF	No association of any activity with cognition, but information processing speed with developmental activity

Menec, Canada	1292	67-95	Social, mental, and productive activities; number of leisure activities	6	Combined physical and mental function index	ADL, IADL, Cog, SH, Morb, LS	Greater overall activity, and social and productive activities with better function
Richards et al., UK	1919	36	Spare-time activity (activities with high social and mental component); physical activities	7	Verbal memory	SES, IQ, SH, dep	Spare-time activity and physical exercise with better memory performance in midlife

All associations were controlled for age, gender, and education. SES=socioeconomic status. Additional control was performed for SRH=self reported health; pers=personality; CD=chronic disease; IADL=instrumental activities of daily living; SH=subjective health; med=drug use; cog=cognitive function; PF=physical function; morb=morbidity; LS=life satisfaction; dep=depression.

Chapter 9: Lifetime activity participation and cognitive ageing in the LBC1921

Self-reported activity participation was collected from the LBC1921 in tandem with the assessment of social support (when the participants were aged about 80 and again aged 83); the procedures have been detailed in previous chapters. As with the self-reports of social support, the age 80 assessment was contemporaneous whilst the measures completed at age 83 were retrospective. The scales and items used to measure activity participation across the lifespan will first be described and analysed, before examining the associations between lifetime activity (in the social, physical and intellectual domains) and lifetime cognitive ability level and change.

9.1. Retrospective Self-report

The procedure for mailing the Retrospective Self-report was detailed in Chapter 5 [and labelled ***E*** on the LBC1921 Study timeline (Figure 3.1)]. Section III: Activities – pages 19-22 of the booklet shown in Appendix III – assessed activity participation across the lifespan. The level of activity participation (physical, social and intellectual) was assessed during 3 age periods (ages 20-35, 40-55 and 60-75). The age period being assessed was highlighted at the start of each page, and throughout (Appendix III).

9.1.1. Activities

On the first page of the Activities section, the general level of physical activity at 20-35, 40-55 and 60-75 years old was assessed on a 6-point scale: from movement associated with necessary (household) chores to keep-fit/heavy exercise or competitive sport. This item was based on research conducted by Hirvensalo and coworkers (Hirvensalo, Lampinen, & Rantanen, 1998).

A number of intellectual and social activities were also selected for assessment, drawn from those most commonly used in previous work (including Hultsch et al., 1999; Richards et al., 2003; Wilson et al., 2002; Wilson et al., 2003; Glass, de Leon, Marottoli, & Berkman, 1999). The same 15 activities were listed separately for each of the 3 age periods, and included, for example, visits to the library, reading a newspaper or magazine, and visits to friends or family. Participants were required to state on a 5-point scale (from every day or about every day to less than once a year/never) the frequency with which they generally did each activity during the specified age period. Additional spaces were provided for participants to note activities not listed in the table, and the frequency of participation in these.

9.1.2. Response

Of the 384 participants [157 (40.9%) men and 227 (59.1%) women] who responded to Section III (Activities) of the Retrospective Self-report, 363 (94.5%) returned complete responses and 21 (5.5%) remained incomplete after corrections and reminders.

9.2. Age-80 Self-report

The procedure for mailing the age-80 Self-report to the cohort was described in Chapter 7 [and labelled **C** on the LBC1921 Study timeline (Figure 3.1)]. The following measures relating to activity were included in this.

9.2.1. Typical Intellectual Engagement (TIE) questionnaire (adapted from Goff & Ackerman, 1992)

The TIE questionnaire contains 59 items such as "I think deeply about things" and "I rarely read widely on any one subject". These questions describe the core construct of 'typical intellectual engagement' and are taken from a larger battery of questions for assessing intellectual engagement (Goff & Ackerman, 1992). For the purposes of this study, the wording of certain questions was altered (with the permission of the authors): for example, the item "You are philosophically inclined, that is, inclined to philosophise about things" was changed to "I think deeply about things"; "The notion of thinking abstractly is not appealing to me" was replaced with "Thinking about theories or abstract ideas is not appealing to me". The revised TIE questionnaire is reproduced in Appendix XI. Participants were required to read each item and answer on a 6-point scale as to how much they agreed with the statement (strongly disagree to strongly agree).

9.2.2. Activity Lifestyle questionnaire (adapted from Glass et al., 1999)

Glass et al. (1999) suggested 14 items of importance in assessing lifestyle, grouped into social, fitness and productive categories. These categories and items were used as a guide for creating an appropriate scale for use in the LBC1921 Study. Items referring to preparing meals and shopping were removed from the list, since information about this had already been obtained from participants. An item concerning "other paid employment" was also removed as it was felt this would not be relevant to the cohort (although "paid community work" was retained). Four items were added concerning talking to and visiting friends and relatives. In total, the Activity Lifestyle questionnaire contained 17 items grouped under 3 headings: social (11 items), fitness (3 items) and productive (3 items). The questionnaire is reproduced in Appendix XII. Participants were required to place a tick according to whether they never, rarely, sometimes or frequently took part in each activity.

9.2.3. Age-80 physical activity

Participants were also asked on how many days in an average month they did sport or physical exercise (e.g. dancing or brisk walking) that made them out of breath and caused them to sweat, which they did for more than 20 minutes at a time. Gentler exercise was assessed by asking whether the participants had done any walks for pleasure or other reasons, such as shopping, of 2 miles or more (defined as usually taking about an hour or so) during the last year. A yes or no response was required. The format of these items is reproduced in Appendix XIII.

9.3. Results

9.3.1. Lifetime physical activity

Three hundred and seventy-six individuals answered the items relating to sport and exercise at 20-35, 40-55 and 60-75 years old (in the Retrospective Self-report). In each age group, responses ranged from moving only in connection with necessary (household) chores (1) to keep-fit/heavy exercise or competitive sports several times a week (6). Although the modal response was walking or other outdoor activities several times per week (3) during each age period, there were statistically significant decreases in the mean physical activity level with increasing age: at 20-35 years old, the mean level was 3.3 ($sd = 1.4$), decreasing to 3.0 ($sd = 1.2$) at 40-55, and then to 2.6 ($sd = 1.0$) at 60-75 [for the difference in mean physical activity level between 20-35 and 40-55 years old, $t(375) = 7.591$ ($p < .001$), and between 40-55 and 60-75 years old, $t(374) = 7.505$ ($p < .001$)]. Men reported being more physically active than women during each of the 3 age periods: the mean level of physical activity at 20-35 years old was 3.8 ($sd = 1.5$) for men versus 3.0 ($sd = 1.2$) for women [$t(291.7) = 5.432$ ($p < .001$)]; at 40-55 years old, the mean level was 3.1 ($sd = 1.2$) for men versus 2.8 ($sd = 1.1$) for women [$t(374) = 2.757$ ($p = .006$)]; and at 60-75 years old, the mean level was 2.9 ($sd = 1.0$) for men versus 2.4 ($sd = 0.9$) for women [$t(374) = 4.401$ ($p < .001$)].

The level of physical activity carried out at 20-35 years old correlated .72 and .53 (both $p < .001$) with the levels at 40-55 and 60-75 years old respectively, and the level at 40-55 correlated .66 ($p < .001$) with the level at 60-75 years old. An overall lifetime physical activity score was therefore created by summing the levels during the 3 age periods. Men had a mean lifetime activity score of 9.8 out of a maximum of

18 (sd = 3.2), which was significantly higher than the mean of 8.3 (sd = 2.8) in women [$t(373) = 4.956$ ($p < .001$)]. From now on, these levels of sport and exercise will be referred to as Physical Activity 20-35, Physical Activity 40-55, Physical Activity 60-75, and Lifetime Physical Activity.

9.3.2. Lifetime activity participation

The 15 activities assessed in each of the 3 age periods (45 activities in total) were subjected to a PCA. The overall MSA was .80 with watching television (20-35 years old) having the lowest individual value (.55). The 1st unrotated principal component explained 19.3% of the variance and was described by 36 items loading over .30 (Table 9.1). These items were summed to produce an overall Lifetime Activity score (Cronbach's alpha = .90).

The scree plot produced (Figure 9.1) suggested the extraction of either 4, 6 or 8 factors explaining 40.9%, 51.7% and 59.9% of the variance respectively. Extraction of each of these solutions was carried out with direct oblimin rotation. The 4-factor solution is shown in Table 9.1; the 6- and 8-factor solutions are shown in Appendix XIV but will not be analysed further (the factors produced lacked the breadth of those in the 4-factor solution, often being defined by only one or two activities across the 3 age periods).

In the 4-factor solution (Table 9.1), 14 items loaded over .30 on the 1st component, although 2 items (going to pubs or social clubs at 20-35 and 40-55) also had higher cross-loadings. Twelve items were therefore used to define the 1st rotated component, the majority of which involved a social dimension (participation in social groups and visits to friends or family in each age period, for example). This factor was labelled Lifetime Social Engagement. The 2nd component was described by 12 items such as going to the cinema or restaurants and going to sporting events or concerts in the 3 age periods. As all the items refer to pastimes or activities associated with 'going out', the factor was labelled Lifetime 'Going Out'. The 3rd factor was defined by 11 items such as reading a newspaper or magazine and listening to the radio in each age period (activities often based in the home in free-time) and is labelled Lifetime Spare-time Leisure. Eight items loaded over .30 on the final component, 2 of which displayed higher cross-loadings. The 6 remaining items were visits to the library and reading a book (in the 3 age periods), and is therefore labelled Lifetime Reading. Scores were computed for each of the 4 factors by summing the appropriate items, with Cronbach's alphas ranging from .80 to .89. The correlations between the 4 lifetime activity participation factors are shown in Table 9.2. All associations were positive and statistically significant ($p < .001$), and ranged from .25 between Lifetime Spare-time Leisure and Lifetime Reading, to .34 between Leisure Social Engagement and Lifetime 'Going Out'.

Men and women differed in their levels of overall activity participation across the lifespan, and on all the rotated activity factor scores (except Lifetime 'Going Out'). Women had higher Lifetime Activity [68.3 (17.6) versus 61.1 (16.7): $t(366) = -3.930$, $p < .001$], Lifetime Social Engagement [21.1 (8.1) versus 17.9 (7.6): $t(368) = -3.772$, $p < .001$], Lifetime Spare-time Leisure [34.2 (7.1) versus 32.3 (7.2): $t(374) = -2.474$, $p = .014$] and Lifetime Reading [12.7 (5.6) versus 10.2 (5.5): $t(374) = -4.383$, $p < .001$].

9.3.3. Activity participation by age period

PCA were also conducted separately for the 3 age periods. Firstly, for the 15 activities at 20-35 years old, the overall MSA was .71, however, watching television and going to pubs or social clubs had individual values of .50 and .47 respectively and so were removed from the analysis. The resultant overall MSA was .74. For the activities assessed at 40-55 years old, the overall MSA was .76, however, going to pubs or social clubs had a value of .46 and so was excluded from the analysis resulting in an overall MSA of .78. Finally, for the activities at 60-75 years old, the overall MSA was .75. Again, going to pubs or social clubs was excluded due to a low individual MSA value (.45). The resultant overall MSA was .77.

In each age period, the scree plot (Figures 9.2-9.4) suggested 1 factor described the items effectively, explaining between 23.3% and 25.1% of the variance. Table 9.3 shows the factor loadings on this 1st unrotated principal component separately for each of the 3 age periods. Twelve activities loaded over .30 on this factor at 20-35 years old which were summed to give an activity score in young adulthood (Cronbach's alpha = .72). Similarly, 12 activities at 40-55 years old were summed to give an activity score in middle age (Cronbach's alpha = .75) and 11 were summed at 60-75 to give an activity score in old age (Cronbach's alpha = .72). Hereafter, these scores will be referred to as Activity 20-35, Activity 40-55 and Activity 60-75.

Activity 20-35 correlated .87 ($p < .001$) with Activity 40-55, which correlated .70 ($p < .001$) with Activity 60-75. During each of the 3 age periods, women had higher activity scores than men: at 20-35 years old, women had a mean activity score of 24.6 ($sd = 6.4$) versus 21.8 ($sd = 5.8$) for men [$t(372) = -4.360$ ($p < .001$)]; at 40-55 years old, women had a mean activity score of 23.3 ($sd = 6.7$) versus 20.9 ($sd = 6.1$) for men [$t(371) = -3.459$ ($p = .001$)]; at 60-75 years old, women had a mean activity score of 16.7 ($sd = 5.9$) versus 14.7 ($sd = 5.6$) for men [$t(370) = -3.267$ ($p = .001$)].

9.3.4. Age-80 physical activity

At age 80, participants reported doing vigorous physical activity (for at least 20 minutes) on a mean of 6.2 days/month ($sd = 8.5$). Men were significantly more physically active, recording they did physical activity on an average of 7.7 days/month ($sd = 9.1$) compared with 5.1 days/month ($sd = 7.9$) for women [$t(401.3) = 3.281$ ($p = .001$)]. However, 49.6% (239) of the 482 individuals answering this item recorded doing no activity. This variable (age-80 physical activity) was therefore collapsed into 2 categories: none versus some physical activity. A similar pattern of activity emerged for walking; of the 490 participants answering this item, 58.8% (288 individuals) reported they had walked 2 miles or more in the last year on any one occasion (this variable will be referred to as age-80 walking).

9.3.5. Age-80 Typical Intellectual Engagement and Activity Lifestyle

The Typical Intellectual Engagement (TIE) and Activity Lifestyle (AL) questionnaires completed by participants when aged 80 have been analysed previously using principal components analysis (Gow et al., 2005a; Gow, 2003). A summary is provided in Appendices XV and XVI respectively. Scores for the following factors were computed and will be examined in subsequent analyses: from the TIE scale, an overall age-80 Typical Intellectual Engagement score; from the AL scale, an age-80 Activity Lifestyle (AL) score, in addition to factors labelled age-80 Socialising/Visiting and age-80 Outside Participation. There were no significant sex differences for the TIE score: mean Typical Intellectual Engagement was 121.3 (sd = 24.8) for men and 122.7 (sd = 24.7) for women [$t(461) = -.596$ ($p = .551$)]. With respect to the computed Activity Lifestyle scores, there were no sex differences for overall Activity Lifestyle or Outside Participation: mean Activity Lifestyle was 21.6 (sd = 5.6) for men versus 22.6 (sd = 5.8) for women [$t(479) = -1.955$ ($p = .051$)]; mean Outside Participation was 11.1 (sd = 4.4) for men versus 10.8 (sd = 4.7) for women [$t(482) = .646$ ($p = .519$)]. However, women scored higher on the Socialising/Visiting factor with a mean of 13.7 (sd = 2.9) versus 12.9 (sd = 3.1) for men [$t(482) = -3.058$ ($p = .002$)].

9.3.6. Activity associations with cognition

9.3.6.1. Physical activity

The associations between the physical activity variables discussed above and cognition across the lifespan are shown in Table 9.4. In the total sample (and in men when the sample was split), the level of physical activity assessed retrospectively for

20-35, 40-55 and 60-75 years old was not significantly related to any of the cognitive measures. Lifetime Physical Activity (created by summing the level of physical activity during the 3 age periods) was also unrelated to cognitive ability in the full sample and separately in men (Table 9.4). In women, however, increased physical activity between 20 and 35 years old was significantly associated with better cognitive performance in later life (age-79 IQ $r = .14, p = .035$; age-79 cognitive ability $r = .15, p = .025$; and age-83 cognitive ability $r = .19, p = .017$), but not later life cognitive change ($r = .11, p = .197$). The levels of physical activity at ages 40-55 and 60-75 years old were also related to increased cognitive performance at ages 79 and 83 in women ($r = .14$ to $.24, p < .05$), but only the level of physical activity at 40-55 was related to later life cognitive change from 79 to 83 years old ($r = .19, p = .021$). In women, greater lifetime physical activity was associated with higher age-79 IQ ($r = .14, p = .039$), and higher cognitive ability at ages 79 and 83 [($r = .18$ ($p = .011$) and .24 ($p = .002$) respectively]; there was no association between lifetime physical activity and later life cognitive change from age 79 to 83 ($r = .16, p = .052$). When the associations between age-79 IQ and the level of physical activity at 20-35 years old and across the lifespan in women were adjusted for age-11 IQ, the associations were reduced and no longer significant (both $r = .14, p = .149$ and .153 respectively). This suggests that increased physical activity in women is related to a higher level of ability, but not to changes in ability over time.

The associations between the indicators of physical activity collected at age 80 (Age-80 Physical Activity: being none versus some physical activity; Age-80 Walking: walking 2 miles/more on one occasion the previous year versus not having done so) and cognitive ability are also shown in Table 9.4. Age-80 Physical Activity was not significantly associated with any of the cognitive measures, in the full sample or when analysed separately by gender. However, there was a small association between Age-80 Walking and age-79 IQ ($r = .13, p =.005$), and later life cognitive change ($r = .15, p = .011$); participants who walked had a significantly higher mean age-79 IQ [102.4 (13.4) versus 98.6 (15.4); $t(466) = -2.800, p = .005$)] and showed less cognitive decline from age 79 to 83 [.12 (.98) versus -.18 (.98); $t(291) = -2.559$,

$p = .011$]. When the association between walking and age-79 IQ was adjusted for age-11 IQ, it remained essentially unaltered ($r = .15$, $p = .002$). These results suggest that those walking at age-80 were more cognitively able at age 79 (independent of age-11 ability) and showed less cognitive decline up to 83 years old.

When the results were analysed by gender (Table 9.4), age-80 Walking was associated with age-79 IQ in men ($r = .15$, $p = .030$). This was no longer significant after age-11 IQ was controlled ($r = .13$, $p = .070$), although the effect size hardly alters. Interestingly, although there was no significant association in women between walking and age-79 IQ ($r = .10$, $p = .102$), when age-11 IQ was adjusted, the correlation became significant ($r = .14$, $p = .026$). Walking in women was also associated with better cognitive ability at age 83 and less cognitive decline from age 79 to 83 [$r = .17$ ($p = .033$) and .20 ($p = .010$) respectively]; women who walked declined less over 4 years in later life compared with those not walking [.23 (1.10) versus -.21 (.98); $t(159) = -2.613$, $p = .010$].

9.3.6.2. Activity participation

The associations between the activity variables described above and cognitive function across the lifespan are shown in Table 9.5. Lifetime activity participation was positively associated with age-11 IQ and age-79 IQ (in the full sample and both men and women separately $r = .21$ to .29, all $p < .01$). Individuals who reported participating in more activities throughout their life were more able in childhood, and performed better in later life. However, when the Lifetime Activity-age-79 IQ association was adjusted for age-11 IQ, it was reduced and no longer significant ($r = .10$, $p = .060$), suggesting that the association between increased activity across the lifespan and improved cognitive function at age 79 is explained by prior ability. Three of the four lifetime activity factors derived by PCA (Lifetime Social Engagement, Spare-time Leisure and Reading) were also associated with better cognitive function at ages 11 and 79 (Table 9.5: $r = .13$ to .22, $p < .05$); there was no association between Lifetime 'Going Out' and age-11 or age-79 IQ [$r = .03$ ($p = .631$) and .08 ($p = .148$) respectively]. After adjusting for age-11 IQ, only Lifetime

Spare-time Leisure remained significantly correlated with age-79 IQ ($r = .14$, $p = .014$). That is, those individuals who reported listening to the radio, reading newspapers or magazines or playing games, for example, showed improved cognitive performance at age 79, independently of their level of childhood ability. The associations between the lifetime activity factors and cognition differed by gender. In men, Lifetime Social Engagement was associated with higher age-11 IQ ($r = .24$, $p = .004$) and age-79 IQ ($r = .20$, $p = .017$), and Lifetime Spare-time Leisure was associated with age-79 IQ ($r = .29$, $p < .001$). Only the association between Lifetime Spare-time Leisure and age-79 IQ remained after adjusting for age-11 IQ ($r = .28$, $p = .001$). In women, Lifetime Reading was associated with higher ability in childhood ($r = .27$, $p < .001$) and late adulthood ($r = .29$, $p < .001$); the latter association was reduced, but remained significant after age-11 IQ was controlled ($r = .15$, $p = .040$). One way to interpret these results would be to suggest that, across the lifespan, men benefit cognitively from activities such as listening to the radio or reading newspapers or magazines, for example, whereas women benefit from reading books.

The associations between activity participation at each of the 3 age periods separately and cognition are also shown in Table 9.5. Increased activity in each age period was always associated with better cognitive function at ages 11 and 79 ($r = .18$ to $.26$, all $p < .001$), although only increased activity at 40-55 years old was associated with age-79 IQ once age-11 IQ was controlled ($r = .15$, $p = .01$). Similar patterns were evident when the sample was split by gender; again, however, when age-11 IQ was controlled, only the association between activity at 40-55 years old and age-79 IQ remained [for men, $r = .19$ ($p = .025$), and for women, $r = .18$ (p = .014)]. Individuals who were more active in midlife were cognitively better off in later life, independently of their level of prior functioning.

Increased intellectual engagement at age 80 (the age-80 TIE score) was associated with higher IQ assessed at ages 11 and 79 [Table 9.5: $r = .21$ ($p < .001$) and .13 ($p = .005$) respectively]. The latter association was eliminated when adjusted for age-11

IQ ($r = -.01, p = .912$) which suggests that those who have higher childhood ability are more likely to be intellectually engaged. The association between TIE and later life functioning therefore appears to be an artefact of its association with childhood ability. Increased activity at age 80 (assessed by the Activity Lifestyle questionnaire) was associated with higher age-79 IQ ($r = .16, p = .001$) which remained after adjusting for age-11 IQ ($r = .14, p = .005$). In addition, the 2 factors derived from the AL questionnaire (age-80 Socialising/Visiting and Outside Participation) were associated with age-79 IQ [$r = .17$ and .18 (both $p < .001$) respectively]; again, the associations remained after adjustment for age-11 IQ [$r = .13$ ($p = .007$) and .14 ($p = .003$) respectively]. The correlations between the age-80 Activity Lifestyle factors and cognition appear to be exclusive to women (Table 9.5), in whom the associations of age-80 Socialising/Visiting and Outside Participation with age-79 IQ (adjusted for age-11 IQ) were .24 ($p < .001$) and .16 ($p = .013$) respectively. Women who were more active in later life had higher cognitive ability in later life independent of their level of prior cognitive function.

Table 9.5 also shows the associations between the measures of activity and cognitive ability at ages 79 and 83, and the change in ability over this time. In general, increased activity (across the lifespan or in later life) was related to higher cognitive ability at ages 79 and 83, with the significant correlations ranging from .12 ($p = .027$) between Lifetime Social Engagement and cognitive ability at age 79, to .22 ($p < .001$) between cognitive ability at age 83 and activity level at 40-55 years old and age-80 Typical Intellectual Engagement. Of greater interest, however, are the associations not with the level of later life ability, but with the change in cognition over 4 years. Increased Lifetime Spare-time Leisure and age-80 Typical Intellectual Engagement were positively associated with the change in cognitive ability from age 79 to 83 [$r = .12$ ($p = .041$) and .13 ($p = .029$) respectively]. Individuals who were active throughout their life in the form of reading newspapers or magazines or listening to the radio (for example), or who were more intellectually engaged in later life, experienced less cognitive decline from 79 to 83 years old. When the sample was split by gender (Table 9.5), Lifetime Spare-time Leisure was associated with cognitive change in men ($r = .18$, $p = .042$), whereas in women, Lifetime Reading and age-80 Typical Intellectual Engagement were associated with cognitive change [$r = .19$ ($p = .016$) and .17 ($p = .032$) respectively].

9.4. Regression analyses

The preceding results have examined the univariate associations between activity-related variables and cognitive outcomes. The final stage of analysis will use significant correlations to guide the selection of variables in regression analyses. Firstly, the activity predictors of age-79 IQ will be sought. [As in previous chapters, standardised β are reported throughout.].

9.4.1. Predicting age-79 IQ

The activity factors which remained associated with age-79 IQ when age-11 IQ was adjusted may account for changes in cognition across the lifespan. These were the variables which were therefore selected for further analysis. A hierarchical regression was conducted with age-79 IQ as the dependent variable. Age-11 IQ and sex were entered as independent variables in block 1. In the 2^{nd} block, the following variables were entered in a stepwise fashion: Activity 40-55, age-80 Walking, age-80 Socialising/Visiting and age-80 Outside Participation (the latter 2 factors being part of the Activity Lifestyle questionnaire). In the first model, age-11 IQ ($\beta = .64$, $p < .001$) and sex ($\beta = -.07$, $p = .096$) accounted for about 41% of the variance in age-79 IQ (Table 9.6 *A*). Activity 40-55 and age-80 Socialising/Visiting entered in the next 2 models, accounting for 3% and 1% of the variance in age-79 IQ respectively. Individuals who were more active in general in midlife (when aged 40 to 55 years old) and who were more active socially at age 80 (visiting and talking with friends and family, for example) had improved cognitive function at age 79, independent of childhood ability.

The regression analysis was re-run with Lifetime Spare-time Leisure and age-80 Activity Lifestyle included in block 2 instead of Activity 40-55, age-80 Socialising/Visiting and age-80 Outside Participation (the former factors included items which also appeared in the latter). In this analysis (Table 9.6 *B*), age-11 IQ and sex accounted for about 41% of the variance in age-79 IQ; Lifetime Spare-time Leisure and age-80 Activity Lifestyle entered in the next 2 models, accounting for 2% and 1% of the variance in age-79 IQ respectively.

Regressions were also performed separately for men and women. In men, age-11 IQ explained about 38% of the variance in age-79 IQ. Activity 40-55 was entered stepwise in the 2nd block which added about 3% to the variance accounted for. The regression was re-run replacing Activity 40-55 with Lifetime Spare-time Leisure (these 2 factors were the only activity variables in men to display significant associations with age-79 IQ after age-11 IQ was controlled, but were analysed separately due to their shared constituent items). Age-11 IQ accounted for 38% of the variance and Lifetime Spare-time Leisure contributed a further 5%. In women, Lifetime Reading, age-80 Walking and age-80 Activity Lifestyle were entered stepwise in the 2nd block. Age-11 IQ accounted for 43% of the variance in age-79 IQ, and age-80 Activity Lifestyle and Lifetime Reading contributed a further 3% and 2% respectively. Finally, the analysis was re-run removing Lifetime Reading and age-80 Activity Lifestyle, and including Activity 40-55, age-80 Socialising/Visiting and age-80 Outside Participation. Age-11 IQ accounted for 43% of the variance in age-79 IQ, and age-80 Socialising/Visiting and Activity 40-55 contributed a further 5% and 2% respectively. Therefore, independently of childhood ability, men who performed cognitively better when aged 79 were more active across the lifespan with respect to reading newspapers or magazines and listening to the radio, for example. Women who read more throughout their life and were more active in general at age 80, or who were more active in general in midlife and were more active socially at age 80 (visiting and talking with friends and family, for example) had higher mental ability at age 79 (independent of childhood ability).

9.4.2. Predicting later life cognitive change

Regression analyses were also conducted with cognitive change from age 79 to 83 as the dependent variable. Age-11 IQ and sex were entered in the 1st block, followed stepwise by those variables with significant associations with the outcome in block 2 (Lifetime Spare-time Leisure, age-80 Walking and age-80 Typical Intellectual Engagement). Table 9.7 summarises this analysis. In the 1st model, age-11 IQ and sex accounted for about 2% of the variance in cognitive change from age 79 to 83 (although age-11 IQ did not make a significant contribution). The only other variable entering the model was age-80 Walking, also accounting for about 2% of the variance. Participants who reported having walked 2 miles or one on any one occasion the year prior to the age-80 self-report showed less relative cognitive decline in later life.

When the analysis was repeated separately by gender, in men, the only activity variable entered was Lifetime Spare-time Leisure (being the only variable significantly associated with later life cognitive change). However, this did not contribute to the final model. In women, Physical Activity 40-55, Lifetime Reading, age-80 Walking and age-80 Typical Intellectual Engagement were entered stepwise in the 2nd block after age-11 IQ was entered in the 1st block. Age-11 IQ accounted for about 1% of the variance in later life cognitive change. The only activity variable accounting for additional variance was Physical Activity 40-55, contributing a further 5% to the variance explained. Women who were more physically active in midlife experienced less relative cognitive decline from 79 to 83 years old.

9.5. Discussion

In the final lifestyle domain to be considered in the current thesis, the Lothian Birth Cohort 1921 participants answered a range of questions about their participation in activities of a physical, social and intellectual nature. Activity participation across the adult lifespan was indexed by employing both retrospective and contemporaneous assessment techniques. The associations between activity over the life course and cognition were examined. As in the preceding examination of occupational characteristics or social support and cognitive ageing, the associations of greatest interest are those between the activity factors and age-79 IQ which remained significant after adjustment for childhood ability, and between the activity factors and later life cognitive change. Participation in these activities might partly account for individual differences in cognitive ageing trajectories.

9.5.1. Summary of results

Cognitive ability in childhood was not related to physical activity across the lifetime; however, higher early ability was associated with increased participation in other types of activity. Those who performed cognitively better in childhood were more active generally during each of the 3 age periods assessed retrospectively (correlation coefficients were .21-.23), across the lifespan overall (.24), and in particular in the areas of lifetime social engagement (participation in social groups for example), spare-time leisure (including listening to the radio or playing games) and reading (.13-.22). In later life, these individuals were also more active socially (such as visiting or talking to friends and relatives) and outside the home (including unpaid community work: .10 and .11 respectively), as well as being more intellectually engaged (.21). With childhood ability controlled, higher age-79 IQ was related to increased activity at 40 to 55 years old and spare-time leisure throughout life, and also to walking and increased activity (overall and separately for the socialising/visiting and outside participation factors) at age 80. When these factors were examined in a regression analysis (controlling for age-11 IQ and sex), activity at 40-55 years old and socialising/visiting at age 80 accounted for about 3% and 1% of the variance in age-79 IQ respectively. Alternatively, lifetime spare-time leisure and overall activity at age 80 accounted for about 2% and 1% respectively, depending on the factorial level of description used.

The only physical activity indicator associated with later life cognitive change from age 79 to 83 was walking (versus not) at age 80 (.15), whereas lifetime spare-time leisure and intellectual engagement at age 80 were associated with less cognitive decline (.12 and .13 respectively). In the regression analysis (controlling for age-11 IQ and sex), walking was the only factor which significantly accounted for variance in later life cognitive change, explaining about 2% of the variance; those who walked in later life showed less cognitive decline over 4 years.

9.5.2. Physical activity and cognition

The LBC1921 participants reported their level of physical activity on 2 separate occasions. One of these assessments was retrospective and asked participants to rate the amount of sport or exercise they took during 3 distinct periods of their lives: 20-35, 40-55 and 60-75 years old. This gave an indication of physical activity across the adult lifespan. Participants also provided physical activity information when aged about 80 years old, thus assessing their participation in old age. The associations found between the lifetime measures of sport and exercise and cognitive ageing will be discussed first.

9.5.2.1. Lifetime sport and exercise

In the full LBC1921 sample, and also separately in men, there were no significant associations between physical activity participation across the lifespan and any of the cognitive measures. In women, however, increased physical activity in each of the 3 age periods assessed was associated with better cognitive function in later life although only physical activity at 40-55 years old was related to later life cognitive change. Indeed, sport and exercise in midlife accounted for about 5% of the variance in cognitive change from 79 to 83 years old in women: greater physical activity in mid-adulthood predicted less cognitive decline in old age. [That activity patterns might be confounded by social class will be considered in the next chapter.] Such gender differences are interesting and may have consequences for any suggested interventions. Dik et al. (2003) – also investigating retrospective physical activity and cognitive change – suggested that physical activity was cognitively protective, but only in men when the sample was split by gender. Reasons for the contradictory findings may lie in the assessments of activity and cognition. In the current thesis, physical activity during 3 age periods was assessed; in Dik et al. (2003), only activity between 15 and 25 years old was considered. Furthermore, the LBC1921 were given 3 tests of cognitive ability combined into a composite ability measure whereas Dik et al. (2003) used a single test of information processing speed. Gender differences in lifetime activity patterns, and performance (and change) on the cognitive tests utilised might therefore explain the discrepancy in the findings. Due to a lack of other studies employing similar retrospective methodologies, it is difficult to interpret these findings at present. Future studies with older cohorts and lifetime physical activity data are needed to allow a thorough investigation of this issue. Nevertheless, the current finding of a protective effect of increased midlife sport and exercise in women is potentially important and the proposed explanatory mechanisms will be considered after the results with physical activity in old age are discussed. Socioeconomic status is a likely confounder of this association, with those of higher status being more likely to have the time and resources to participate in sport and exercise (and other forms of activity). Social class and further potential confounders of the LBC1921 findings will be considered in Chapter 10.

9.5.2.2. Physical activity in old age

The LBC1921 were asked about their level of physical activity when they were aged about 80. This included whether they had taken any walks of 2 miles or more in the past year (yes/no) and on how many days they had participated in vigorous sport/exercise for over 20 minutes (recoded as none versus some physical activity). This latter measure was not associated with cognition, either in childhood or old age. Walking, however, appeared to be cognitively protective. Those who reported having walked 2 miles or more on any one occasion in the preceding year had higher age-79 IQ, controlling for childhood ability, and showed less decline from age 79 to 83 years old. As with the retrospective assessment of physical activity, the association between physical activity (walking in this instance) and cognitive change was only significant in women. Not having walked such a distance in a whole year may be a marker for poor health although a previous study reported that women who walked more when aged about 70 years old were less likely to experience cognitive decline over the subsequent 7½ years (Yaffe et al., 2001). The number of blocks walked and stairs climbed on a daily basis was their indicator of walking behaviour which is more detailed than that employed in the LBC1921 (although their cognitive assessment was limited to the MMSE). Yaffe et al. (2001) also indexed more vigorous physical activity which was expressed as energy expenditure; this too was protective of cognition. More vigorous activity was not cognitively protective in the current analysis, however, again, the physical assessment in the LBC1921 was cruder (being a none versus some physical activity dichotomy). The Yaffe et al. (2001) sample was 12-fold larger than the full LBC1921 group with a follow-up in old age almost twice as long and would therefore have had greater power to detect any effects. Yet, their sample only included women and so it is unclear whether men would benefit from physical activity as assessed. Another study highlighted the protective effect of physical activity – including walking – for women (Weuve et al., 2004). These data and the current analysis with the LBC1921 suggest that there is a cognitive benefit to be derived from physical activity, in women at least, and that this activity need not be more strenuous than walking. Further investigation, particularly with respect to activity participation in elderly men, is warranted. This is especially important as van Gelder et al. (2004) reported that intensity, but not duration, of physical activity was cognitively protective in men, and that decreasing physical activity may also be detrimental to cognitive health. There are no measures of duration or intensity of physical activity with the LBC1921 and so this point cannot be investigated presently.

Interestingly, when walking was entered in the current regression analyses, it did not explain variance in age-79 IQ (whereas other activity factors to be discussed below did) but accounted for about 2% of the variance in later life cognitive change in the full sample. This is similar to the findings of Richards et al. (2003) who suggested that physical activity was not predictive of the level, but rather the change in ability (over 10 years), although their sample was much younger (change was assessed between 43 and 53 years) and the assessment of cognition considered only memory.

Bearing in mind such caveats and the clear differences between the studies, more detailed work is certainly recommended. Separate analyses by gender in the LBC1921 suggested that it was only the women who were benefiting from increased physical activity. However, when both physical activity in midlife and walking at age 80 were entered in the regression predicting later life cognitive change (in women), only midlife physical activity significantly accounted for variance in the outcome. This might suggest that it is important to be physically active earlier in the life course, rather than just in old age, and that walking behaviour in later life might be an index of sport and exercise participation from throughout the lifespan. As walking is the most common exercise taken by older individuals (World Health Organization, 1998), a beneficial effect of this simple, low-cost workout would potentially be among the most straightforward to influence. Nevertheless, it is necessary to determine whether walking would in fact be cognitively beneficial or whether any advantage has to be accrued (via increased lifetime participation in sport and exercise or improved health) before old age.

9.5.3. Potential mechanisms

Overall, the results with the LBC1921 are in accordance with the Fratiglioni et al. (2004) review which highlighted a beneficial effect of physical activity. In the current instance, this effect may only hold for women, and it may be more important for improved cognitive outcomes to be physically active from earlier in the lifespan. If there is a cognitive benefit from increased sport or exercise participation – whether a lifetime of activity or specifically in old age, and whether vigorous or of a less strenuous nature – the pathways underlying the association could be numerous, as illustrated in Chapter 8. Physical activity was highlighted as protective of cognitive function in the NIH review (Hendrie et al., 2006) with a proposed mechanisms for the association being via a reduction in cardiovascular risk factors or disease. Yaffe et al. (2001) also considered the mechanistic link between physical activity, CV factors and cognitive change.

> It is possible that physical activity may prevent cognitive decline but not improve cognitive performance during a short period in otherwise high-

> functioning elderly persons. This is plausible if physical activity-induced effects are associated with long-term protective benefits, such as a reduction in cardiovascular or cerebrovascular risk factors (Yaffe et al., 2001, p. 1707).

Increased exercise is therefore assumed to protect against cognitive decline by reducing the likelihood of cardiovascular disease, in addition to its associated risk factors, which are themselves predictors of cognitive decline (Hendrie et al., 2006).

Another of the mooted pathways considers a direct effect of exercise on the brain, both structure and function. In a recent paper by Dishman et al. (2006) – summarising the consensus from a meeting of experts in exercise and neurobiology – it was suggested that brain growth factors expressed as a result of increased physical activity are one explanatory mechanism. Furthermore, "chronic physical activity may also have neurogenerative and neuroprotective influences on the brain by stimulating the growth and development of new cells" (p. 346). The authors did note that

> it is important to continue to consider whether neurobiological outcomes of enhanced physical activity are specific to increased physical exertion or are a non-specific response to stress or some other psychological state that might be an unintended consequence of the exercise regimen (p. 350).

This consideration was primarily aimed at the animal models often used to examine the mechanisms but it is applicable to human studies also. It has to be clear that any protective effect is due to the physical activity assessed rather than an unmeasured factor (such as social class or health status), otherwise suggested interventions may fail. Dishman et al. (2006) concluded their review by highlighting a number of outstanding issues in the field, including the requirement to precisely characterise the exercise undertaken by type, intensity, frequency, duration and motivation to participate to more fully understand the underlying effect. Importantly, longitudinal work is vital to examine the continuing effect of physical activity, primarily "whether there is a "priming effect", whereby prior exercise might potentiate the impact of later exercise" (p. 351). The presence of such a lifelong, continuous effect of physical activity has been suggested in the LBC1921 women, however, as discussed, further research is required. This may need to move from the prospective studies discussed thus far, to intervention and randomised trials in which exercise factors are manipulated (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005).

9.5.4. Intervention studies

Physical activity may be related to improved cognitive functioning in later life, and yet "conclusions must be tempered by the limits of prospective observational designs (e.g. self selection into exercise levels, limited cognitive and fitness assessments, etc.)" (Kramer et al., 2005, p. 125). To suggest successful interventions for future application, a knowledge of what physical activity, when, and for how long, is required. This information may be more easily obtained from trials manipulating the level of exercise in the populations under investigation. Colcombe and Kramer (2003) conducted a meta-analysis of studies investigating the relationship between fitness training and mental ability in later life. They identified 18 studies with effect sizes ranging from -0.9 to 6.4, but importantly, those given exercise interventions were seen to increase more on their cognitive abilities across testing sessions than the control groups (with effect sizes of .478 and .164 respectively). Of course, there was a marked degree of variation in the nature of the intervention applied, which could be gentle exercise such as walking, to more demanding circuit training. The activities comprising the interventions were split into aerobic (solely for cardiovascular fitness) and combination exercises (cardiovascular and strength training combined). Significant improvements were observed in both exercise groups, although combination training led to significantly greater increases in cognitive test performance, with an effect size of .59 compared with .41 for aerobic exercises (Colcombe & Kramer, 2003). Overall, training sessions of less than 30 minutes led to no significant improvement, whilst 31-45 or 46-60 minutes sessions had effect sizes of .614 and .466 respectively. Concerning the length of the intervention trial, training programs of 6 months or longer led to the greatest increase in cognitive performance compared with more reduced training regimens (effect size = .674). Finally, the studies with more than 50% female participants showed a greater improvement (effect size = .604) than those where the gender composition was equal or skewed towards a male majority (effect size = .150). The studies reviewed had participants aged 55 and over, but when they were split into different age categories, the mid-old group (66-70 years old) showed the greatest improvement in performance, with an effect size of .693 compared with .298 in the young-old (55-65 years) and .549 in the old-old (71-80).

Colcombe and Kramer (2003) concluded unequivocally that there is a significant, favourable effect of physical training to be had on cognitive function:

> fitness training increased performance 0.5 *SD* on average, regardless of the type of cognitive task, the training method, or participants' characteristics (Colcombe et al., 2003, p. 128).

The effect of these interventions is proposed to act via improved fitness leading to actual changes in the brain, as discussed above. Importantly, do such interventions have long term effects on cognitive function, or are the benefits time limited to the intervention period? Due to a lack of long-term follow-up in such trials, longitudinal prospective studies are still an important source of information in this regard. However, what the brief *précis* suggests is that interventions (on a small-scale at least) are both possible and apparently beneficial. Continued work will determine more fully the critical times for such interventions to occur.

9.5.5. Social and intellectual activity and cognition

9.5.5.1. Lifelong participation

Of course, sport and exercise pastimes are but one aspect of an active and engaged lifestyle. The LBC1921 participants were also asked about their participation in a range of other activities such as reading or visiting friends or relatives across the lifespan and in old age. The frequency of participation in a range of activities during the 3 retrospectively assessed age periods was summed to give an overall indicator of activity. Whilst this was related to the level of ability in both childhood and later adulthood, the latter association did not hold after adjustment for prior ability, and there was no relationship between lifetime activity and cognitive change from 79 to 83 years old. This suggests that individuals of higher initial ability are more active in a variety of activities throughout their lives. The association between greater overall activity across the lifespan and later functioning is therefore a consequence of early ability predicting both factors. Increased activity overall might be related to a higher *level* of ability, but not to *changes* in this level. Nevertheless, when the activities and interests were grouped by factor analytic methods, 1 lifetime activity factor was associated with age-79 IQ independently of age-11 IQ: spare-time leisure. This factor was described by activities including playing games (like cards, chess, bingo or crosswords), watching television and listening to the radio during the 3 age periods. Furthermore, increased spare-time leisure activity predicted less cognitive decline in old age. The protective effect of this factor (on lifetime and later life cognitive change) was found separately in men, although in women it was an indicator of lifetime reading (visiting the library and reading books) which appeared to be protective (again predicting a higher level of ability in old age independently of childhood ability and less decline in old age). This distinction might indicate that men and women differ in their choice of reading material, or that the types of activity pursued in leisure time vary by gender.

In the regression analyses, lifetime spare-time activity accounted for about 2% of the variance in age-79 IQ in the full sample, adjusting for age-11 IQ. In men, this factor accounted for about 5% of the variance, whereas in women, lifetime reading accounted for about 2%. With respect to later life cognitive change, none of these factors significantly contributed to the models. These results suggest that greater spare-time activity and reading (for men and women respectively) across the lifespan predict a higher level of functioning in old age, independent of the level of prior ability, but do not predict changes in cognition in later life. Again, this is in accordance with the work of Richards et al. (2003) who suggested leisure-time activity at 36 years old predicted the level of memory performance at age 43 adjusting for childhood ability, but not decline over the subsequent 10 years (this was predicted by physical activity, as discussed above). This and the current work with the LBC1921 are important as they suggest that the findings reported between increased activity and better cognitive outcomes (as reviewed by Fratiglioni et al., (2004) for example) are not entirely due to individuals of higher initial ability being more active. The 2 factors of lifetime activity emerging as important in the LBC1921 analysis both cover aspects of mental engagement, perhaps suggesting activities involving some intellectual stimulation are protective of cognition. The other 2 lifestyle factors both included aspects of social activity (social engagement: visiting friends and family or participation in social groups; and 'going out': going to the cinema or restaurants, sporting events or concerts) and so there is no evidence, in the LBC1921 at least, of a cognitive benefit from increased social activity across the lifespan. Whilst this is contrary to the previous literature reporting a protective effect of social activity in later life on subsequent cognitive change, as there are no studies with data pertaining to social activity across the lifespan it is not possible at present to integrate the current findings. It is, of course, possible that any beneficial effect of social activity is only apparent in old age, or that the effect is not cumulative but rather dissipates over time if social engagement and contact are not maintained.

The finding that lifetime activity involving a mental component is predictive of cognition was previously reported by Wilson et al. (2003), although their analysis had to assume the measure of lifetime cognitive activity was indexing something more than just prior ability. In the LBC1921, it has been possible to demonstrate this as an effect independent of childhood ability has been shown. The mechanisms proposed to account for this effect will be discussed below. However, Wilson et al. (2003) only reported the *level* of cognitive ability in old age. As they continue to follow their cohort longitudinally it will require another wave of testing to determine whether cognitive activity across the lifespan is protective against decline also; this was not apparent in the LBC1921.

In the current analysis, the activity data were also grouped according to age period to determine whether there existed a critical period for increased activity to occur to affect later cognitive ability. When examined in this way, although increased activity during each period was associated with higher ability in childhood and later life, only increased activity in midlife (from 40 to 55 years of age) was related to later ability after controlling for prior ability. This result was replicated in men and women separately suggesting that increased activity in midlife is beneficial for cognitive change across the life course (accounting for about 2-3% of the variance when entered in the regression analyses predicting age-79 IQ). Again, however, social class is a potential confounder of this relationship. Those who have had time throughout their lives to participate in a range of activities are likely to be more affluent and of higher status; it may therefore be social class which explains the improved cognitive outcome. There was no link between increased activity during the 3 age periods and later life cognitive change. This suggests again that increased participation in non-physical activities predicts the level of ability in old age, but not changes in later life. Due to the nature of this analysis, there was no specification between social and intellectual pastimes in the 3 age periods. This was not pursued as separate domain scores would each have been described by a small number of items. From the foregoing discussion of the separate lifetime activity factors, however, it might be predicted that it is those activities requiring intellectual engagement or producing mental stimulation which are driving the effect between midlife activity and cognition. More detailed assessment and analysis is required to confirm this assumption. As mentioned above, integration with previous literature is complicated by a lack of studies employing similar methods. Although Wilson and coworkers (2003) enquired about activity at different points across the lifespan (retrospectively for 6, 12, 18 and 40 years old, and contemporaneously at about 84 years old), they focussed on cognitive activity only. The information was combined in a lifetime cognitive activity score but the analysis was not repeated examining activity in the different age periods separately. At present, a direct comparison with the LBC1921 results is not possible. In a study which was able to access archival school records to collect activity participation information, greater activity was related to cognitive status (normal versus MCI/dementia) assessed about 60 years later (Fritsch et al., 2005). The activity measure was a simple count and there were no details of the type of activity included. It is therefore not possible to determine whether it is just increased early activity in general, or some specific form of engagement, which is leading to the effect. However, the results do indicate that activity from youth can impact on cognitive function in later life (and in Fritsch et al. (2005), this effect was independent of childhood ability). No further data were available for activity participation across the lifespan and so the effect of other periods of engagement and stimulation could not be examined. Whilst it might be suggested from the LBC1921 that mid-adulthood presents a critical period for activity participation to occur to affect the level of ability in later life, more studies are needed before this can be more definitively stated.

9.5.5.2. Later life engagement

When aged about 80 years old, the LBC1921 also supplied details of their current activity participation. Increased activity at age 80 (whether as an overall activity factor or separately as participation outside the home and socialising/visiting factors) was associated with higher ability in later life, independently of childhood ability. This association was only significant in women. A more active lifestyle at age 80 was not related to cognitive change from age 79 to 83. In comparison, when specifically intellectual engagement was examined, increased intellectual engagement at age 80 was associated with higher IQ at ages 11 and 79. The latter association was attenuated to non-significance when age-11 IQ was controlled suggesting that although increased intellectual engagement in late adulthood might be associated with the level of cognitive ability at this time, this link is due to the fact that higher childhood ability predicts both intellectual engagement and later cognitive ability. However, increased intellectual engagement at age 80 was associated with less cognitive decline in later life (again, this was significant in the full sample and separately for women).

In the regression analyses, increased activity at age 80 or socialising/visiting each accounted for about 1% of the variance in age-79 IQ, independently of childhood ability (these factors were entered in separate analyses as they share items). For women, the percentage of variance explained was about 3% and 5% respectively. This agrees with previous work whereby those who are more active (in general or specifically in a social context) are more cognitively able (Fratiglioni et al., 2004). Social activity and engagement in later life might be beneficial for cognitive function. A positive effect of lifetime social activity was not observed and so it is possible that any benefit is short-lived, or that it is dependent on a continued level of social engagement, or that there is a measurement difficulty with respect to social activity across the lifespan. Further work would be required to more fully investigate this. However, it may be that those who have not experienced deleterious cognitive change over the course of their lives remain more active. Due to the timing of the assessments, it is not possible to determine which causal explanation is more likely. If it is assumed that an active lifestyle at age 80 is a relatively stable indicator of previous activity then the causal direction could be activity affecting cognition, although at present it is not possible to be more definitive. What is perhaps more interesting though, is the lack of an association between later cognitive ability and intellectual engagement after childhood ability is controlled. This has major implications for much of the previous research in the area which is unable to control for prior cognitive function.

Individuals with higher pre-morbid function are more likely to be engaged in cognitively stimulating activities. These individuals also experience less cognitive decline in later life as a result of their higher initial ability. Childhood ability therefore confounds the association between cognitive activity and cognitive decline. The difficulty in the area of intellectual activity and cognitive decline was discussed by the Victoria Longitudinal Study researchers, who stated:

> the VLS produced empirical evidence that is consistent with the hypothesis that intellectually engaging activities buffer against longitudinally measured cognitive decline. However, these findings are also broadly consistent with the hypothesis that high-ability adults lead intellectually active lives until cognitive decline in old age begins to limit their intellectually related activities. In general, the evidence in favor of positive lifestyle effects on cognitive change appears to us to be less compelling than recent research reports and some of the secondary reviews of the literature might suggest. Of course, it could be the case that the VLS will produce more compelling evidence of lifestyle relationships to cognitive change when we have longer term longitudinal data, or when we can separate terminal decline individuals from other adults using death records and other data after sufficient incidence of mortality occurs in this sample (Hultsch et al., 1999, p. 262).

The shared variance between ability and activities of a specifically cognitive nature has made examining this area open to misinterpretation. It should also be noted that in the LBC1921, intellectual engagement as currently discussed was assessed in old age, and that perhaps, intellectual engagement throughout the lifespan may still be protective independent of childhood ability (as detailed above). In this instance, cognitive change was essentially indexed across the whole lifespan with activity participation assessed at the end of this period. The mismatch in assessment timeframes make any causal arguments problematic. The associations with subsequent cognitive decline are, perhaps, easier to interpret.

However, when predicting later life cognitive change, greater overall activity at age 80 was not associated with a protective effect, going against previous studies including those highlighted by Fratiglioni et al. (2004). It is possible that the cognitive decline observed in the LBC1921 was not of a sufficient magnitude for any protective effect of later life activity to become apparent. Alternatively, if there exists a publication bias, null results may not have been reported thus inflating the size of the effect (Anstey et al., 2000). Furthermore, although age-80 intellectual engagement was entered in the regression analyses it did not significantly account for variance in later life cognitive change (rather it was physical factors which partially explained this variance, discussed earlier). Again, it is possible too little change has occurred to allow an effect to manifest itself. This could also suggest that either physical activity is more important with respect to cognitive decline, or that controlling for early ability has attenuated the association between cognitive activity and decline in old age. Richards et al. (2003) also found that physical activity was important for protecting against decline, rather than a measure of non-physical activity. Those studies which only investigate one type of activity, or that do not enter different activity domains simultaneously are unable to determine which form may be of increased importance. For example, if only cognitive (but not physical) activity had been assessed in the LBC1921, this may have predicted later life cognitive change in the regression analysis. Including a full activity assessment across domains is therefore essential to ensure important aspects of engagement are not omitted. Unlike other studies, Richards et al. (2003) and the LBC1921 are able to control for early ability. With this adjustment, the level of intellectual activity in later life does not appear to be protective, but rather may be an effect of having not declined cognitively. Further research is needed to more fully account for this, especially if activity at earlier points in the lifespan is found to offer some degree of protection.

9.5.6. Proposed mechanistic explanations

If there does exist a beneficial effect of certain activities on later cognitive functioning at any point in the lifespan, then plausible mechanistic and physiological pathways would be required to explain this. Specific pathways underlying the observed cognitive benefits of sport and exercise have been detailed above. In the case of social activity (the level of which in later life may be important in predicting ability in old age), the pathways are often linked to the increased social support derived from being around other individuals: "active living improves mental health and often promotes social contacts" (World Health Organization, 2002, p. 23). Such mechanisms were discussed in Chapters 6 and 7. It may be that simply being more active (in any domain) is but one aspect of a more complex environment (Schooler, 1984); this will in turn require greater engagement and interaction, leading to the development, maintenance and preservation of cognitive abilities. Although it is uncertain whether this active engagement would be required during critical developmental periods (when individuals are in formal school education, for example), or whether there is a continued effect outwith this timeframe (Anstey et al., 2000), the current analysis with the LBC1921 would suggest that midlife activity may be of particular importance.

The cognitive stimulation resulting from increased activity is often suggested as the key to the protective effect. That is, activities which are specifically cognitive, or those from other domains also necessitating some level of cognitive engagement, may act through a shared pathway. Fratiglioni et al. (2004) summarised such potential mechanisms with reference to AD and dementia, but they are clearly also relevant to normal cognitive ageing. These suggest that the health (mental or otherwise) promoting effects of intellectually stimulating activity may be the result of a "use it or lose it" scenario. An engagement model of cognitive level and decline has therefore emerged, whereby those who show a greater degree of engagement with their environment are less likely to suffer the adverse effects of cognitive ageing or at least delay the onset of such age-related cognitive decline. Use or disuse of mental abilities (via engagement in activities) may therefore lead to actual structural or functional changes in the brain (number of synapses, speed of dendrites, etc.) which will then determine an individual's future engagement with their environment (Anstey et al., 2000; Kramer et al., 2004).

These changes in the central nervous system are often linked to the notion of 'reserve capacity', that is "the amount of damage that can be sustained before reaching a threshold for clinical expression" (Stern, 2002, p. 449), or in this case, until cognitive ageing becomes apparent. This reserve could be expressed as some brain parameter, such as overall size or the number and density of synapses for example, or via the use of alternative cognitive processes or structures after damage to 'normal' pathways. The latter model of reserve is often defined as active as the brain has to seek out these alternative routes or recruit other networks in order to cope with some insult or decline, compared with the former passive models (Stern, 2002). Individuals who develop a greater 'reserve' by participation in activities which stimulate them intellectually, for example, might therefore be spared the process of cognitive ageing until a later age compared with their peers who developed less reserve across the lifespan. The reserve model has been described as being too

> static…and does not give proper recognition to the remarkable use-dependent plasticity that characterizes the corticolimbic regions of the brain. Effortful mental activity may not only strengthen existing synaptic connections and generate new ones; it may also stimulate neurogenesis, especially in the hippocampus. This, persistent engagement by the elderly in effortful mental activities may promote plastic changes in the brain that circumvent the pathology underlying the symptoms of dementia [or normal cognitive ageing] (Coyle, 2003, p. 2490).

Most studies which report an effect of activity on cognitive function refer to the concept of reserve and the 'use it or lose it' notion in some form. However, there are issues of causality which can rarely be addressed whereby those of higher ability are also more likely to be active in, and engaged with, their environment (Kramer et al., 2004). Less cognitive decline in these individuals may not be due to some greater built-up reserve, but rather due to their initial capacity. Evaluating this recently, Salthouse (2006) stated:

> the relation [between mental exercise and mental ageing] could occur because, as proposed by the mental-exercise hypothesis, the amount of mental activity throughout one's life contributes to the level of mental ability at later periods in life, but the relation could also originate because the amount of mental activity at any age is at least partially determined by one's prior, and current, level of mental ability. More generally, although it is tempting to attribute some of the variability in cognitive performance apparent at any given age to individual differences in prior rates of age-related change in cognitive abilities, it is important to consider the possibility that much of that variability was present at earlier ages, and may have little or nothing to do with differential aging (p. 70).

By controlling for prior ability and still finding an effect of activity, it might be that there is evidence in the LBC1921 that increased activity may well contribute to successful cognitive ageing. The mechanism for this could be via some form of brain or cognitive reserve capacity, however, it is not possible to state with the current data what the underlying pathway might be.

9.6. Strengths and limitations

The current chapter has described the assessment of lifetime activity participation in the LBC1921. This has covered a range of pastimes including sport and exercise, and social and intellectual engagement at various points throughout the lifespan. Such coverage has not been reported previously. All the activity domains and age periods were analysed simultaneously in an attempt to identify the source (both type of activity and period of participation) of any protective effect. However, the measures used, particularly for physical activity, were relatively crude (though comparable to the previous research from where they were drawn). For example, it would be advantageous to also consider other aspects of exercise, such as the type, intensity and duration, or some index of energy expenditure. This could more precisely indicate the level of physical activity required to produce a beneficial effect on cognition. The retrospective assessment of activity participation was kept brief as participants were required to reflect on 3 different periods in their distant past.

Assessing a greater number of activities would have allowed specific aspects of engagement (such as social or intellectual) to be considered rather than simply overall activity. This could also have addressed the fact that the lifetime activity factors were based on the same few activities during the 3 age periods. The validity of these factors is dependent on accurate recall of each activity during each age period.

Recall biases are a major issue with the potential for participants to misremember their activity history. As the retrospective items for the 3 age periods were completed on the same occasion, it is possible that the association between activity participation across times was an artefact of this. Cognitive changes in later life may result in less accurate responses to the items which would clearly skew any reported associations. Participants did, however, complete the items with little apparent difficulty and indeed, it may be that reflecting on past activity is easier and more accurate than recalling social support across the lifespan.

Throughout, it has been assumed that activity participation is affecting changes in cognitive function, yet reverse causation is also an explanation of the associations. That is, those experiencing greater decline withdraw from activity as a result of their loss of function. Cognitive decline would therefore predict decreased activity, rather than vice versa. As suggested above, cognitive decline may also interfere with the completion of the items, particularly those requiring participants to reflect on the distant past. The causal explanation is further complicated because the activity assessment in later life occurred shortly after age-79 cognitive testing. Further follow-up of the cohort into old age is one way to address this issue, allowing a better characterisation of cognitive change in the LBC1921. Losses due to attrition might lessen the utility of this. As with the analysis of occupational characteristics and social support networks, the effects reported in the current analysis were small in magnitude and drawn from a large number of associations. Type I errors cannot be ruled out and replication is therefore required to validate the conclusions derived. However, the presence of prior ability is advantageous, especially as activity participation across the lifespan and in different domains is determined by this. By being able to control for childhood ability, the effect of activity participation independent of this has been reported, although other unmeasured confounders may also account for the associations.

9.7. Conclusions

If lifestyle variables do have a positive impact upon cognitive ageing, such findings are of great importance, perhaps more so than genetic or biological influences as lifestyle factors, including activity participation, may be "more directly amenable to psychological intervention" (Schaie, 1984, p. 476). The assessment of lifetime activity participation in the Lothian Birth Cohort 1921 has therefore produced some intriguing findings. With respect to cognition assessed across the lifespan, greater activity in midlife and in old age or increased lifetime spare-time activity and socialising/visiting in later life may be protective. Both men and women appear to reap the cognitive benefit of increased activity in middle adulthood, although women who read more across the lifetime and who are more active overall or socially in later life show maintained ability, whereas for men, lifetime spare-time leisure appears to be important. Regarding later life cognitive decline, walking behaviour was the only factor preserving function in the full sample, although for women it was increased physical activity in midlife which was protective. In summary,

> for correlates of cognitive aging to be considered predictors of cognitive change, there must be evidence that the level of that correlate is associated with change in the level of the measure of cognitive performance over a certain time period. A predictor of change may be associated with decline, improvement or maintenance of cognitive function over time. For example, intellectual activity may improve cognitive performance, physical activity may prevent decline (Anstey et al., 2000, p. 163).

In the LBC1921, greater activity appeared to predict the level of ability in old age, whilst physical activity was associated with the maintenance of this over time. Engagement in a range of activities across the life course may be necessary to ensure cognitive vitality in later life although replication of these effects is clearly required before interventions could be suggested. These would be most likely to take the form of public health promotion, rather than actual interventions as such. By disseminating information to the public about which simple, cheap, everyday activities can be beneficial for their continued cognitive health, it would be hoped future generations could make informed decisions to ensure their own successful cognitive ageing, in much the same way as is presently the case for smoking, alcohol or diet and general health. Individuals taking responsibility in this way has been emphasised by WHO:

> it seems that physical exercise and other forms of physical activity are the most significant means whereby individuals can influence their own health and functional ability, and accordingly maintain a high quality of life into old age (World Health Organization, 1998, p.10).

This style of intervention is perhaps more appropriate for activity participation, especially as large scale activity manipulations in later life may be less effective and perhaps difficult to envisage or realise (Hendrie et al., 2006). Promoting "heart-smart lifestyles in mid and late life [might have an] important bearing on continued cognitive health" (Welsh-Bohmer et al., 2006 p. 259).

Table 9.1 PCA of lifetime activity participation items

		1st unrotated	Rotated component			
		component	1	2	3	4
Age 20-35	Visits to the library	**.59**	-.03	.09	.11	**-.74**
	Reading a newspaper or magazine	**.38**	.00	.05	**.69**	-.07
	Reading a book	**.54**	-.06	-.07	.12	**-.83**
	Writing	**.59**	**.35**	.21	.09	-.25
	Playing games (like cards, chess, bingo or crosswords)	**.30**	-.05	.04	**.53**	-.12
	Watching television	.05	.09	.03	.20	.17
	Listening to the radio	**.41**	.13	.00	**.58**	-.10
	Visits to friends or family	**.43**	**.47**	.01	.16	-.02
	Study course at work or evening classes	.22	.19	.14	-.18	-.12
	Going to the cinema or restaurants	**.46**	.15	**.41**	.12	-.07
	Going to sporting events or concerts	**.48**	.06	**.72**	-.04	-.02
	Trips to the theatre, galleries or museums	**.58**	.15	**.44**	.05	-.25
	Participation in social groups	**.47**	**.57**	.17	-.01	.05
	Church or religious activities	**.41**	**.83**	-.22	.04	.09
	Going to pubs or social clubs	.06	**-.36**	**.61**	.10	.15
Age 40-55	Visits to the library	**.60**	-.03	.08	.08	**-.79**
	Reading a newspaper or magazine	**.39**	.06	.02	**.71**	-.05
	Reading a book	**.53**	-.06	-.15	.14	**-.86**
	Writing	**.63**	**.36**	.24	.10	-.27
	Playing games (like cards, chess, bingo or crosswords)	**.36**	.01	.04	**.52**	-.16
	Watching television	.15	.06	.02	**.53**	.19
	Listening to the radio	**.43**	.12	.04	**.57**	-.11
	Visits to friends or family	**.44**	**.51**	.02	.14	-.01
	Study course at work or evening classes	.27	.12	.17	-.26	-.27
	Going to the cinema or restaurants	**.50**	.09	**.51**	.13	-.10

	Going to sporting events or concerts	**.55**	.18	**.68**	-.01	-.02
	Trips to the theatre, galleries or museums	**.64**	.16	**.47**	.07	**-.31**
	Participation in social groups	**.52**	**.55**	.21	.01	.01
	Church or religious activities	**.42**	**.87**	-.23	.01	.08
	Going to pubs or social clubs	.06	**-.35**	**.66**	.12	.22
Age 60-75	Visits to the library	**.55**	.03	.07	.04	**-.67**
	Reading a newspaper or magazine	**.33**	.02	.02	**.61**	-.06
	Reading a book	**.44**	-.09	-.17	.09	**-.81**
	Writing	**.54**	**.38**	.18	.02	-.22
	Playing games (like cards, chess, bingo or crosswords)	.28	-.03	-.02	**.50**	-.14
	Watching television	.04	-.06	.01	**.35**	.10
	Listening to the radio	**.41**	.10	.07	**.51**	-.12
	Visits to friends or family	**.46**	**.48**	.09	.13	-.02
	Study course at work or evening classes	**.32**	.16	.19	-.16	-.23
	Going to the cinema or restaurants	**.51**	.24	**.40**	-.05	-.16
	Going to sporting events or concerts	**.52**	.18	**.62**	-.05	-.06
	Trips to the theatre, galleries or museums	**.62**	.20	**.40**	.01	**-.32**
	Participation in social groups	**.39**	**.52**	.10	-.06	.02
	Church or religious activities	**.40**	**.84**	-.19	-.01	.12
	Going to pubs or social clubs	.13	-.21	**.67**	.05	.23
	Percentage variance explained	19.3%	19.3%	7.9%	7.0%	6.7%
	Cronbach's alpha	.90	.85	.84	.80	.89

Note. Loadings over .30 are highlighted in bold. Scores were produced by summing the highlighted items for each factor (unless an item loaded on more than one rotated factor; in these cases, only the highest loading was considered).

Table 9.2 Correlations between lifetime activity participation factors (N = 368-375)

	1	2	3	4
1. Lifetime Social Engagement	-			
2. Lifetime 'Going Out'	.34	-		
3. Lifetime Spare-time Leisure	.28	.28	-	
4. Lifetime Reading	.33	.26	.25	-

Note. All correlations were significant, $p < .001$.

Table 9.3 First unrotated component of activity participation items by age period

	Age period		
	20-35	40-55	60-75
Visits to the library	**.65**	**.60**	**.57**
Reading a newspaper or magazine	**.40**	**.43**	.24
Reading a book	**.54**	**.51**	**.45**
Writing	**.58**	**.65**	**.56**
Playing games (like cards, chess, bingo or crosswords)	**.31**	**.38**	.27
Watching television	-	.17	.00
Listening to the radio	**.43**	**.43**	**.40**
Visits to friends or family	**.48**	**.47**	**.56**
Study course at work or evening classes	.29	.27	**.42**
Going to the cinema or restaurants	**.55**	**.57**	**.60**
Going to sporting events or concerts	**.52**	**.59**	**.62**
Trips to the theatre, galleries or museums	**.64**	**.68**	**.72**
Participation in social groups	**.52**	**.56**	**.44**
Church or religious activities	**.43**	**.41**	**.43**
Percentage variance explained	25.1%	24.9%	23.3%
Cronbach's alpha	.72	.75	.72

Note. Watching television has no component loading for 20-35 as it was excluded from this analysis. Going to pubs or social clubs is not listed as it was excluded from all analyses. Loadings over .30 are highlighted in bold. Scores were produced by summing the highlighted items for each factor.

Table 9.4 Correlations between physical activity and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
Physical Activity 20-35	.00	-.09	.10	.07	-.09	.14*	.08	-.07	.15*	.04	-.14	.19*	-.00	-.07	.11
Physical Activity 40-55	-.01	-.06	.04	.03	-.12	.12	.06	-.08	.14*	.08	-.10	.21**	.07	-.07	.19*
Physical Activity 60-75	.07	.01	.13	.07	-.04	.11	.08	-.08	.17*	.11	-.04	.24**	.06	.04	.12
Lifetime Physical Activity	.02	-.06	.10	.06	-.10	.14*	.08	-.09	.18*	.08	-.11	.24**	.04	-.05	.16
Age-80 Physical Activity	-.06	-.03	-.06	.01	.03	-.03	.07	.08	.05	.04	.05	.02	-.01	-.01	.01
Age-80 Walking	.03	.08	-.01	.13**	.15*	.10	.07	.02	.10	.10	.00	.17*	.15*	.07	.20**

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Age-80 Physical Activity and age-80 Walking are dichotomous variables. T = total sample (N = 280-468), M = male (N = 129-198), F = female (N = 151-270).
$*p < .05$, $**p < .01$

Table 9.5 Correlations between activity participation and cognition across the lifespan

	Age-11 IQ			Age-79 IQ			Cognitive ability age 79			Cognitive ability age 83			Cognitive ability change (79-83)		
	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F
Lifetime Activity Participation	.24***	.28**	.21**	.23***	.29***	.25***	.18**	.21*	.21**	.18**	.18*	.19*	.08	-.02	.11
Lifetime Social Engagement	.18**	.24**	.14	.13*	.20*	.13	.12*	.14	.14*	.08	.10	.07	-.01	-.09	-.01
Lifetime 'Going Out'	.03	.09	-.02	.08	.05	.08	.07	.01	.09	.07	.00	.12	.02	-.04	.07
Lifetime Spare-time Leisure	.13*	.12	.13	.19***	.29***	.14	.14***	.24**	.10	.18**	.31***	.09	.12*	.18*	.06
Lifetime Reading	.22***	.16	.27***	.20**	.14	.29***	.15**	.10	.22**	.15*	.02	.26**	.07	-.15	.19*
Activity 20-35	.21***	.23**	.20**	.20***	.25**	.22**	.13*	.15	.16*	.13*	.13	.13	.06	-.04	.08
Activity 40-55	.22***	.27**	.19**	.26***	.31***	.26***	.21***	.24**	.22**	.22***	.23**	.21**	.09	.01	.11
Activity 60-75	.23***	.29**	.19**	.18***	.23**	.20**	.16**	.19*	.17*	.14*	.15	.14	.04	-.05	.06
Age-80 TIE	.21***	.17*	.24***	.13**	.12	.14*	.15**	.13	.16*	.22***	.19*	.25**	.13*	.07	.17*
Age-80 AL	.08	.12	.05	.16**	.13	.19**	.16**	.16*	.17**	.14*	.09	.20*	.03	.00	.03
Age-80 Socialising/Visiting	.10*	.13	.07	.17***	.12	.22***	.15**	.19**	.13*	.13*	.15	.13	.02	.07	-.03
Age-80 Outside Participation	.11*	.13	.09	.18***	.17*	.18**	.19***	.13	.22***	.16**	.07	.24**	.03	-.05	.08

Note. Age-11/79 IQ = the raw age-11/79 MHT score corrected for age in days at the time of testing and then converted into IQ scores (by definition, IQ at 11 and 79 both have a mean of 100, and a standard deviation of 15). Cognitive ability ages 79 and 83 is the first unrotated principal component from a factor analysis of Raven's Matrices, Verbal Fluency and Logical Memory at ages 79 and 83. Cognitive ability change is the standardised residual from a linear regression with age-83 cognitive ability as dependent variable and age-79 cognitive ability as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. TIE = Typical Intellectual Engagement. AL = Activity Lifestyle. T = total sample (N = 277-463), M = male (N = 128-198), F = female (N = 150-265).
$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 9.6 Summary of regression analyses with activity factors predicting age-79 IQ

A

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.64***	.41	.41***
	Sex	-.07		
2	Age-11 IQ	.60***	.44	.03***
	Sex	-.10*		
	Activity 40-55	.19***		
3	Age-11 IQ	.60***	.45	.01*
	Sex	-.11*		
	Activity 40-55	.16**		
	Age-80 Socialising/ Visiting	.09*		

*$p < .05$, **$p < .01$, ***$p < .001$

B

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.64***	.41	.42***
	Sex	-.08		
2	Age-11 IQ	.63***	.43	.02**
	Sex	-.10*		
	Lifetime Spare-time Leisure	.14**		
3	Age-11 IQ	.63***	.44	.01*
	Sex	-.11*		
	Lifetime Spare-time Leisure	.12**		
	Age-80 Activity Lifestyle	.09*		

*$p < .05$, **$p < .01$, ***$p < .001$

Table 9.7 Summary of regression analysis with activity factors predicting later life cognitive change

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.08	.02	.03*
	Sex	.14*		
2	Age-11 IQ	.07	.02	.02*
	Sex	.14*		
	Age-80 Walking	.15*		

$^*p < .05$

Figure 9.1 Lifetime activity participation scree plot

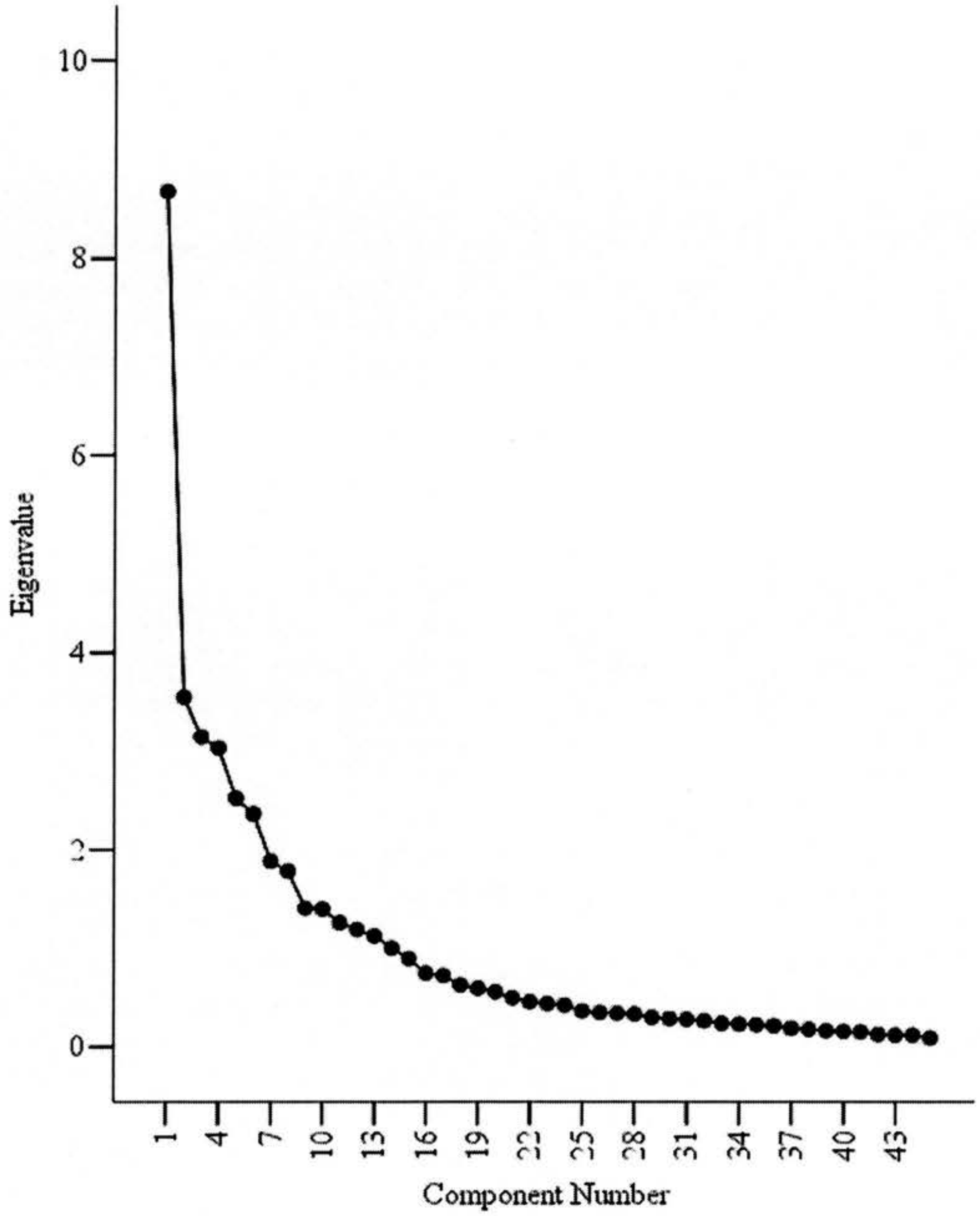


Figure 9.2 Scree plot of activity participation 20-35 years old

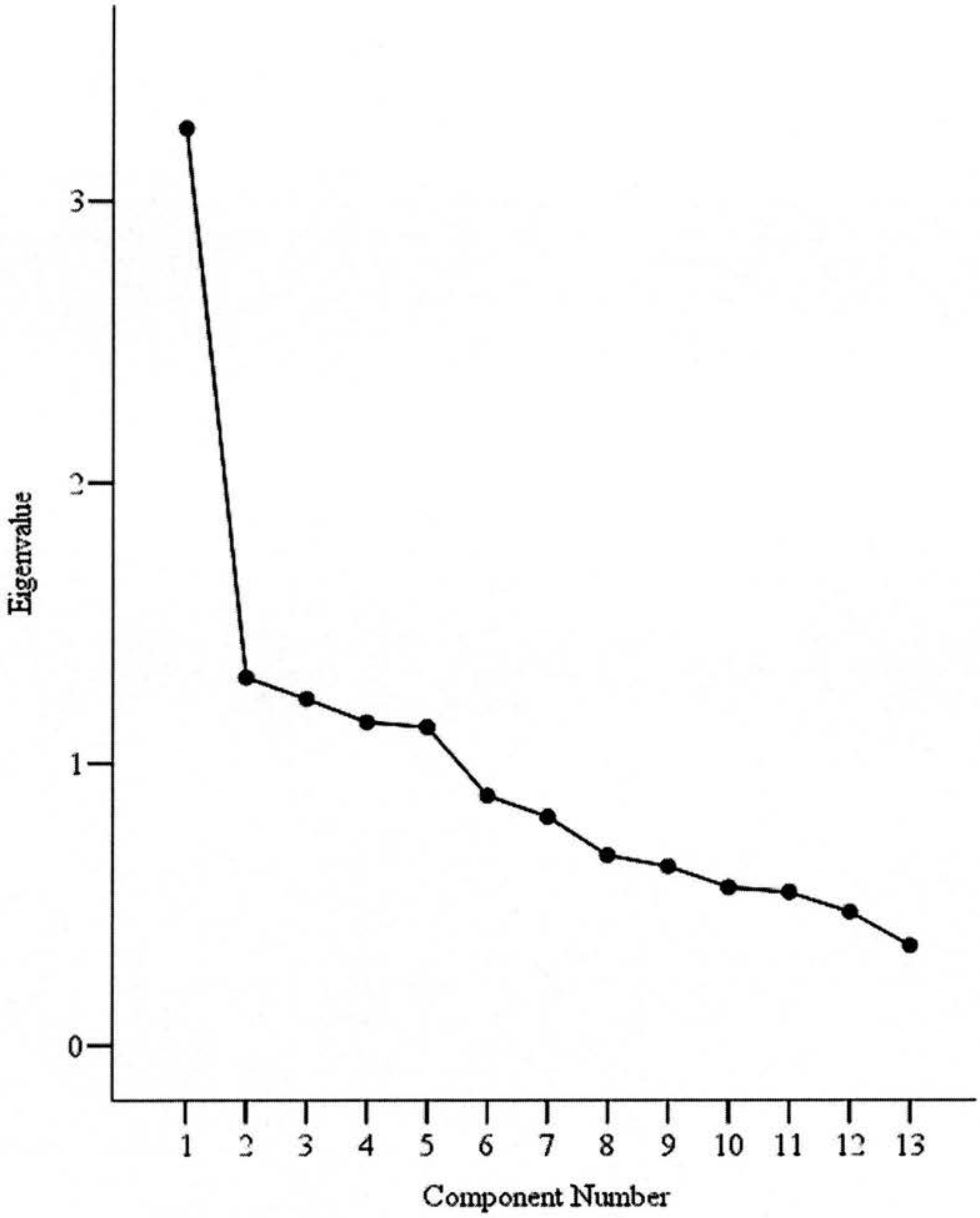


Figure 9.3 Scree plot of activity participation 40-55 years old

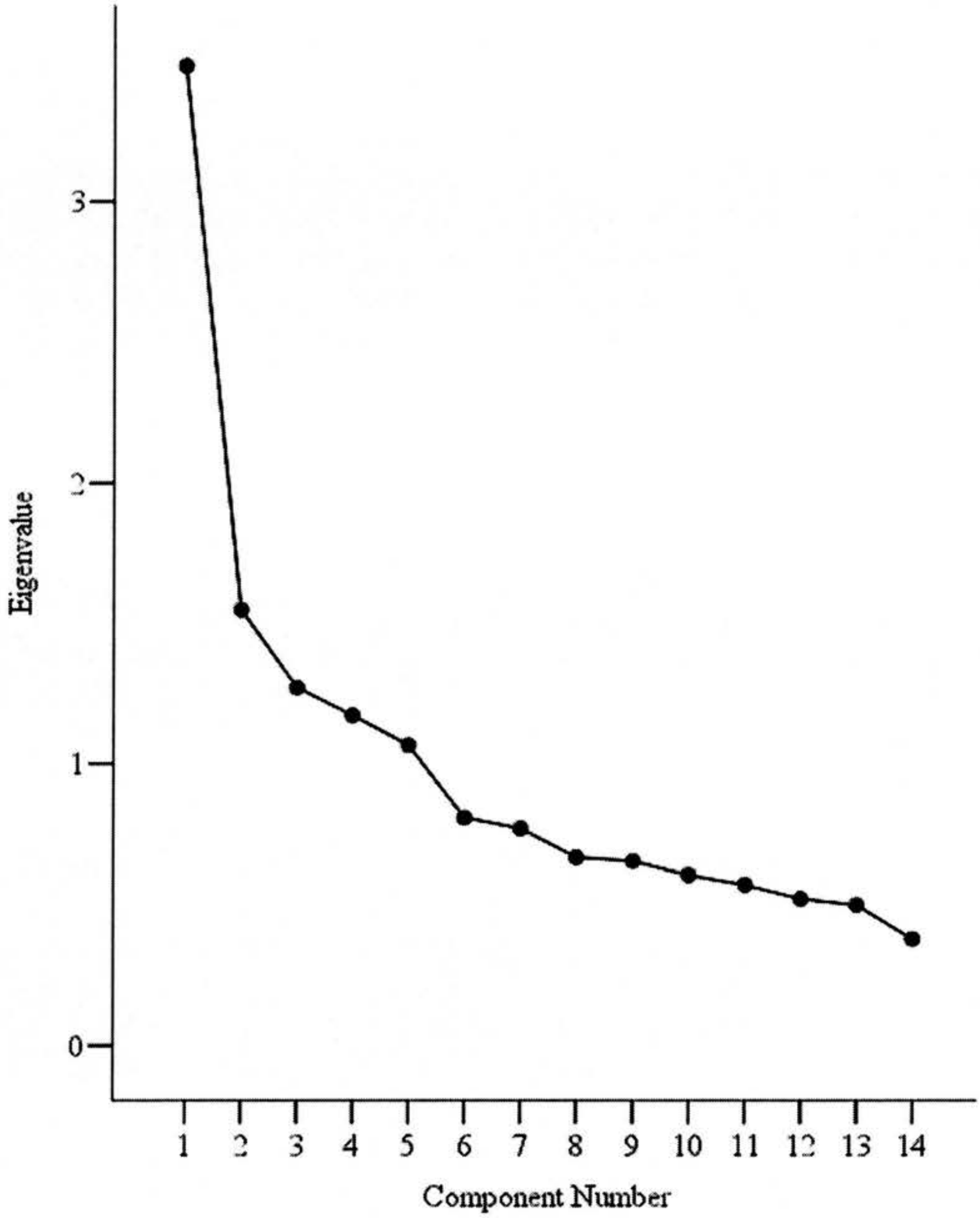
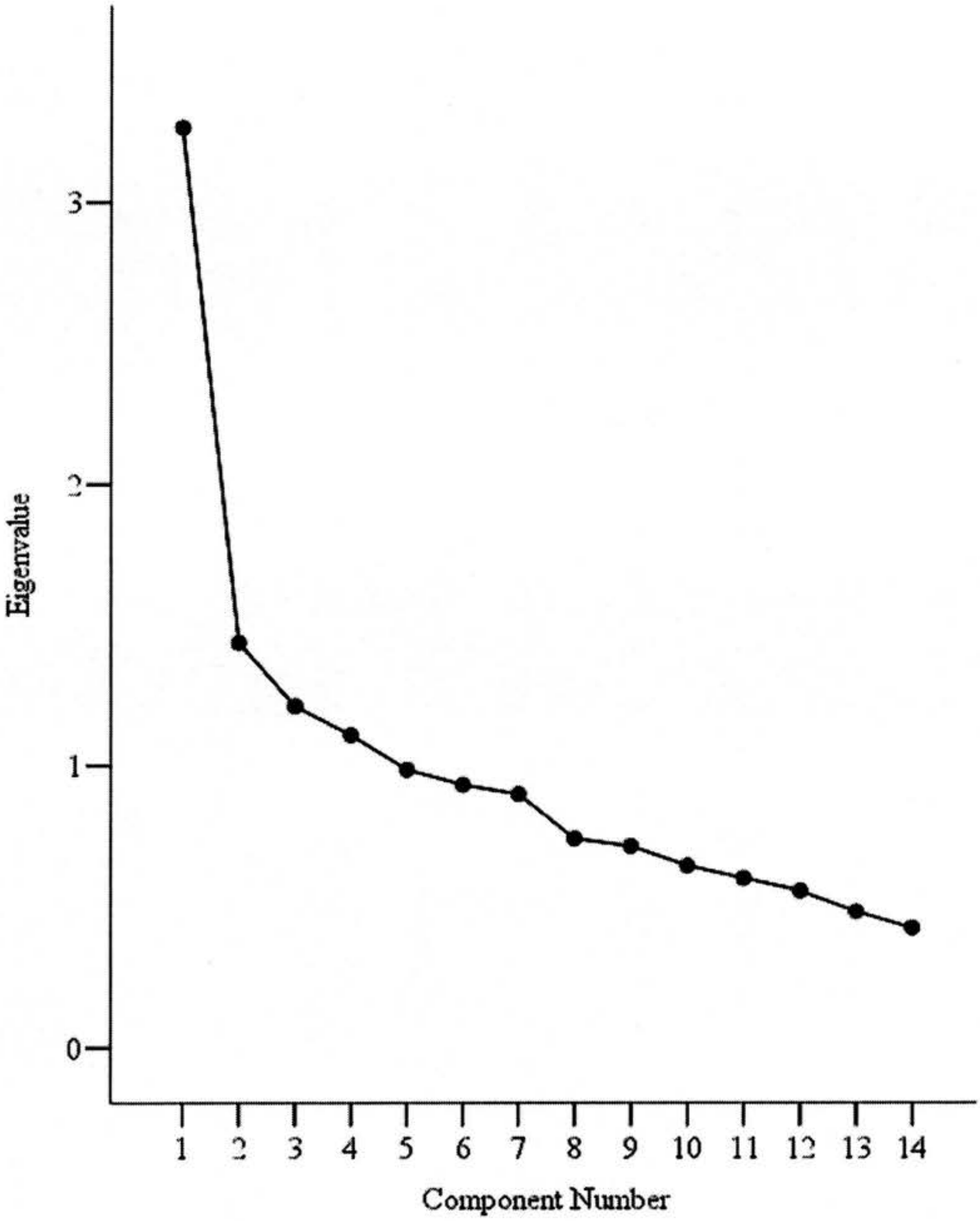


Figure 9.4 Scree plot of activity participation 60-75 years old



Chapter 10: Breaking it down; piecing it together

In the preceding review chapters, when lifestyle domains were investigated as potential predictors of cognitive ageing, a recurrent criticism was the over-reliance on single, broad measures of cognition (in certain instances this comprised one general test while in others a composite score based on a number of tests was used). Analysing only a general cognitive test or factor may neglect important domain-specific variation. This criticism could equally be levelled at the current analysis with the Lothian Birth Cohort 1921. Within each analysis chapter cognitive ability has been defined either by performance on the Moray House Test (an omnibus test of ability, transformed to give IQ scores) or general cognitive ability composed of 3 cognitive tests (Raven's Progressive Matrices, Verbal Fluency and Logical Memory). Specific domains of intellectual functioning might be differentially affected by psychosocial lifestyle factors. As such, and where possible, the predictors of changes in these separate domains across time should be investigated alongside general cognitive function. This analysis in the LBC1921 will be detailed below.

Secondly, the areas of lifestyle thought to be predictive of cognitive ageing are often examined in isolation to other potentially important lifestyle domains, an approach which has been repeated with the LBC1921 in Chapters 5, 7 and 9.

> Whilst researchers have addressed the direct effect of job complexity and the direct effects of leisure activities, we know very little about the combined effect of these or other environmental variables (Schaie et al., 1990, p. 62).

In the final analysis to be reported, predictors of cognitive ageing identified from the 3 distinct lifestyle domains assessed (occupational characteristics, social networks and support and activity participation) will be investigated simultaneously. But first, breaking it down by cognitive domain.

10.1. Lifestyle predictors of domain-specific cognitive ageing in the LBC1921

At ages 79 and 83, participants in the Lothian Birth Cohort 1921 were given 3 tests of cognitive ability assessing different domains of intellectual function: Raven's Matrices to assess non-verbal reasoning, Verbal Fluency to assess executive function and Logical Memory to assess verbal declarative memory. Examining what predicts changes in these separate tests over time is therefore possible, as well as whether a lifestyle factor affects all 3 domains (and cognitive ageing overall by referring to earlier analyses) or is more specific. Significant decline was observed over 4 years in the LBC1921 for Raven's Matrices and Verbal Fluency but not Logical Memory (Chapter 3). Due to a lack of observable change in the latter test (although the 'lack' of change might be a combination of age-related decline and practice), it is unlikely that any of the lifestyle factors will predict changes in this test.

Predictors of domain-specific cognitive change will be analysed as follows. Associations between the lifestyle factors and 4-year change in the 3 cognitive tests will be presented. These change measures were described in Chapter 3, but in summary, the age-83 cognitive test score (age-adjusted) was entered as the dependent variable in a linear regression; the age-79 cognitive test score (age-adjusted) was entered as the independent variable; the standardised residual produced was used as a measure of later life cognitive change (79 to 83 years old) for the particular cognitive test; a higher score represents less relative cognitive decline over the 4 years. For simplicity, only partial correlations controlling for age-11 IQ between these change measures and the lifestyle factors are being considered. That is, any significant relationships are independent of childhood ability.

10.1.1. Occupational characteristics and domain-specific cognitive ageing

From Chapter 5, cognitive change in old age (based on the 3-test composite measure) was associated with the following work history and occupational variables: age of retirement, coworker support, social support (supervisor plus coworker support) and physical isometric loads. In the regression analysis, the level of coworker support was the only factor contributing to the variance in cognitive change from age 79 to 83 (accounting for about 2%), controlling for age-11 IQ and sex. The associations between work history and occupational characteristics and 4-year change in each of the cognitive tests are shown in Tables 10.1 and 10.2. In this analysis, the association between retirement age and cognitive change was only significant for Verbal Fluency ($r = -.14$, $p = .020$); those who retired later showed greater decline in Verbal Fluency performance over the 4-years of follow-up in later life, independently of childhood ability. Retirement choice (own versus forced) was negatively associated with the change in Raven's matrices ($r = -.13$, $p = .041$). Those who felt forced into retirement showed a greater decline in Raven's Matrices performance compared with those who decided to retire [Raven's change score = -0.05 (1.00) versus 0.22 (0.91); $t(256) = 1.967$, $p = .050$].

Increased social support at work (overall and specifically from coworkers) was associated with less decline in Verbal Fluency from age 79 to 83, adjusting for age-11 IQ [$r = .16$ ($p = .014$) and .20 ($p = .001$) respectively]. Increased physical isometric loads at work (the requirement to work with the body in physically awkward positions, for example) was negatively associated with the change in Raven's Matrices independent of pre-morbid ability ($r = -.14$, $p = .026$). Finally, the associations between household work and test-specific change are shown in Table 10.3. There were no significant associations between household work and cognitive decline based on the 3-test composite measure, however, increased household work at 60 to 75 years old was associated with reduced decline on Logical Memory ($r = .15$, $p = .011$). Individuals who reported being less active in the home showed greater negative changes in this test, independently of childhood IQ. From the significant test-specific associations reported, it appears the occupational or work-related factors are affecting the change in performance on particular tests, rather than cognitive function overall, as no factor was associated with decline in more than one domain.

10.1.2. Social networks and support and domain-specific cognitive ageing

When social networks and support were examined in Chapter 7, there were no significant associations in the full sample between these factors and cognitive change (based on the 3-test composite measure). Perhaps unsurprisingly, this pattern is repeated when change is reported separately for the 3 cognitive tests (Tables 10.4-10.7). [Note that for the Significant Others Scale, only the association between the presence/absence of the named significant other and change is reported. Correlations with the level of support received (and discrepancy measures) from particular significant others were not conducted due to a reduction in sample size in these specific groups.] There were no significant associations between later life cognitive change in the 3 distinct domains and measures of lifetime social networks and support, independent of prior ability.

10.1.3. Activity participation and domain-specific cognitive ageing

In Chapter 9, Lifetime Spare-time Leisure, and walking and Typical Intellectual Engagement at age 80 were all associated with reduced 4-year cognitive decline in the full sample. In the regression analysis which controlled for age-11 IQ and sex, walking was the only factor which significantly contributed to the variance in later life cognitive change. Tables 10.8 and 10.9 display the associations between change in the separate cognitive measures and physical and non-physical activity respectively. Walking at age 80 was the only physical activity factor significantly associated with cognitive change, correlating .13 ($p = .026$) with the change in Raven's Matrices after adjustment for age-11 IQ. Interestingly, the correlation between walking and Verbal Fluency change is of a similar magnitude ($r = .11$), but is not significant at generally accepted levels ($p = .060$). Those individuals who reported having walked 2 miles or more in the previous year on any single occasion showed significantly less decline on Raven's Matrices [Raven's change score = 0.11 (0.99) versus -0.16 (0.98); $t(292) = -2.312$, $p = .021$; the change in Verbal Fluency failed to reach accepted levels of significance: Verbal Fluency change score = 0.11 (1.00) in those who walked versus -0.13 (0.97) in those who did not; $t(294) = -1.952$, $p = .052$].

In terms of non-physical activity, only age-80 intellectual engagement was associated with the change in Raven's Matrices after adjustment for childhood ability, correlating .12 ($p = .049$). Those who were more intellectually engaged showed less cognitive decline in later life. Lifetime Spare-time Leisure (suggested as a potential predictor of cognitive change based on the 3-test composite) was not associated with change in any of the separate tests adjusting for age-11 IQ.

The associations discussed above are necessarily exploratory as only a single test was used as a marker for each domain. Consequently, and due to the increased chance of type I errors from the number of associations reported, neither correlations separately by gender nor regression analyses predicting change in the specific tests were conducted. This will be discussed in more detail below, after the combined effect on cognitive change throughout the lifespan across the assessed lifestyle domains has been examined.

10.2. Integrated lifestyle analysis

The second potential criticism of the analyses conducted thus far concerns the fact that the lifestyle domains have been considered as separate entities. Doing so has allowed the examination of each area in some detail by assessing a diverse range of factors. And yet, without an integrated and simultaneous analysis of these disparate lifestyle domains it is not possible to state whether the variance in cognitive change accounted for by a factor from a particular lifestyle domain is independent of the variance explained by factors from other domains. That is, perhaps any protective effects noted across different aspects of lifestyle are explaining the same few percent in the measures of cognitive change due to some shared, underlying factor. The 'predictive' factors might therefore be no more than markers of some latent 'better lifestyle' trait, suggesting that any cognitively beneficial effect is not something specific about the factor assessed *per se*. The associations between the variables included in the regression analyses conducted in Chapters 5, 7 and 9 will be examined. The regressions predicting age-79 IQ and later life cognitive change will then be repeated combining all the potential predictors from the 3 lifestyle domains considered.

10.2.1. Lifestyle and age-79 IQ

Table 10.10 displays the correlations among the factors which were included in the regression analyses predicting age-79 IQ (these were the factors which had a significant association with age-79 IQ after age-11 IQ was controlled). The associations of most interest for current purposes are those between factors from different domains. For example, individuals who reported having received greater support at work were less lonely at age 80 ($r = .15$, $p = .010$) and were more active in midlife and old age ($r = .12\text{-}.21$, $p < .05$). Those who were employed in more physically demanding, physically awkward or hazardous occupations were less active in midlife ($r = -.12$ to $-.15$, $p < .05$), whilst individuals with more complex jobs were more active in mid and later life ($r = .11\text{-}.20$, $p < .05$). Those individuals who reported reduced feelings of loneliness at age 80 were also more active at this time ($r = .12\text{-}.17$, $p < .05$).

The regression analysis predicting age-79 IQ was run as before with age-11 IQ and sex entered in the 1st block. In the 2nd block, all variables which remained significantly associated with age-79 IQ after childhood ability was adjusted were entered stepwise: Supervisor Support, Physical Exertion, Physical Isometric Loads, Hazardous Conditions, voice level at work, Job Complexity, the numbers of years with a spouse/partner at 20-35 years old, the number of close friends/relatives at 20-35, 40-55 and 60-75 years old, the presence of a confidant at 60-75 years old, the presence of a spouse at age 80, living alone at age 80, loneliness at age 80, Activity 40-55, age-80 Walking, age-80 Socialising/Visiting and age-80 Outside Participation. The regression is summarised in Table 10.11 *A*. Age-11 IQ and sex accounted for about 40% of the variance in age-79 IQ. In the final model, Hazardous Conditions (at work) and Activity 40-55 also made significant contributions, each accounting for about 3% of the variance.

Some of the variables included in the above analyses were constituents of higher-order factors which were also associated with age-79 IQ independently of age-11 IQ. The regression was therefore re-run as before, substituting the appropriate factors: Supervisor Support was replaced with Social Support (at work), Hazardous Conditions was replaced with Total Physical Hazards, Activity 40-55 was replaced with Lifetime Spare-time Leisure and age-80 Socialising/Visiting and Outside Participation were replaced with age-80 Activity Lifestyle. The results (Table 10.11 *B*) suggest that Physical Exertion, the number of years lived with a spouse or partner from 20 to 35 years old and voice level at work each contributed about 1-2% to the variance explained (after age-11 IQ and sex which accounted for about 39% of the variance). A final regression was conducted removing Total Physical Hazards and Physical Exertion and replacing them with Total Physical Stressors, summarised in Table 10.11 *C*. In this analysis, variance in age-79 IQ was accounted for by Total Physical Stressors (~3%), Lifetime Spare-time Leisure (~1%) and loneliness at age 80 (~1%), after age-11 IQ and sex.

10.2.2. Lifestyle and later life cognitive change

From Chapters 5, 7 and 9, a number of lifestyle variables were associated with cognitive change in later life. The correlations among these variables are shown in Table 10.12. Individuals who were employed in physically awkward occupations (shown by increased Physical Isometric Loads) participated less frequently in spare-time leisure activities (such as listening to the radio, or reading newspapers or magazines) across the lifespan ($r = -.13$, $p = .020$). Those who received increased support at work (from coworkers or coworkers plus supervisors) were more intellectually engaged at age 80 and were likely to have walked 2 miles of more (on any one occasion in the year preceding the age-80 self-report; $r = .12$-$.14$, $p < .05$).

In the next set of regressions conducted, cognitive change from 79 to 83 years old was the dependent variable, with age-11 IQ and sex entered in block 1. In the 2nd block, the following variables having significant associations to the outcome were entered in a stepwise fashion: age at retirement, Coworker Support, Physical Isometric Loads, Lifetime Spare-time Leisure, age-80 Walking and age-80 Typical Intellectual Engagement. Age-11 IQ and sex accounted for about 3% of the variance in later life cognitive change [$\beta = .15$ ($p = .031$) and .11 ($p = .112$) respectively], however, none of the lifestyle factors entered the model (Table 10.13 *A*). Finally, a model replacing Coworker Support with Social Support was run, summarised in Table 10.13 *B*. In this model, age-11 IQ and sex accounted for about 2% of the variance, and walking in later life contributed a further 1%.

10.2.3. Controlling potential confounders

In the foregoing analyses, a number of factors across different lifestyle domains have emerged as potential predictors of cognitive change. However, the underlying explanation for any observed effects could lie with some unmeasured confounder. But for age-11 IQ and sex (and education in the analysis of occupational characteristics) there has been no control for other factors. To counter this, regressions were conducted for a final time as detailed above with additional control variables included in the 1st block alongside age-11 IQ and sex. These potential confounders – collected at the age-79 Cognitive Testing session – were the number of years in full-time, formal education, social class [the highest occupational position achieved, coded according to the Classification of Occupations (General Register

Office, 1956), ranging from 1 (highest) to 5 (lowest); for married women, the social class of their husband was used], smoking status (current, former or never smoker), number of alcohol units consumed per week, depression [from the Hospital Anxiety and Depression Scale (HADS: Zigmond & Snaith, 1983)], medication use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.

The results obtained were similar to the unadjusted regression analyses. The 3 regressions conducted to predict age-79 IQ are summarised in Table 10.14 (*A-C*). From these analyses, the confounders (entered together in block 1) accounted for 39-40% of the variance in age-79 IQ, although only the contributions of age-11 IQ and sex were significant. In the first variation (Table 10.14 *A*), Hazardous Conditions and Activity 40-55 each accounted for about 2-3% of the variance in age-79 IQ (this is the same as the unadjusted model above). In the second variation (Table 10.14 *B*), voice level at work, Lifetime Spare-time Leisure and Total Physical Hazards contributed to the model, accounting for about 1-2% each. Finally (Table 10.14 *C*), Total Physical Stressors and Lifetime Spare-time Leisure accounted for about 2% each in age-79 IQ, similar to the unadjusted analyses but without a significant contribution from loneliness at age 80.

In the unadjusted models above, walking at age 80 was the only lifestyle predictor of later life cognitive change. The adjusted regression analyses are summarised in Table 10.15 (*A* and *B*), conducted in the same order as before. Walking significantly accounted for variance in cognitive change form 79 to 83 years old, explaining about 2%. In the second analysis (Table 10.15 *B*), age at retirement also accounted for about 1% of the variance explained.

10.3. Discussion

To address potential criticisms of the results reported in previous chapters, some final analyses were carried out with the Lothian Birth Cohort 1921. This was deemed necessary as cognitive decline had only been indexed by a general score rather than examining the change in different domains of functioning separately, and the lifestyle areas assessed were analysed in isolation rather than simultaneously. These final results will be summarised and discussed below, before a closing appraisal of the strengths and limitations of the thesis. The practical implications arising and recommendations for future study will be the subject of Chapter 11.

10.3.1. Summary of results

Regarding the domain-specific analyses reported, the lifestyle factors identified previously as being related to cognitive change in later life were also associated with 4-year change in one of the 3 separate cognitive tests. Interestingly, no lifestyle factor was associated with change in more than one test. This might suggest that any protective or detrimental effects of these factors with respect to cognitive ageing are specific to particular tests or domains. However, a number of weaknesses in this analysis (detailed below) limit the usefulness of these domain-specific results. Furthermore, it has been suggested that:

> environmental factors appear to have greater impact on general (e.g., MMSE, memory composites) than specific measures of cognitive decline… many of the general cognitive ability and memory tests that were sensitive to environmental factors were heavily loaded on aspects of verbal ability and knowledge (i.e., crystallized abilities) (Kramer et al., 2004, p. 945).

It will be necessary to address a number of issues before more thorough domain-specific analyses can occur. This cannot be achieved with the LBC1921 and so these results will not be discussed further.

When the potential predictors of cognitive change from the assessed lifestyle areas were analysed simultaneously, certain factors emerged as important. Variance in IQ at age 79 was accounted for by measures of the hazards and dangers of work, activity in midlife, spare-time leisure activity across the lifespan and the level of loneliness in later life. When further control – in addition to age-11 IQ and sex – was made for a number of potential confounders of these associations (including social class, smoking, medication use and a range of diseases), a measure of the physical dangers and hazards associated with an individual's working environment (Hazardous Conditions or Total Physical Stressors) and a measure of their activity participation (Activity 40-55 or Lifetime Spare-time Leisure) continued to account for variance in age-79 IQ. Each factor contributed between 1% and 3% to the variance explained, where the work hazards were detrimental to, and increased activity was beneficial for, cognitive ability level in old age. In the prediction of later life cognitive change, walking accounted for about 1% of the variance in the model adjusting for age-11 IQ and sex, and about 2% in the fully-adjusted model. Age of retirement also entered the latter model, accounting for a further 1% of the variance in cognitive change from 79 to 83 years old.

10.3.2. Underlying pathways

It is interesting to note that retrospectively assessed factors are contributing to the level of ability in old age (age-79 IQ), independently of a range of potential confounders. Among these are indicators of the hazards encountered at work; the suggested pathways from these to a decrease in cognitive ability were considered in Chapter 5. Furthermore, increased activity in midlife or spare-time activity across the lifespan (such as playing games like cards, chess, bingo or crosswords, or listening to the radio) were protective of cognitive function. Potential pathways underlying this relationship were considered in Chapters 8 and 9, including that the beneficial effect was a consequence of increased social contacts or support derived from being more active, or that participating in the activities themselves has direct effects on the brain, for example. With respect to cognitive change in later life, it was a measure of physical activity in old age which emerged as important: walking. The pathways explaining this effect were also considered in Chapters 8 and 9, and may involve neuroprotective or neurogenerative processes. Age at retirement entered the final model predicting later life cognitive change, whereby those who retired earlier showed less cognitive decline from 79 to 83 years old. This association cannot be explained in terms of those of higher socioeconomic status being able to retire earlier, as social class was controlled in the model. It is more likely that the association is caused by a subgroup of women who left work to take on a homemaker role, and who subsequently never returned to paid employment. If these women who 'retired' early declined less in later life, then the association between retirement age and cognitive ageing is spurious. Furthermore, a link between retirement age and cognition would be difficult to act upon, as a number of factors are likely to influence this decision. Retirement age will therefore not be considered as a predictor of successful cognitive ageing.

Thus in this final, comprehensive analysis of lifestyle factors and cognitive ageing in the LBC1921, occupational hazards and activity are predictive of the outcome. This:

> implies that the vulnerability to cognitive impairments associated with lower IQ can [potentially] be decreased through lifestyle modification. The search for mutable risk factors to decrease the occurrence of dementia [or indeed reduce the deleterious effects of normal cognitive ageing] is vital (Fritsch et al., 2005, p. 1195).

The search for "mutable risk factors" continued in the current thesis is ongoing, and the results here reported now require replication.

10.3.3. Strengths and limitations

In the foregoing analyses, attempts were made to address potential criticisms. As the LBC1921 completed a battery of cognitive tests, it was possible to investigate change in these separately. This is not possible if studies rely on a single, general measure of ability. The domain-specific analyses were conducted with one cognitive test acting as a marker for a domain of cognitive function. However, multiple markers are necessary to effectively index a given domain – examining changes over time in single, specific tests may be insufficient for this purpose. In the LBC1921, multiple markers were not present which has limited the domain-specific analyses. Furthermore, a lack of significant change in one of the tests employed suggests a longer follow-up may be required before this analysis is fruitful given the differences observed in decline across cognitive domains. There were a number of associations between lifestyle factors and change on a specific test which were not significant at accepted levels but were of a similar magnitude to those that were. Given a larger battery with multiple markers for each domain, or an increased follow-up time (allowing greater decline in the measures to occur), a more thorough investigation of this point will be feasible. At present, it is not possible to conclude whether the lifestyle factors were associated with change in only one of the tests, as reported, or if their effect was actually over a broader range of skills (these associations having failed to reach statistical significance). Due to the problems with the domain-specific analyses highlighted, these were not repeated separately by gender. Type I errors were already a concern and additional correlations would have increased the likelihood of this still further.

In combining the factors across lifestyle domains, the final analysis was, in essence, an attempt to identify which of those potentially predictive of cognitive change were the most 'important'. This is possible because of the range of lifestyle factors assessed in the LBC1921. Rarely do studies examine various aspects of lifestyle together even though it is important to identify where any suggested interventions might be most effectively targeted. However, due to the various levels of description possible (for example, higher-order scales being composed of shorter scales which were analysed as standalone factors in their own right) the factors across lifestyle domains could be entered in the analysis in a number of combinations. The route chosen here was to enter those essentially simpler scales first before investigating the higher-order constructs (after removal of their composite parts from the analysis). The actual factors included will have affected the final regression outcomes. Having said that, certain factors emerged regardless of the level of description employed (notably those covering hazards at work or activity participation throughout the lifespan); it is these areas which may therefore be seen as noteworthy with respect to cognitive ageing. Further efforts aimed at a more detailed specification of these areas is suggested. The strengths and weaknesses discussed above refer to the final analyses conducted. In Chapter 11, more general strengths and limitations of the current analyses will be considered as part of recommendations for further study.

Table 10.1 Correlations between work history variables and later life cognitive change (N = 255-284)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Principal occupation years	.08	-.03	-.01
Principal occupation hours/week	-.06	.08	-.00
Lifetime years worked	.00	-.10	-.06
Retirement age	-.01	-.14*	-.09
Retirement choice	-.13*	.09	-.02

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Retirement choice is a dichotomous variable. All correlations are adjusted for age-11 IQ.
*$p < .05$

Table 10.2 Correlations between occupational characteristics and later life cognitive change (N = 236-284)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Skill Discretion	-.01	-.02	-.10
Decision Authority	-.08	-.02	-.03
Decision Latitude	-.05	-.03	-.06
Psychological Job Demands	-.06	-.05	-.05
Coworker Support	.02	.20**	.09
Supervisor Support	.07	.05	.05
Social Support	.06	.16*	.09
Physical Exertion	-.02	-.07	.00
Physical Isometric Loads	-.14*	-.11	-.01
Hazardous Conditions	-.04	-.02	-.01
Toxic Exposures	-.01	.02	.04
Total Physical Hazards	-.03	.00	.01
Total Physical Stressors	-.03	-.04	.01
Job Complexity	.01	-.06	-.08
Mental Work Demands	-.01	-.03	-.07
Voice level at work	-.08	-.01	-.08

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Decision Latitude = Skill Discretion + Decision Authority; Social Support = Coworker Support + Supervisor Support; Total Physical Hazards = addition of z-scored Hazardous Conditions + z-scored Toxic Exposures; Total Physical Stressors = addition of z-scored Physical Exertion + z-scored Total Physical Hazards. All scales are from the Job Content Questionnaire except Job Complexity and Mental Work Demands. All correlations are adjusted for age-11 IQ.
*$p < .05$, **$p < .01$

Table 10.3 Correlations between household work and later life cognitive change (N = 280-284)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Household work 20-35	.02	.02	.06
Household work 40-55	-.00	.09	.09
Household work 60-75	.00	.07	.15*
Lifetime household work	.01	.07	.11

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. All correlations are adjusted for age-11 IQ.
*$p < .05$

Table 10.4 Correlations between lifetime social network characteristics and later life cognitive change (N = 227-285)

		Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Number of years lived alone	20-35	.12	-.01	.11
	40-55	.03	-.02	.06
	60-75	-.01	.05	.06
Lived with spouse/partner	20-35	-.05	-.06	-.01
	40-55	-.05	-.04	-.00
	60-75	.01	-.08	-.06
Years lived with spouse/ partner	20-35	-.02	.02	-.03
	40-55	-.06	.05	-.10
	60-75	-.09	.05	.05
Number of children at home	20-35	-.06	-.01	-.09
	40-55	-.07	-.03	-.01
	60-75	.06	-.03	.00
Number of 'close' friends/relatives	20-35	.01	-.02	.04
	40-55	-.01	.02	.03
	60-75	-.02	-.01	.01
Presence of confidant	20-35	.02	.00	-.03
	40-55	.06	.01	.03
	60-75	.07	-.01	.00
Presence of practical support	20-35	-.01	.00	-.00
	40-55	-.06	.01	-.00
	60-75	-.01	.03	-.03
Adequacy of practical support	20-35	-.00	-.05	-.03
	40-55	.02	-.04	.03
	60-75	.03	-.05	.04

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Lived with spouse/partner, presence of confidant, presence of practical support and adequacy of practical support are dichotomous variables. All correlations are adjusted for age-11 IQ.

Table 10.5 Correlations between lifetime level of social support, support satisfaction and later life cognitive change (N = 273-279)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Social Support 20-35	-.06	.04	.06
Social Support 40-55	-.06	.03	-.00
Social Support 60-75	-.09	.02	-.01
Lifetime Social Support	-.08	.03	.01
Social Support Satisfaction 20-35	-.03	.03	.03
Social Support Satisfaction 40-55	-.06	.02	-.04
Social Support Satisfaction 60-75	-.08	.02	.02
Lifetime Social Support Satisfaction	-.06	.03	-.00

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. All correlations are adjusted for age-11 IQ.

Table 10.6 Correlations between age-80 social support factors, household composition, loneliness and later life cognitive change (N = 285-288)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Number of significant others age 80	.06	-.10	.00
Overall Support age 80	.08	-.08	.05
Overall Support Discrepancy age 80	.02	-.10	-.08
Average Support age 80	.03	-.01	.11
Average Support Discrepancy age 80	.01	-.07	-.04
People in house age 11	.03	-.04	-.11
People in house age 80	.03	-.08	-.03
Alone at age 80	.08	-.10	-.03
Loneliness age 80	.05	-.06	.04

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Overall/Average Support Discrepancy = the difference between the ideal and actual level of overall/average support received. Alone at age 80 is a dichotomous variable. All correlations are adjusted for age-11 IQ.

Table 10.7 Correlations between the presence of significant others and later life cognitive change (N = 285-288)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Spouse	.04	-.05	.02
Closest Sibling	.03	-.08	-.03
Other Sibling	.04	-.10	.01
Closest Child	-.05	-.07	-.01
Best Friend	.10	.05	.04

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Correlations shown are between the presence (versus absence) of the named significant other and the outcome. All correlations are adjusted for age-11 IQ.

Table 10.8 Correlations between physical activity and later life cognitive change (N = 278-288)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Physical Activity 20-35	.03	-.00	-.03
Physical Activity 40-55	.07	.10	-.07
Physical Activity 60-75	.08	.11	-.08
Lifetime Physical Activity	.07	.07	-.04
Age-80 Physical Activity	.04	-.01	-.01
Age-80 Walking	.13*	.11	.03

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. Age-80 Physical Activity and age-80 Walking are dichotomous variables. All correlations are adjusted for age-11 IQ.
$^{*}p < .05$

Table 10.9 Correlations between activity participation and later life cognitive change (N = 275-288)

	Raven's Matrices change 79-83	Verbal Fluency change 79-83	Logical Memory change 79-83
Lifetime Activity Participation	.03	.04	.01
Lifetime Social Engagement	-.05	.03	-.06
Lifetime 'Going Out' - rotated factor 2	.03	-.00	-.00
Lifetime Spare-time Leisure	.06	.06	.09
Lifetime Reading	.06	.02	.00
Activity 20-35	.04	.01	-.03
Activity 40-55	.04	.03	.06
Activity 60-75	-.01	.05	-.03
Age-80 TIE	.12*	.02	.08
Age-80 Activity Lifestyle	-.05	.04	.06
Age-80 Socialising/Visiting	-.06	-.00	.09
Age-80 Outside Participation	-.04	.07	.02

Note. The cognitive test change measures are the standardised residuals from a linear regression with age-83 cognitive test performance as the dependent variable and the corresponding age-79 cognitive test performance as the independent variable; a positive change score represents a relative improvement in performance from 79 to 83 years old. TIE = Typical Intellectual Engagement. All correlations are adjusted for age-11 IQ.
$^*p < .05$

Table 10.10 Correlations between the lifestyle factors associated with lifetime cognitive change (N = 253-490)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1.Supervisor Support	-																					
2.Social Sup (Work)	*.86* ***	-																				
3.Physical Exertion	-.16 **	-.18 **	-																			
4.Phys Iso Loads	-.18 **	-.22 ***	.54 ***	-																		
5.Hazardous Conditions	-.14 *	-.13 *	.46 ***	.40 ***	-																	
6.Total Phys Hazards	-.12 *	-.11	.48 ***	.41 ***	*.93* ***	-																
7.Tot Phys Stressors	-.16 **	-.16 **	*.86* ***	.55 ***	*.81* ***	*.86* ***	-															
8.Voice level at work	-.08	-.12 *	.32 ***	.20 ***	.49 ***	.42 ***	.43 ***	-														
9.Job Complexity	.15 **	.21 ***	-.20 ***	-.20 ***	-.02	.04	-.09	-.16 **	-													
10.Yrs lived with spouse 20-35	-.10	-.11	.11	.05	.12	.07	.10	.16 **	-.18 **	-												
11.No. close friends/relatives 20-35	.03	.1	.16 **	.11*	.16 **	.16 **	.20 ***	.09	-.04	.14*	-											
12.No. close friends/relatives 40-55	-.02	.05	.15 **	.11*	.15 **	.16 **	.19 **	.09	-.04	.10	.85 ***	-										
13.No. close friends/relatives 60-75	-.01	.08	.13*	.11*	.08	.10	.14 **	.05	-.09	.10	.79 ***	.84 ***	-									
14.Confidant 60-75	.03	.08	.09	-.05	.02	.01	.06	.08	-.01	.11	.08	.11*	.10*	-								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
15.Spouse age 80	.01	.01	.09	.02	.11*	.12*	.13*	.05	.11*	-.22***	-.04	-.03	-.02	.15**	-							
16.Alone at age 80	-.02	-.01	.08	.01	.05	.06	.08	.01	.12*	-.21***	-.06	-.06	-.05	.11*	.81***	-						
17.Loneliness age 80	.07	.15**	-.02	-.08	-.02	-.02	-.01	.04	.14**	-.13*	.04	.05	.08	.08	.45***	.46***	-					
18.Activity 40-55	.09	.16**	-.15**	-.13*	-.12*	-.08	-.14*	-.12*	.20***	-.08	.03	.05	.07	.06	-.03	-.01	.06	-				
19.Lifetime Spare-time Leisure	.00	.06	-.16**	-.13*	-.08	-.03	-.11*	-.11*	.01	-.03	.02	.01	-.00	.07	.03	-.00	-.00	*.63***	-			
20.Age-80 Soc/Visiting	.12*	.20**	-.10	-.08	-.05	-.01	-.06	-.08	.16**	.01	.13*	.14**	.12*	.12*	-.05	-.09	.17***	.32***	.20***	-		
21.Age-80 Outs Partic	.09	.16**	.01	-.01	.01	.06	.04	-.02	.27***	-.11	.09	.12*	.12*	-.03	.03	.03	.06	.36***	.15**	.36***	-	
22.Age-80 AL	.14*	.21***	-.02	-.04	.00	.05	.02	-.04	.23***	-.03	.14**	.15**	.15**	.05	-.03	-.06	.12*	.42***	.20***	*.78****	*.83****	-
23.Age-80 Walking	.05	.12*	-.01	.07	.13*	.14*	.07	-.02	.11*	-.18**	.01	.02	.03	-.03	.10*	.08	.13**	.24***	.07	.13**	.37***	.32***

Note. The factors in the table above are those which displayed significant associations with age-79 IQ when age-11 IQ was controlled. Items 1-9 are from the assessment of occupational characteristics (Chapter 5), 10-17 are from the assessment of social networks and support (Chapter 7), and 18-23 are from the assessment of activity participation (Chapter 9). Social Sup (Work) = Social support at work (Supervisor Support + Coworker Support); Phys Iso Loads = Physical Isometric Loads; Total Phys Hazards = Total Physical Hazards (addition of z-scored Hazardous Conditions + z-scored Toxic Exposures); Tot Phys Stressors = Total Physical Stressors (addition of z-scored Physical Exertion + z-scored Total Physical Hazards); Age-80 Soc/Visiting = Socialising/Visiting factor from the Activity Lifestyle questionnaire; Age-80 Outs Partic = Outside Participation factor from the Activity Lifestyle questionnaire; Age-80 AL = Activity Lifestyle. Confidant 60-75 is a dichotomous variable for the presence (versus absence) of a confidant at 60-75 years old. Spouse age 80 is a dichotomous variable for the presence (versus absence) of a spouse at age 80. Alone at age 80 is a dichotomous variable for living with others versus alone at age 80. Part-whole correlations (where there are shared items) are shown in italics.

$*p < .05$, $**p < .01$, $***p < .001$

Table 10.11 Summary of regression analyses predicting age-79 IQ

A

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.62***	.39	.39***
	Sex	-.11		
2	Age-11 IQ	.59***	.42	.04***
	Sex	-.14*		
	Hazardous Conditions	-.20***		
3	Age-11 IQ	.55***	.45	.03**
	Sex	-.17**		
	Hazardous Conditions	-.20***		
	Activity 40-55	.17**		

$*p < .05$, $**p < .01$, $***p < .001$

B

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.62***	.39	.39***
	Sex	-.12*		
2	Age-11 IQ	.57***	.41	.03**
	Sex	-.10		
	Physical Exertion	-.18**		
3	Age-11 IQ	.55***	.42	.02*
	Sex	-.07		
	Physical Exertion	-.17**		
	Years lived with spouse/partner 20-35	-.13*		
4	Age-11 IQ	.55***	.43	.01*
	Sex	-.10		
	Physical Exertion	-.14*		
	Years lived with spouse/partner 20-35	-.12*		
	Voice level at work	-.11*		

$*p < .05$, $**p < .01$, $***p < .001$

C

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.62***	.39	.39***
	Sex	-.12*		
2	Age-11 IQ	.57***	.42	.04**
	Sex	-.13*		
	Total Physical Stressors	-.19**		
3	Age-11 IQ	.56***	.43	.01*
	Sex	-.14**		
	Total Physical Stressors	-.20***		
	Lifetime Spare-time Leisure	.12*		
4	Age-11 IQ	.56***	.44	.01*
	Sex	-.12*		
	Total Physical Stressors	-.20***		
	Lifetime Spare-time Leisure	.13*		
	Loneliness age 80	.11*		

*$p < .05$, **$p < .01$, ***$p < .001$

Table 10.12 Correlations between the lifestyle factors associated with later life cognitive change (N = 298-462)

	1	2	3	4	5	6	7
1. Retirement age	-						
2. Coworker Support	-.03	-					
3. Social Support (Work)	.00	*.80****	-				
4. Physical Isometric Loads	.05	-.20***	-.22***	-			
5. Lifetime Spare-time Leisure	-.05	.10	.06	-.13*	-		
6. Age-80 TIE	.06	.14*	.12*	.03	.20***	-	
7. Age-80 Walking	.03	.14*	.12*	.07	.07	.11*	-

Note. The factors in the table above are those which displayed significant associations with the measure cognitive of change from 79 to 83 years old (from the cognitive ability composite). Items 1-4 are from the assessment of occupational characteristics (Chapter 5) and 5-7 are from the assessment of activity participation (Chapter 9). Social Support (Work) = Supervisor Support + Coworker Support; TIE = Typical Intellectual Engagement. Age-80 Walking is a dichotomous variable. Part-whole correlations (where there are shared items) are shown in italics

*$p < .05$, **$p < .01$, ***$p < .001$

Table 10.13 Summary of regression analyses predicting later life cognitive change

A

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.15*	.03	.03*
	Sex	.11		

*$p < .05$

B

Model	Variable	β	Adjusted multiple R^2	R^2 change
1	Age-11 IQ	.15*	.02	.02
	Sex	.04		
2	Age-11 IQ	.14*	.03	.02*
	Sex	.06		
	Age-80 Walking	.15*		

*$p < .05$

Table 10.14 Summary of fully-adjusted regression analyses predicting age-79 IQ

A

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Potential confounders		.39	.43***
2	Potential confounders		.42	.03**
	Hazardous Conditions	-.18**		
3	Potential confounders		.44	.03**
	Hazardous Conditions	-.18**		
	Activity 40-55	.17**		

Note. The potential confounders entered in block 1 were age-11 IQ, sex, number of years in full-time, formal education, social class, smoking status (current, former or never smoker), number of alcohol units consumed per week, depression, medication use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.
$^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

B

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Potential confounders		.40	.43***
2	Potential confounders		.42	.02**
	Voice level at work	-.16**		
3	Potential confounders		.43	.01*
	Voice level at work	-.14*		
	Lifetime Spare-time Leisure	.13**		
4	Potential confounders		.44	.01*
	Voice level at work	-.10		
	Lifetime Spare-time Leisure	.14*		
	Total Physical Hazards	-.13*		

Note. The potential confounders entered in block 1 were age-11 IQ, sex, number of years in full-time, formal education, social class, smoking status (current, former or never smoker), number of alcohol units consumed per week, depression, medication

use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.
*$p < .05$, **$p < .01$, ***$p < .001$

C

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Potential confounders		.40	.43***
2	Potential confounders		.42	.02**
	Total Physical Stressors	-.17**		
3	Potential confounders		.44	.02*
	Total Physical Stressors	-.17**		
	Lifetime Spare-time Leisure	.14*		

Note. The potential confounders entered in block 1 were age-11 IQ, sex, number of years in full-time, formal education, social class, smoking status (current, former or never smoker), number of alcohol units consumed per week, depression, medication use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.
*$p < .05$, **$p < .01$, ***$p < .001$

Table 10.15 Summary of fully-adjusted regression analyses predicting later life cognitive change

A

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Potential confounders		-.01	.05
2	Potential confounders		.01	.02*
	Age-80 Walking	.15*		

Note. The potential confounders entered in block 1 were age-11 IQ, sex, number of years in full-time, formal education, social class, smoking status (current, former or never smoker), number of alcohol units consumed per week, depression, medication use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.
$*p < .05$

B

Model	Variable	*β*	Adjusted multiple R^2	R^2 change
1	Potential confounders		-.00	.05
2	Potential confounders		.02	.02*
	Age-80 Walking	.16*		
3	Potential confounders		.03	.02*
	Age-80 Walking	.16*		
	Retirement age	-.15*		

Note. The potential confounders entered in block 1 were age-11 IQ, sex, number of years in full-time, formal education, social class, smoking status (current, former or never smoker), number of alcohol units consumed per week, depression, medication use (yes/no) and medical history of cerebrovascular disease, cardiovascular disease, diabetes and hypertension.
$*p < .05$

Chapter 11: Future directions and recommendations

11.1. Continuing the LBC1921 follow-up

Continued follow-up with the Lothian Birth Cohort 1921 will allow continued cognitive change in later life to be assessed. Follow-up period is a critical factor in determining whether cognitive ageing is adequately assessed (Anstey et al., 2000). This lengthening of the study should allow a greater degree of cognitive decline to be observed, meaning that lifestyle factors which produce a small effect on cognitive outcomes will have a greater chance of becoming apparent (however, it is likely that a reduction in the sample size will balance this to a degree). Furthermore, an extension of the follow-up will produce a longer time period between the lifestyle assessments in later life and the assessment of cognitive function. At present, the self-reports completed at about age 80 occurred after the first cognitive assessment in old age (which took place at a mean age of 79) and proximate to the latest cognitive assessment at age 83. If this next wave were in 2007, the cohort would be then aged about 86 years old. The lifestyle factors assessed in later life would then be predicting change over about 7 years.

11.1.1. Retrospective assessment

With respect to the retrospective method employed currently, this has been largely under-utilised in cognitive ageing research, however,

> retrospective information on health, psychological characteristics, behavior, environment, and other characteristics of exceptionally long-lived individuals extending back several decades would benefit studies of exceptional survival [or, as in this instance, cognitive ageing] (Hadley et al., 2005, p.232).

Such information is rarely available or collected due to concerns about self-reports from elderly individuals. And yet, the individuals in the LBC1921 were able to complete these measures, with certain retrospectively assessed factors emerging as important in the final analysis. This assumes that these items were completed accurately and without bias. In the current assessment of lifestyle factors across time, the periods were chosen to reflect important but potentially different parts of the lifespan: early, middle and late adulthood. By doing so, it is hoped the participants would be able to more clearly reflect on these given ages during which time their social networks or activity participation could be quite different to the other periods. There are, however, gaps between the ages making the assessment non-continuous. The intervening years are not covered. More work is therefore required to refine and extend this procedure.

11.1.2. Replicating the effects

One of the suggestions discussed throughout is the need to replicate the findings observed. Firstly this is necessary to ensure the effects reported are not cohort-specific. This group of individuals has experienced a potentially very different lifestyle to that being experienced nowadays (including living through the Second World War). They are also 'survivors' in that they are able and have chosen to continue with the study. Furthermore, one of the important lifestyle factors identified was work-related hazards and dangers. Changes in work characteristics over time may have reduced exposure to such conditions, and the types of occupations are likely to have changed with time. The occupational characteristics affecting cognitive ageing in a younger cohort may therefore differ from those reported here.

The numerous associations reported were generally small and the risk of type I errors is a very real possibility. Replication of the effects is possible in follow-ups of the LBC1921, however, sample attrition would become an issue, and this would not overcome any perceived deficiencies in the lifestyle assessment or address possible cohort effects. Ideally, replication should be pursued in a new cohort. Although type 1 errors may have resulted in the current analysis from multiple testing, it is important to examine the significance level of these associations; very low p values are still likely to represent replicable associations in other studies. This new sample would need to fulfill a number of features (as well as being an elderly cohort for whom prior cognitive ability data exist, as with the LBC1921). Firstly, the sample assessed should be larger. This will increase the power to detect small effects of lifestyle on cognitive ageing. The sample should be younger than the LBC1921. This will allow a longer potential follow-up into old age and the examination of a different generation to ensure that any observed effects are not cohort specific. Furthermore, if retrospective assessment techniques are to be utilised, a younger cohort may be better able to reflect on periods of their life which are less distant in time. For instance, when aged 83 the LBC1921 were asked to reflect to midlife (when they were aged 40-55 years old); this is 28 to 43 years in their past. However, if a cohort was aged 70 years old, for example, these individuals would be recalling life events from 25 to 30 years previously. The cognitive assessment undertaken should include a larger battery of tests consisting of multiple markers for each domain being considered. Changes in specific domains of cognitive function over time would then be more amenable to examination.

> Progress is being made toward our understanding of the individual difference in maintenance or decrement of intellectual functioning in adulthood and old age. A number of studies have successfully linked complex work environments, more active lifestyles, as well as advantaged environments and lifestyles to the maintenance of high levels of cognitive performance into old age. Some of this research has indicated that the strength of effect of an environmental factor varies depending upon the specific cognitive ability being investigated. Such findings are precisely what would be expected if we accept that human intelligence can be best understood within a multidimensional framework. Not all activities of daily living will require the skills underlying all intellectual abilities, nor will every environmental context have a direct impact on each of those abilities. This consideration points to the need to better define our environmental factors with greater specificity and sharpen our hypotheses concerning their potential influence upon cognitive functioning (Schaie et al., 1990, p. 62).

Any replication of the current study should therefore build on the results presented, suggesting areas for continued and more detailed assessment (occupational characteristics and midlife activity). It would also be possible to refine the assessment of those areas which seemed more problematic, such as social networks and support. Reflecting on this area may be less accurate than activity participation, for example, and so it might be better to focus on a more detailed contemporaneous assessment of social support, with any retrospective assessment covering only readily definable facts (such as the presence of a spouse/partner) or social support over a period in the more recent past (limited to 10-15 years maximum, for example).

Seeking replication in a new sample also affords the opportunity to consider aspects of lifestyle not assessed in the LBC1921. These unmeasured factors may confound the effects presently reported, or independently explain variation in cognitive ageing. Such factors are varied, but could include diet and nutrition (including a more detailed alcohol history), major life events, childhood deprivation, mood and personality to name a few. Other factors identified in the Hendrie et al. (2006) review worthy of further study include – but are not limited to – genetic and biological factors (inflammation and hormone levels, for example), chronic illness and drug use. The current lifestyle assessment is clearly limited in scope when compared with all the possible variables that could be assessed. However, it was directed toward those areas highlighted in previous research for their potential links to successful ageing and those which offered some chance of modification should an effect on cognition be discovered.

11.2. Successful ageing: more than just smarts?

Although the current thesis has focussed on successful cognitive ageing, successful ageing as a general construct is not a single entity and will not be promoted by focussing on one particular aspect of an individual's life. As was alluded to in Chapter 1, successful ageing has been variously defined and conceptualised. Maintaining cognitive vitality has been advocated as a major part of this in the preceding chapters of this thesis, although it is not the sole defining factor of successful ageing (Jorm et al., 1998a). Well-being, for example, is another potential indicator of successful ageing. The determinants of this and other markers of successful ageing should be identified so that they might be promoted as people grow older, in an attempt to increase their level of well-being and contribute to a successful ageing process (Rowe et al., 1987).

Diener and Seligman (2004) recently proposed that well-being ("which we define as peoples' positive evaluation of their lives", p. 1) should be centrally important, and shape future policy decisions in the domains of social, health and economic concerns, such that promoting increased well-being of individuals becomes a fundamental objective for governments. Diener and Seligman (2004) also highlighted that happiness is "an inherent goal – more basic, as the Declaration of Independence contends, than higher income" (p. 24). If well-being possesses such an important role in people's lives, then identifying the predictors of this, and therefore subsequently enhancing its level, is crucially important for society as a whole.

> As societies grow wealthy, however, differences in well-being are less frequently due to income, and are more frequently due to factors such as social relationships and enjoyment at work (Diener & Seligman, 2004, p. 1).

Aspects of an individual's life from which pleasure, engagement and meaning may be derived are those which would be expected to have direct consequences for how they perceive their life satisfaction.

Many of these lifestyle factors will already be familiar from the previous discussion of the determinants of successful cognitive ageing. Might it be, therefore, that similar factors predict increased well-being? In promoting successful cognitive ageing, might it also be possible to promote well-being in later life?

> Paid work activities can provide not only enjoyable activities, but also a structure for the day, social contact, a means of achieving respect, and a source of engagement, challenge, and meaning (Diener et al., 2004, p. 11).

Furthermore, Diener and Seligman (2004) reviewed the importance of social relationships to well-being, and concluded that the "quality of people's social relationships is crucial to their well-being. People need supportive, positive relationships and social belonging to sustain well-being" (p. 18). Alternative aspects of the successful ageing concept are important and must be investigated in ageing individuals. It is very likely that similar lifestyle factors might influence – to varying degrees – diverse aspects of successful ageing, producing several benefits from single interventions (assuming that a person 'accepts' the given intervention). Alternative aspects of successful ageing (including life satisfaction and quality of life) can be examined in the LBC1921 and other studies of ageing individuals, in conjunction with cognitive ability (Gow et al., 2005b).

11.3. Practical implications

With respect to the level of cognitive ability in later life, independent of childhood ability, a number of lifestyle factors emerged as predictive. From the occupational characteristics considered, Hazardous Conditions, Voice level at work and Supervisor Support accounted for variance in age-79 IQ. As mentioned, it may be that changes in working conditions will have altered the degree to which individuals are subjected to dangerous working environments. This result may not, therefore, offer any further suggestions for intervention, although further study is required to determine if alternative work characteristics are now more detrimental or protective (such as Job Complexity). Regarding support from a supervisor being cognitively beneficial, occupational changes are possible whereby individuals requiring extra support in times of increased workload or stress can be identified and assisted. Again, further research is required due to changes in the workplace which will have occurred since the LBC1921 were in employment.

When social support and network characteristics were examined, no real interventions could be recommended. Getting married later appeared to be beneficial, but as discussed, this is likely to have been confounded by higher ability women delaying marriage, rather than there actually being any underlying cognitive benefit. However, for women at least, greater loneliness in later life was related to a poorer cognitive outcome. Although causality cannot be attributed, loneliness in old age may be a marker of reduced social contact and support over a period of time, and therefore interventions aimed at tackling loneliness (in elderly men and women) may be advantageous. This has been a key policy of WHO, in an effort to "reduce risks for loneliness and social isolation" (World Health Organization, 2002, p. 48). In addition to perhaps enhancing or maintaining cognitive functions, social networks may be important for improved well-being in the elderly. Identifying those most socially isolated individuals in the hope of enhancing their social engagement might therefore influence multiple domains of successful ageing.

Activity participation may be the area of lifestyle most amenable to intervention, or at least be included as part of a major public health education programme. The links with physical activity and better health make this more likely still. For an increased level of ability in later life, activities which engage and stimulate an individual may be seen as beneficial. It is important that populations are made aware that their behaviour in midlife can have an impact on their thinking and memory skills many decades later. From the current work, it should be noted that these advantages are not simply due to those of higher initial ability (or social class) being the ones who are more active throughout their lives. There are small, but significant independent effects of increased activity on cognitive ability in old age. With respect to changes in cognitive ability in later life, walking emerged as potentially protective. The coarse nature of the assessment makes it difficult at present to determine what level of physical exertion is required, although "modest levels of physical activity and exercise can have beneficial effects on several cognitive processes of middle aged and older individuals" (Kramer et al., 2005, p. 125). Walking is a free, natural activity which can be done everyday in tandem with other necessary tasks. Simple changes in generally healthy individuals can increase the level of physical activity (taking the stairs instead of the lift for example: World Health Organization, 1998). Increasing the amount of moderate physical activity taken by elderly individuals may present one avenue for the promotion of successful cognitive ageing.

11.4. Closing summary

In this thesis, I investigated potential determinants of cognitive ageing in the Lothian Birth Cohort 1921. This group of individuals were given tests of cognitive ability when aged 11, 79 and 83 years old allowing cognitive change to be assessed across the entire lifespan. The current analysis found that reduced exposure to workplace hazards, increased lifetime activity and decreased feelings of loneliness in old age had favourable consequences for the level of cognitive function in later life (independently of childhood ability), whilst walking behaviour in old age reduced cognitive decline in later life.

In putting it all together, I recommend that:

- Individuals and medical practitioners are advised of the importance of activity from midlife for cognitive health outcomes many decades later. Patterns of activity might be easier to maintain into old age if these are started early, rather than attempting to make major behavioural changes later in life. Methods for identifying inactive and disengaged individuals must be developed so that interventions aimed at increasing activity in those 'at risk' might occur at a point when they are likely to accrue some benefit over time. In old age, the importance of remaining as active as possible (even through behaviours as simple as walking) must be stressed for the continued protection of cognitive skills. Socially isolated individuals also need to be identified, where possible, and integrated within a supportive network; methods to achieve this need to be developed. Whether such prescriptions will reduce or delay cognitive ageing requires further research, but they may be of benefit to other aspects of well-being and quality of life in elderly individuals.
- Future research aimed at replicating the findings reported is important, particularly in the occupational domain where changes may have already reduced exposure to detrimental conditions. Further studies aimed at identifying pathways, causes and potential interventions are now especially important.

Throughout, a number of lifestyle factors have been investigated for their prediction of later life ability in the Lothian Birth Cohort 1921. However, as has been observed (i.e. Schaie, 1984), the complex inter-relatedness of such lifestyle factors hampers investigation of their separate influences. Causal attributions are problematic although the LBC1921 is now longitudinal and prospective, and with continued waves of testing, can begin to look in more detail at the further predictive value of lifestyle factors for cognitive ageing.

> We would endorse and recommend to adults of all ages that they engage in intellectually stimulating activities, that they function as informed citizens in society, and that they take on and solve difficult and challenging problems at work and in their everyday lives. We would do so because we endorse the view that intellectual engagement and an active personal and social life are a component of quality of life and, in older adults, one possible indication of successful aging (e.g., Rowe & Kahn, 1998). Older adults, like anyone else, should do crossword puzzles and other activities they find entertaining and enjoyable. Whether they should consider such activities to be the analog of aerobic exercise for the cortex, and therefore solve puzzles in order to foster maintenance of their cognitive functioning, is still very much a matter for debate (Hertzog et al., 1999, p. 533).

The current results would support this advice, specifically where activity participation is concerned, as "ageing well – to which physical activity can make a substantial contribution – is a challenge that brings its own rewards to those who are prepared to face it" (World Health Organization, 1998, p.13).

As Marx (Groucho) is reputed to have said:

> Anyone can get old – all you have to do is live long enough.

Well, more of us *are* living long enough and it is therefore important that generations of future aged individuals are given the opportunity to age successfully by disseminating knowledge of the lifestyle choices which may contribute to making this a reality. The research focus is therefore necessarily turning from what promotes survival to what predicts successful ageing. The NIH report concluded that

> a number of individual lifestyle and health behaviors that alter risk for maintenance of cognitive…health [have been identified]. The evidence suggests that combinations of these factors are more likely to be predictive of high function over time than any one factor alone. However, it is not yet possible to develop prescriptions on an individual basis. Moreover, individuals who have optimal patterns of behavior may still show declines in function. That is to say, that the factors reported here should not be considered deterministic in any fashion. The limitations of this review [and the current thesis], as outlined above, suggest that a number of important factors remain to be identified, which may play an important role in altering outcomes (Hendrie et al., 2006, p. 26).

Much has been learned from the search for the determinants of cognitive ageing but there is much work to be done. This is becoming an increasingly pressing issue with the continued and progressive ageing of the world's population. "Sustaining an older population is the responsibility of everyone – from the government, to the private sector, to individuals themselves. As people are living longer, they clearly must plan to take better care of themselves throughout life" (Butler, 1997, p. 1084). This is predicated on knowing what is protective, and what is detrimental with respect to cognitive ageing. With a concerted effort, such prescriptions will perhaps be possible for future aged individuals.

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Appendices

Appendix I The Moray House Test

The Verbal Test section of the Group Test used in the 1932 Scottish Mental Survey (SMS1932) is reproduced on the following pages (Scottish Council for Research in Education, 1933). The Verbal Test was based on the Moray House Test Number 12, and will be referred to throughout as the Moray House Test or MHT.

DO NOT OPEN THIS BOOKLET OR TURN IT OVER UNTIL YOU ARE TOLD.

THE SCOTTISH COUNCIL FOR RESEARCH IN EDUCATION

1932 MENTAL SURVEY TEST

SEX
(indicate by X)

Boy.
Girl.

INSTRUCTIONS TO PUPILS

Listen carefully to the teacher and do quickly and carefully what you are told to do

Surname: ... Christian Names: ...

Name of Pupil in block capitals, Surname first ....

Name of Education Authority.	Burgh or Parish.	School.

Date of Birth *

Day.	Month.	Year.

To be completed by Teacher.

Class in School.

FOR MARKER'S USE ONLY.

VERBAL TESTS

Page.	Score.	Marked by	
3			
4			
5			
6			
7			
Total of pages 3 to 7.			

PICTURE TEST

Score.	Marked by	

Checked by........................

Entered in nominal roll by..................

Tabulated by......................

* To be checked from register by Teacher.

PUBLISHED FOR THE SCOTTISH COUNCIL FOR RESEARCH IN EDUCATION, BY THE UNIVERSITY OF LONDON PRESS LTD., 10 AND 11 WARWICK LANE, LONDON, E.C.4 PRICE: FOURPENCE

Read each question carefully and then answer it in the bracket or as you are told in the question. Begin at the beginning and go straight through. Try each question as you come to it, but if you cannot do it, go on to the next. The alphabet is printed here to help you with some of the questions.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

1. Do you understand that you must do your best and not ask questions? If so write L in the bracket ... ... ( )
2. Do you understand that you have to go on trying till time is up? If so write 5 ... ... ( )
3. Write the letter which comes before M in the alphabet ... ... ( )
4. I have three uncles. Uncle Fred lives farther away than Uncle Alec, but Uncle Jack lives farthest away of all. Which lives nearest to me?
   Underline the right answer in the bracket. ... ... (Fred, Alec, Jack)
5. Fill in the number which has been left out in the top line of this addition sum, and write it in the bracket as well—

```
   3 . 2   ... ... ... ... ... ... ( )
 1 7 6 6
 -------
 2 1 1 8
```

6. "Tragu" is cheaper than "vashol," and "vashol" is dearer than "spongop." Which is the dearest? ... ... ( )

   Look at this example:—
   Finger is to toe as hand is to ... ... (foot, knee, arm, shoe, nail)
   The answer is one of the words in the bracket. The right answer is foot, and it is underlined.
   Now look at this next example, and then underline the right answers in questions 7, 8, and 9.
   EXAMPLE:—Man is to clothes as what is to fur? ... ... (coat, animal, bird, skin, cloth)

7. Fin is to fish as wing is to ... ... (feather, air, bird, sail, herring)
8. Eat is to drink as bread is to ... ... (iron, water, lead, stones, grass)
9. Father is to son as mother is to ... ... (aunt, nephew, daughter, sister, cousin)
10. If 19 is the same as a dozen and a half, write R, if not write G ... ... ( )

   Look at these five words:—Dog, elephant, sparrow, cow, lion. Sparrow is different from the other four, because all the others have four legs, so it is underlined.
   Look at this example:—Hot, freezing, warm, cold, wet. Here wet is different because all the others are about temperature. Now underline the "different" word in these five:—

11. Eye, pen, nose, chin, ear.

   Do the next three in the same way:—

12. Sixpence, shilling, penny, farthing, franc.
13. Rain, snow, storm, mast, hail.
14. Boy, waggon, kitten, girl, puppy.
15. John is younger than Jim, and Jim is younger than Bill. Which is the oldest of the three?
   Underline the right answer in the bracket. ... ... (John, Jim, Bill)

Go on to NEXT PAGE without waiting to be told

16. If G is found before J in the alphabet and R is found before L, write S. But if only one of these is true write P ... ... ( )

17. Underline the word in the bracket which means nearly the SAME as *little* (large, round, small, bent, wide)

18. Cross out with an X, plainly, the word in the bracket which is nearly the OPPOSITE of *good* (fine, bad, nice, clever, dark)

19. EGAIRRAC is a word written backward. Write it as it usually appears ... ( )

Underline the right answer in the bracket:—

20. Foot is to man as hoof is to ... ... (leather, hard, cow, leg, boot)

21. The words in this sentence have been mixed up. Write it as it ought to be, beneath the printed sentence:—

HUMP CAMEL HAS A HIS A BACK ON

Underline the right answer in the bracket:—

22. Dog is to terrier as what is to Liverpool? ... ... (city, cow, horse, state, cotton)

Underline the "different" word in each of the next three questions:—

23. Knife, saucer, spoon, fork, tart.

24. Radiator, violin, flute, piano, saxophone.

25. Cheap, sweet, sour, salty, bitter.

26. Oak makes better piles for a pier than pine, but not so good as teak. Which wood makes the best piles? Underline the right answer in the bracket. ... ... (oak, pine, teak)

27. If G and H changed places in the alphabet, what would the 8th letter be? ... ... ( )

28. Fill in the missing number in this subtraction sum, and write it in the bracket as well:—

3 . 8 4 5 ... ... ( )
2 5 9 3 6
―――――
1 3 9 0 9

29. If O and N come together in the alphabet write J, if not write C ... ... ( )

30. If $\frac{1}{6}$ is larger than $\frac{1}{5}$ write Q, if not write E ... ... ( )

31. Write the odd numbers that come between 2 and 8 and then cross out the middle one ( )

32. Write the letter that comes most often in the word *Constantinople* ... ... ( )

33. Write this sentence as it ought to read:—

BELL MOST TELEPHONES HAVE ATTACHED A

Go on to **NEXT PAGE** without waiting to be told

34. Do the same with this:—

TRUE BOUGHT CANNOT FRIENDSHIP BE

35. If there are more I's in DIMINISHING than in TRINITARIAN write P, unless there are more N's in the second than in the first, in which case write R ... ... ( )

36. Suppose every fourth letter (D, H, L, and so on) were lost, what would then be the tenth letter? ... ... ( )

37. John's mother has no brothers or sisters. His father has a bachelor brother Frank, and a married sister Mary who has two daughters and one son (Annie, Elizabeth, and Timothy). How many aunts has John? ... ... ( )

38. How many nieces has John's father? ... ... ( )

39. If I am facing the west with my arms stretched sideways, in what direction is my left arm pointing? ... ... ( )

Underline the "different" word in each of the next three questions:—

40. Rain, water, calico, wine, milk.

41. Sheep, lily, cart, trout, thrush.

42. Right, night, bright, black, fright.

Underline the word in the bracket which means nearly the SAME as

43. *accept* ... ... (take, give, hear, learn, find)

Cross out with an X the word in the bracket which is nearly the OPPOSITE of

44. *cautious* ... ... (publish, appoint, suit, careful, heedless)

Underline the right answer in the bracket:—

45. Establish is to abolish as begin is to ... ... (work, year, end, commence, despair)

46. If the letter A occurs most often in the word CANADA write the middle letter of the word SLEEP unless P and R come next to one another in the alphabet, in which case write Y instead ... ... ( )

47. Look at these three proverbs. Two of them mean nearly the same. Put a cross plainly after the other one:—

Well begun is half done.
It's the first step that counts.
Waste not, want not.

48. Do the same with these three. Find which of them mean nearly the same, and then put a cross after the other one:—

Time and tide wait for no man.
It's an ill wind that blows nobody good.
Make hay while the sun shines.

49. Which is the first month after Midsummer Day which has an r in its name? ... ( )

Go on to NEXT PAGE without waiting to be told

In the next three questions underline the right answer in the bracket:—

50. Meeow is to bow-wow as what is to dog? ... ... (hen, cat, donkey, speech, bark)

51. Bullet is to lead as what is to gold? ... ... (paper, coin, silver, copper, purse)

52. Duck is to bird as iron is to ... ... (water, goose, metal, steel, lead)

53. Three posts are at the corners of a large equilateral triangle, that is an equal-sided triangle. From where I am standing, the post nearest to me seems to be exactly half-way between the other two. If I now take two sidesteps to the left, will the posts look more like this I   I I

or more like this? I I   I

Mark the right one with tick √.

In each of the next three questions underline the ONE of the four answers to each statement which seems to you to be correct:—

54. Vitamin is found in—(fresh milk and fruits, lard, dried fruits, stale bread).

55. Metals can be joined together by—(gluing, riveting, nailing, polishing).

56. The forecastle of a ship is at the—(bow, stern, bridge, quarterdeck).

57. Write the letter which is midway in the word BLUEBIRD between the two letters which are the same ... ... (   )

In a certain secret writing

l z q k c o f u,	f t t r	y g g r	means
STARVING,	NEED	FOOD	

58. In the same secret writing you find this. Write below it what it means:—

y o c t   k g c t k l   r t q r

59. Write the two letters in the word TRENCH which have three letters between them in the alphabet ... ... (   )

60. Two of these proverbs have somewhat similar meanings. Mark the other one with a cross:—

Two heads are better than one.
Too many cooks spoil the broth.
Many hands make light work.

61. Do the same with these three. Find which of them mean nearly the same, and then put a cross after the other one:—

There's a skeleton in every cupboard.
It's an ill wind that blows nobody good.
Every cloud has a silver lining.

Go on to NEXT PAGE without waiting to be told

Look at the word in front of the bracket, and in the bracket find one word which is either nearly the same, or nearly the opposite. Underline it if it is the same, cross it out with an X if it is opposite.

62. *no* ... ... (thanks, please, yes, perhaps, what)

63. *appeal* ... ... (split, cleave, remind, beseech, revoke)

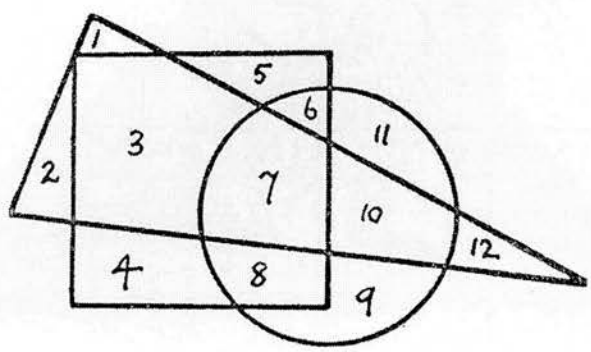
64. *jumps* ... ... (runs, flies, swims, leaps, rests)

65. *bring* ... ... (take, think, make, mend, drop)

66. *fragrant* ... ... (transparent, odorous, critical, brave, fragile)

67. *legislature* ... ... (executive, municipal, parliament, court, palace)

68. *oscillate* ... ... (bring, swing, king, sing, bright)



69. What number is in the triangle and square but not in the circle? ... ... (   )

70. What is the sum of the two numbers which are in the circle only? ... ... (   )

71. Subtract the number which is in the circle and triangle but not in the square from the sum of all the numbers which are in the square but outside the circle ... ... (   )

In each of the next three questions underline the ONE statement which seems to you to be correct:—

72. If your clothes catch fire—(roll yourself in rug or blanket, run about, 'phone fire-brigade).

73. To ventilate a room properly a window must be—(made of stained glass, open top and bottom, polished with chamois leather, covered with curtains).

74. To prevent tools from rusting rub with—(sandpaper, tar, vaseline, file).

The next question is written in the secret writing you have already seen in question 58. Write down what it means and answer it. You can get most of the letters from the explanation in front of question 58, but there are some letters you will have to guess.

75. o l z g r q n D g f r q n ? ... ... (   )

Answer ... ... (   )

The End.

If you are finished before time is up, revise your answers on pages 3 to 7.

PRINTED IN GREAT BRITAIN BY NEILL AND CO., LTD., EDINBURGH

Appendix II Publications from the follow-ups of the 1932 and 1947 Scottish Mental Surveys

2000

Deary, I. J., Whalley, L. J., Lemmon, H., Crawford, J. R., & Starr, J. M. (2000). The stability of individual differences in mental ability from childhood to old age: follow-up of the 1932 Scottish Mental Survey. Intelligence, 28, 49-55.

Starr, J. M., Deary, I. J., Lemmon, H., & Whalley, L. J. (2000). Mental ability age 11 years and health status age 77 years. Age and Ageing, 29, 523-528.

Whalley, L. J., Starr, J. M., Athawes, R., Hunter, D., Pattie, A., & Deary I. J. (2000). Childhood mental ability and dementia. Neurology, 55, 1455-1459.

2001

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Appendix III

Retrospective Self-report

Lothian Birth Cohort 1921 Study

Questionnaire Booklet 2004

LBC
1921

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRES

There are 4 questionnaires in this booklet. YOU DO NOT HAVE TO COMPLETE ALL THE QUESTIONNAIRES AT THE SAME TIME. Each questionnaire is printed on a different coloured sheet so you will know when one ends and another begins. Please feel free to fill them out one at a time at your own pace. The instructions for each questionnaire are printed at the beginning of each sheet.

Some of the questions ask you to think back to different times in your life. You might find it helpful to try to remember where you were living at the time that is being asked about, or what work you were doing, for instance.

Feel free to ask someone to help you fill out the questionnaire, but please make sure that all the answers are your own.

PLEASE ANSWER ALL THE QUESTIONS.

All the information you provide will be kept completely confidential.

Please contact me (Alan Gow) on **0131 651 1685** if you have any queries or problems completing the questionnaires.

When you have completed all the information in the booklet, please check that you have not missed out any pages and return the booklet to me in the pre-paid envelope provided.

THANK YOU FOR YOUR HELP

LBC0172R

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SECTION I: WORK

PART A: YOUR EMPLOYMENT

The following questions are about the main job you held (that is, the job you had for the longest time). Please give the answer that is right for you. If you are unsure about what response to give, please choose the one that appears most appropriate.

1. In your adult life, was your main job (put an "**X**" in the correct box):

☐ full-time ☐ part-time ☐ was not in paid employment

If you mainly worked part-time or were not in paid employment, please go to **Part B** on **page 7**.

If you mainly worked full-time, please go to **question 2**.

2. What was the full title of your main job (the job you had for the longest time)?

____

3. How many years did you do this job? ☐ years

4. How many hours did you work at this job in an average week?

☐ hours

5. Considering your whole working life, how many years did you work full-time altogether?

☐ years

6. What age did you retire? ☐ years old

7. Was retirement your own choice or did you feel forced into it?

☐ own choice ☐ forced

Please answer all the following questions about the job you named in question 2. **Circle** the answer that best fitted your job situation (from strongly disagree, disagree, agree or strongly agree). Sometimes none of the answers fits exactly. Please choose the answer that comes closest.

		strongly disagree	disagree	agree	strongly agree
8.	My job required that I learnt new things.	SD	D	A	SA
9.	My job involved a lot of repetitive work.	SD	D	A	SA
10.	My job required me to be creative.	SD	D	A	SA
11.	My job allowed me to make a lot of decisions on my own.	SD	D	A	SA
12.	My job required a high level of skill.	SD	D	A	SA
13.	On my job, I had very little freedom to decide how I did my work.	SD	D	A	SA
14.	I got to do a variety of different things in my job.	SD	D	A	SA
15.	I had a lot of say about what happened on my job.	SD	D	A	SA
16.	I had an opportunity to develop my own special abilities.	SD	D	A	SA
17.	My job required working very fast.	SD	D	A	SA
18.	My job required working very hard.	SD	D	A	SA
19.	My job required a lot of physical effort.	SD	D	A	SA
20.	I was not asked to do an excessive amount of work.	SD	D	A	SA
21.	I had enough time to get the job done.	SD	D	A	SA
22.	I was often required to move or lift heavy loads on my job.	SD	D	A	SA
23.	My work required rapid and continuous physical activity.	SD	D	A	SA
24.	I was free from conflicting demands that others made.	SD	D	A	SA
25.	My job required long periods of intense concentration on the task.	SD	D	A	SA
26.	My tasks were often interrupted before they could be completed, requiring attention at a later time.	SD	D	A	SA
27.	My job was very hectic.	SD	D	A	SA
28.	My work was monotonous.	SD	D	A	SA
29.	I used my knowledge and skills in my work.	SD	D	A	SA
30.	My work required thinking and weighing decisions.	SD	D	A	SA

		strongly disagree	disagree	agree	strongly agree
31.	At work, I repeated the same partial task or tasks.	SD	D	A	SA
32.	I had to keep on learning new things in my work.	SD	D	A	SA
33.	My work was mentally demanding.	SD	D	A	SA
34.	I had to concentrate strongly during work.	SD	D	A	SA
35.	My work required great precision.	SD	D	A	SA
36.	I regularly worked under time pressure.	SD	D	A	SA
37.	I was often required to work for long periods with my body in physically awkward positions.	SD	D	A	SA
38.	I was required to work for long periods with my head or arms in physically awkward positions.	SD	D	A	SA
39.	Waiting on work from other people or departments often slowed me down on my job.	SD	D	A	SA
40.	My supervisor was concerned about the welfare of those under him.	SD	D	A	SA
41.	My supervisor paid attention to what I was saying.	SD	D	A	SA
42.	I was exposed to hostility and conflict from my supervisor.	SD	D	A	SA
43.	My supervisor was helpful in getting the job done.	SD	D	A	SA
44.	My supervisor was successful in getting people to work together.	SD	D	A	SA
45.	People I worked with were competent in doing their jobs.	SD	D	A	SA
46.	People I worked with took a personal interest in me.	SD	D	A	SA
47.	I was exposed to hostility or conflict from the people I worked with.	SD	D	A	SA
48.	People I worked with were friendly.	SD	D	A	SA
49.	The people I worked with encouraged each other to work together.	SD	D	A	SA
50.	People I worked with were helpful in getting the job done.	SD	D	A	SA
51.	I got information/feedback from my supervisor about how well I did my job.	SD	D	A	SA
52.	I got information/feedback from my co-workers about how well I did my job.	SD	D	A	SA

For these questions, mark the answer which was right for you with an "X".

53. Did you have a problem with exposure to dangerous work methods on your job?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

54. Did you have a problem with exposure to dangerous chemicals on your job?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

55. Did you have a problem with exposure to air pollution from dusts, smoke, gas, fumes, fibres, or other things on your job?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

56. Did you have a problem with exposure to things placed or stored dangerously on your job?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

57. Did you have a problem with exposure to dirty or badly maintained areas at your workplace?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

58. Did you have a problem with risk of catching diseases on your job?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

59. Did you have a problem with dangerous tools, machinery, or equipment?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

60. Did you have a problem with exposure to fire, burns, or shocks?

☐ Not exposed ☐ I was exposed but it was a slight problem ☐ I was exposed and it was a sizeable problem

61. While you were working, how loudly did you have to talk to be heard by someone standing next to you?

☐ Whisper ☐ Normal voice ☐ Loud voice ☐ Shout

PART B: HOUSEHOLD WORK

This part should be completed by everyone.

Some people work in the home instead of or as well as working in paid employment. The following questions are about how much household work you did in your lifetime. We are going to ask you to think about three periods in your adult life.

For each of the periods below, **circle** the number that corresponds to the level of household work you mainly did. The three periods are when you were **20** to **35** years old, **40** to **55** years old and **60** to **75** years old. Each time, try to think about where you were living, who you were living with, and how much responsibility you had for household tasks.

Please include only those activities that you did for at least 7 hours per week. It may help you to consider what a typical day was for you during each period.

Answer this question for when you were 20 to 35 years old

1. What level of household work did you mainly do between **20** and **35** years old? **Circle only one answer.**

1	I did no household work or helped very rarely.
2	I did household activities that could be done whilst mostly sitting.
3	I did household activities that required minimal physical effort such as those done standing, sitting or with slow walking (light gardening, light household activities such as heating up food, dusting or clearing up).
4	I did household activities that were not exhausting, increased the heart rate slightly and might have caused light perspiration (ordinary gardening, main responsibility for light domestic work such as cooking, dusting, clearing up and making beds).
5	I did household activities that increased the heart rate and caused heavy sweating such as those requiring lifting, moving heavy objects, rubbing vigorously for fairly long periods (heavy gardening, home-repairing, responsible for all domestic activities, light as well as heavy, weekly cleaning with vacuum cleaning, washing floors and window-cleaning).

Now think about when you were 40 to 55 years old

2. What level of household work did you do between **40** and **55** years old? **Circle only one answer.**

1	I did no household work or helped very rarely.
2	I did household activities that could be done whilst mostly sitting.
3	I did household activities that required minimal physical effort such as those done standing, sitting or with slow walking (light gardening, light household activities such as heating up food, dusting or clearing up).
4	I did household activities that were not exhausting, increased the heart rate slightly and might have caused light perspiration (ordinary gardening, main responsibility for light domestic work such as cooking, dusting, clearing up and making beds).
5	I did household activities that increased the heart rate and caused heavy sweating such as those requiring lifting, moving heavy objects, rubbing vigorously for fairly long periods (heavy gardening, home-repairing, responsible for all domestic activities, light as well as heavy, weekly cleaning with vacuum cleaning, washing floors and window-cleaning).

Now think about when you were 60 to 75 years old

3. What level of household work did you mainly do between **60** and **75** years old? **Circle only one answer.**

1	I did no household work or helped very rarely.
2	I did household activities that could be done whilst mostly sitting.
3	I did household activities that required minimal physical effort such as those done standing, sitting or with slow walking (light gardening, light household activities such as heating up food, dusting or clearing up).
4	I did household activities that were not exhausting, increased the heart rate slightly and might have caused light perspiration (ordinary gardening, main responsibility for light domestic work such as cooking, dusting, clearing up and making beds).
5	I did household activities that increased the heart rate and caused heavy sweating such as those requiring lifting, moving heavy objects, rubbing vigorously for fairly long periods (heavy gardening, home-repairing, responsible for all domestic activities, light as well as heavy, weekly cleaning with vacuum cleaning, washing floors and window-cleaning).

SECTION II: SUPPORT FROM OTHERS

People sometimes look to others for companionship, assistance, or other types of support. The following questions ask about people in your life who may have provided you with help or support in the past.

You will be asked the same set of questions 3 times. Each set is for a different period in your life. The periods are **20** to **35** years old, **40** to **55** years old and **60** to **75** years old.

To help you answer the questions, try to think about where you were living and who you were living with, for example, in each period.

Please read the instructions carefully and answer all the questions.

AGE 20 to 35

The first questions are for when you were aged between 20 and 35.
To help you answer the questions, try to think about where you were living and what you were doing at this time.

Please answer all the questions.

1. How many years did you live alone between **20** and **35** years old?
Circle the correct number of years.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

2. At any time between **20** and **35** years old, were you living with a spouse or a partner?

☐ Yes ☐ No

3. If you answered yes, how many years were you living with this person between **20** and **35** years old? **Circle** the correct number of years.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

4. When you were **20** to **35** years old, what was the highest number of children you had living at home?

Write in the highest number of children: ☐

5. When you were aged **20** to **35**, about how many 'close' friends and 'close' relatives did you have ('close' meaning people that you felt at ease with, could talk to about what was on your mind, and could call on for help)?

Write in the number of 'close' friends and relatives: ☐

6. When you were aged **20** to **35**, was there any one special person you knew that you felt very close and intimate with - someone you shared confidences and feelings with, someone you felt you could depend on? (This could be anyone including a spouse, family member, close friend).

☐ Yes ☐ No

7. When you needed some extra help between **20** and **35** years old, could you count on anyone to help with daily tasks like grocery shopping, house cleaning, cooking, telephoning, or to give you a lift somewhere?

☐ Yes ☐ No

8. Did you need more help in your daily tasks than you received?

☐ Yes ☐ No

AGE 20 to 35

Each of the following questions has two parts. Part **a)** asks how often each of the following kinds of support was available to you if you needed it. Part **b)** asks how satisfied you were with the overall support you had. If you had no support, **circle** the words "none of the time" for part **a)** but please still rate your level of satisfaction with this in part **b)**.

Please answer all the questions by **circling** the answer that was generally true for you between **20** and **35** years old.

Answer these questions for when you were 20 to 35 years old.

1a) How often were there people you could really count on to be dependable when you needed help?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

1b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

2a) How often were there people you could really count on to help you feel more relaxed when you were under pressure or tense?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

2b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

3a) How often were there people who accepted you totally, including both your worst and your best points?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

3b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

AGE 20 to 35

Remember to answer these questions for when you were 20 to 35 years old.

4a) How often could you really count on people to care about you, regardless of what was happening to you?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

4b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

5a) How often could you really count on people to help you feel better when you were feeling generally down-in-the dumps?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

5b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

6a) How often could you count on people to console you when you were very upset?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

6b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

AGE 40 to 55

This set of questions is for when you were aged between 40 and 55. Again, try to think about where you were living and what you were doing at this time to help you answer the questions.

Please answer all the questions.

1. How many years did you live alone between **40** and **55** years old?
Circle the correct number of years.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

2. At any time between **40** and **55** years old, were you living with a spouse or a partner?

☐ Yes ☐ No

3. If you answered yes, how many years were you living with this person between **40** and **55** years old? **Circle** the correct number of years.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

4. When you were **40** to **55** years old, what was the highest number of children you had living at home?

Write in the highest number of children: ☐

5. When you were aged **40** to **55**, about how many 'close' friends and 'close' relatives did you have ('close' meaning people that you felt at ease with, could talk to about what was on your mind, and could call on for help)?

Write in the number of 'close' friends and relatives: ☐

6. When you were aged **40** to **55**, was there any one special person you knew that you felt very close and intimate with - someone you shared confidences and feelings with, someone you felt you could depend on? (This could be anyone including a spouse, family member, close friend).

☐ Yes ☐ No

7. When you needed some extra help between **40** and **55** years old, could you count on anyone to help with daily tasks like grocery shopping, house cleaning, cooking, telephoning, or to give you a lift somewhere?

☐ Yes ☐ No

8. Did you need more help in your daily tasks than you received?

☐ Yes ☐ No

AGE 40 to 55

Each of the following questions has two parts. Part **a)** asks how often each of the following kinds of support was available to you if you needed it. Part **b)** asks how satisfied you were with the overall support you had. If you had no support, **circle** the words "none of the time" for part **a)** but please still rate your level of satisfaction with this in part **b)**.

Please answer all the questions by **circling** the answer that was generally true for you between **40** and **55** years old.

Answer these questions for when you were 40 to 55 years old.

1a) How often were there people you could really count on to be dependable when you needed help?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

1b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

2a) How often were there people you could really count on to help you feel more relaxed when you were under pressure or tense?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

2b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

3a) How often were there people who accepted you totally, including both your worst and your best points?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

3b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

AGE 40 to 55

Remember to answer these questions for when you were 40 to 55 years old.

4a) How often could you really count on people to care about you, regardless of what was happening to you?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

4b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

5a) How often could you really count on people to help you feel better when you were feeling generally down-in-the dumps?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

5b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

6a) How often could you count on people to console you when you were very upset?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

6b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

AGE 60 to 75

This set of questions is for when you were aged between 60 and 75. Again, try to think about where you were living and what you were doing at this time to help you answer the questions.

Please answer all the questions.

1. How many years did you live alone between **60** and **75** years old?
Circle the correct number of years.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

2. At any time between **60** and **75** years old, were you living with a spouse or a partner?

☐ Yes ☐ No

3. If you answered yes, how many years were you living with this person between **60** and **75** years old? **Circle** the correct number of years.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

4. When you were **60** to **75** years old, what was the highest number of children you had living at home?

Write in the highest number of children: ☐

5. When you were aged **60** to **75**, about how many 'close' friends and 'close' relatives did you have ('close' meaning people that you felt at ease with, could talk to about what was on your mind, and could call on for help)?

Write in the number of 'close' friends and relatives: ☐

6. When you were aged **60** to **75**, was there any one special person you knew that you felt very close and intimate with - someone you shared confidences and feelings with, someone you felt you could depend on? (This could be anyone including a spouse, family member, close friend).

☐ Yes ☐ No

7. When you needed some extra help between **60** and **75** years old, could you count on anyone to help with daily tasks like grocery shopping, house cleaning, cooking, telephoning, or to give you a lift somewhere?

☐ Yes ☐ No

8. Did you need more help in your daily tasks than you received?

☐ Yes ☐ No

AGE 60 to 75

Each of the following questions has two parts. Part **a)** asks how often each of the following kinds of support was available to you if you needed it. Part **b)** asks how satisfied you were with the overall support you had. If you had no support, **circle** the words "none of the time" for part **a)** but please still rate your level of satisfaction with this in part **b)**.

Please answer all the questions by **circling** the answer that was generally true for you between **60** and **75** years old.

Answer these questions for when you were 60 to 75 years old.

1a) How often were there people you could really count on to be dependable when you needed help?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

1b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

2a) How often were there people you could really count on to help you feel more relaxed when you were under pressure or tense?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

2b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

3a) How often were there people who accepted you totally, including both your worst and your best points?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

3b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

AGE 60 to 75

Remember to answer these questions for when you were 60 to 75 years old.

4a) How often could you really count on people to care about you, regardless of what was happening to you?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

4b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

5a) How often could you really count on people to help you feel better when you were feeling generally down-in-the dumps?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

5b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

6a) How often could you count on people to console you when you were very upset?

All of the time	Most of the time	Some of the time	A little of the time	None of the time

6b) How satisfied were you with this level of support?

Very satisfied	Fairly satisfied	A little satisfied	A little dissatisfied	Fairly dissatisfied	Very dissatisfied

SECTION III: ACTIVITIES

This next set of questions is about how often you have participated in a variety of everyday activities throughout your life.

SPORT AND EXERCISE
You are going to be asked to rate how physically active you were in three periods of your life. For each period, please **circle** the number which best indicates the level of sport or exercise you **mainly** participated in.

AGE 20 to 35

From **20** to **35** years old, what level of physical activity did you mainly do? **Circle only one number.**

1	moving only in connection with necessary (household) chores
2	walking or other outdoor activities 1-2 times per week
3	walking or other outdoor activities several times per week
4	exercising 1-2 times per week to the point of perspiring and heavy breathing
5	exercising several times per week to the point of perspiring and heavy breathing
6	keep-fit/heavy exercise or competitive sport several times per week

AGE 40 to 55

From **40** to **55** years old, what level of physical activity did you mainly do? **Circle only one number.**

1	moving only in connection with necessary (household) chores
2	walking or other outdoor activities 1-2 times per week
3	walking or other outdoor activities several times per week
4	exercising 1-2 times per week to the point of perspiring and heavy breathing
5	exercising several times per week to the point of perspiring and heavy breathing
6	keep-fit/heavy exercise or competitive sport several times per week

AGE 60 to 75

From **60** to **75** years old, what level of physical activity did you mainly do? **Circle only one number.**

1	moving only in connection with necessary (household) chores
2	walking or other outdoor activities 1-2 times per week
3	walking or other outdoor activities several times per week
4	exercising 1-2 times per week to the point of perspiring and heavy breathing
5	exercising several times per week to the point of perspiring and heavy breathing
6	keep-fit/heavy exercise or competitive sport several times per week

In this part, you are being asked about other kinds of activities you might have done. Your participation in these activities will be assessed at three different periods in your life.

AGE 20 to 35

The first time is when you were aged between **20** and **35**. To help you answer, try to think about what you were doing during this time and where you were living, for example.

For each activity in the list, mark an "**X**" to show how often you generally did it when you were **20** to **35** years old. If you can't remember exactly, choose the answer which is your best guess. **Answer each item.**

AGE 20 to 35	Every day or about every day	Several times a week	Several times a month	Several times a year	Less than once a year/never
Visits to the library					
Reading a newspaper or magazine					
Reading a book					
Writing					
Playing games (like cards, chess, bingo or crosswords)					
Watching television					
Listening to the radio					
Visits to friends or family					
Study course at work or evening classes					
Going to the cinema, restaurants					
Going to sporting events or concerts					
Trips to the theatre, galleries or museums					
Participation in social groups					
Church or religious activities					
Going to pubs or social clubs					
If you did something not listed above, write the activity in the spaces below. Mark an "**X**" to show how often you did each activity between **20** and **35** years old.					

AGE 40 to 55

Now repeat this process for when you were aged between **40** and **55**. To help you answer, try to think about what you were doing during this time and where you were living, for example.

For each activity in the list, mark an "**X**" to show how often you gernerally did it when you were **40** to **55** years old. If you can't remember exactly, choose the answer which is your best guess. **Answer each item.**

AGE 40 to 55	Every day or about every day	Several times a week	Several times a month	Several times a year	Less than once a year/never
/isits to the library					
?eading a newspaper or magazine					
?eading a book					
Vriting					
'laying games (like cards, chess, ›ingo or crosswords)					
Vatching television					
.istening to the radio					
/isits to friends or family					
;tudy course at work or evening :lasses					
;oing to the cinema, restaurants					
;oing to sporting events or concerts					
'rips to the theatre, galleries or nuseums					
'articipation in social groups					
:hurch or religious activities					
;oing to pubs or social clubs					

f you did something not listed above, write the activity in the spaces ›elow. Mark an "**X**" to show how often you did each activity between **10** and **55** years old.

AGE 60 to 75

This time, fill in the table for when you were aged between **60** and **75**. To help you answer, try to think about what you were doing during this time and where you were living, for example.

For each activity in the list, mark an "**X**" to show how often you generally did it when you were **60** to **75** years old. If you can't remember exactly, choose the answer which is your best guess. **Answer each item.**

AGE 60 to 75	Every day or about every day	Several times a week	Several times a month	Several times a year	Less than once a year/never
Visits to the library					
Reading a newspaper or magazine					
Reading a book					
Writing					
Playing games (like cards, chess, bingo or crosswords)					
Watching television					
Listening to the radio					
Visits to friends or family					
Study course at work or evening classes					
Going to the cinema, restaurants					
Going to sporting events or concerts					
Trips to the theatre, galleries or museums					
Participation in social groups					
Church or religious activities					
Going to pubs or social clubs					
If you did something not listed above, write the activity in the spaces below. Mark an "**X**" to show how often you did each activity between **60** and **75** years old.					

SECTION IV: RELIGIOUS ACTIVITY

This is the final section of the booklet. The following questions are about your religious or spiritual beliefs. We are interested in your responses even if you have no strong religious beliefs, or are an atheist or agnostic.

Please answer all the questions for your own beliefs. There are no right or wrong answers.

Mark an "**X**" in the box which most accurately describes you.

1. Are you now, or have you ever been a member of a religious establishment (e.g. a church or synagogue)?

☐ Yes, current member ☐ Yes, past member ☐ No

2. How often do you usually attend religious services?

☐ More than once a week
☐ Once a week
☐ Once or more each month
☐ Several times a year
☐ Once a year or less
☐ Never

3. How often do you take part in other religious activities (e.g. bible study or choir group)?

☐ More than once a week
☐ Once a week
☐ Once or more each month
☐ Several times a year
☐ Once a year or less
☐ Never

4. How often do you spend time trying to grow in understanding of your faith?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

5. How often do you read literature about your faith (or church)?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

6. How often in the last year have you shared with another church member the problems and joys of trying to live a life of faith in God?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

7. When faced by decisions regarding social problems, how often do you seek guidance from statements and publications provided by the church?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

Please answer all the questions.

8. How often do you read the Bible?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

9. How often do you pray privately in places other than at church?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

10. How often do you talk about religion with your friends, neighbours, or fellow workers?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

11. When you have decisions to make in your everyday life, how often do you try to find out what God wants you to do?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

12. During the last year, how often have you visited someone in need, besides your own relatives?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

13. In talking with members of your family, how often do you yourself mention religion or religious activities?

☐ Regularly ☐ Fairly Frequently ☐ Occasionally ☐ Never

14. I have often personally tried to convert someone to faith in God.

☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

15. I must admit that I don't do very much to increase my knowledge of God.

☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

16. I have had some unusual religious experiences.

☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

17. It is important to me to spend periods of time in private religious thought and meditation.

☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

18. Religion is important in my life today.

☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

Please answer all the questions.

19. God has influenced my life.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

20. I often ask God to forgive my sins.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

21. I know that God answers my prayers.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

22. I believe in eternal life.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

23. Private prayer is one of the most important and satisfying aspects of my religious experience.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

24. Property (house, automobile, money, investments, etc.) belongs to God; we only hold it in trust for Him.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

25. I believe that God revealed Himself to man in Jesus Christ.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

26. Religion is especially important to me because it answers many questions about the meaning of life.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

27. The church is important to me as a place where I get strength and courage for dealing with the trials and problems of life.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

28. I believe that the Bible provides the basic moral principles to guide every decision of my daily life: with family and neighbours, in business and financial transactions, and as a citizen of the nation of the world.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

29. I believe in salvation as release from sin and freedom for new life with God.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

Please answer all the questions.

30. I believe that the word of God is revealed in the Scriptures.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

31. I believe in God as Heavenly Father who watches over me and to whom I am accountable.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

32. I believe that Christ is a living reality.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

33. I know how it feels to repent and experience forgiveness of sin.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

34. I have about given up trying to understand "worship" or get much out of it.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

35. I frequently feel very close to God in prayer, during public worship, or at important moments in my daily life.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

36. I know that I need God's continual love and care.
☐ Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

For each of the following statements, **circle** the one choice that best indicates the extent of your agreement or disagreement as it describes your personal experience. **Please answer all the questions.**

	strongly agree	moderately agree	agree	disagree	moderately disagree	strongly disagree
1. I don't find much satisfaction in private prayer with God.	SA	MA	A	D	MD	SD
2. I don't know who I am, where I came from, or where I'm going.	SA	MA	A	D	MD	SD
3. I believe that God loves me and cares about me.	SA	MA	A	D	MD	SD
4. I feel that life is a positive experience.	SA	MA	A	D	MD	SD
5. I believe that God is impersonal and not interested in my daily situations.	SA	MA	A	D	MD	SD
6. I feel unsettled about my future.	SA	MA	A	D	MD	SD
7. I have a personally meaningful relationship with God.	SA	MA	A	D	MD	SD
8. I feel very fulfilled and satisfied with life.	SA	MA	A	D	MD	SD
9. I don't get much personal strength and support from my God.	SA	MA	A	D	MD	SD
10. I feel a sense of well-being about the direction my life is headed in.	SA	MA	A	D	MD	SD
11. I believe that God is concerned about my problems.	SA	MA	A	D	MD	SD
12. I don't enjoy much about life.	SA	MA	A	D	MD	SD

	strongly agree	moderately agree	agree	disagree	moderately disagree	strongly disagree
13. I don't have a personally satisfying relationship with God.	SA	MA	A	D	MD	SD
14. I feel good about my future.	SA	MA	A	D	MD	SD
15. My relationship with God helps me not to feel lonely.	SA	MA	A	D	MD	SD
16. I feel that life is full of conflict and unhappiness.	SA	MA	A	D	MD	SD
17. I feel most fulfilled when I'm in close communion with God.	SA	MA	A	D	MD	SD
18. Life doesn't have much meaning.	SA	MA	A	D	MD	SD
19. My relation with God contributes to my sense of well-being.	SA	MA	A	D	MD	SD
20. I believe there is some real purpose for my life.	SA	MA	A	D	MD	SD

THANK YOU VERY MUCH FOR COMPLETING THESE QUESTIONNAIRES.
The information you give us is very helpful. We could not do this study without your help.

Please could you look back to check that you haven't missed any questions by mistake or turned two pages at once.

Once you have checked things over, please send the booklet back to us in the envelope provided.

Appendix IV

Retrospective Self-report – Cover letter

LOTHIAN BIRTH COHORT 1921
Department of Psychology
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone 0131 651 1685

00/00/00

«TITLE» «FORENAMES» «SURNAME»
«ADDRESS1»
«ADDRESS2»
«CITY»
«POSTCODE»

Dear «TITLE» «SURNAME» «STUDYNO»

LOTHIAN BIRTH COHORT 1921 STUDY

My name is Alan Gow, and I recently joined the LBC1921 Study team. I have been working with some of the information you have already provided. This is proving very useful and interesting, and I thank you for the time you have already given to the study. You may remember in our Christmas Newsletter we mentioned new phases of the study. The questionnaire booklet enclosed with this letter is part of this. I would like to gather information about the things you may have done throughout your life (like the type of work or activities you did), as it is believed these things may have an impact on later thinking and memory skills.

To add to the information you have already given us, I have produced the questionnaire booklet enclosed. I would be most grateful if you could find some time to fill this out. It has 4 main sections, and you can complete it at your own pace. Some of the questions may seem similar to ones you have done before, but they are asking about different times in your life. More detailed instructions are included in the booklet.

The information you provide is very important to us. We would be most grateful if you would be able to complete the booklet and send it back in the envelope provided. I look forward to receiving your response.

Yours sincerely,

Alan Gow
LBC1921 Study

Appendix V

Retrospective Self-report – Reminder letter

LOTHIAN BIRTH COHORT 1921
Department of Psychology
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone 0131 651 1685

00/00/00

«TITLE» «FORENAMES» «SURNAME»
«ADDRESS1»
«ADDRESS2»
«CITY»
«POSTCODE»

Dear «TITLE» «SURNAME» «STUDYNO»

LOTHIAN BIRTH COHORT 1921 STUDY

You may remember we sent you a letter a few weeks ago asking if you would be willing to complete a questionnaire as part of the LBC1921 Study. We would be very grateful if you could fill in and return the questionnaire if you are able to and wish to do so. If you have already done this, then we do apologise for bothering you again.

We have enclosed a questionnaire booklet and prepaid envelope in case the first set never arrived or was mislaid. We would appreciate it if you are able to spend some time to complete the booklet at your own pace, as it will be very helpful indeed for our research. As ever though, you are under no obligation to complete the booklet, or to give a reason for not doing so.

If you have already replied to our earlier mailing, or are in the process of doing so, we would like to thank you. In that case please return the second questionnaire blank, in the prepaid envelope. If you feel you are unable to complete the questionnaire, or do not wish to, please just return a blank questionnaire in the envelope provided.

Please feel free to contact me (0131 651 1685) if you have any queries about the study or if you have any problems completing the booklet. Thank you once again for all your help with the LBC1921 Study. The information you provide is very important to us.

Yours sincerely,

Alan Gow BSc MSc
LBC1921 Study

Appendix VI

Retrospective Self-report – Correction letter

LOTHIAN BIRTH COHORT 1921
Department of Psychology
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone 0131 651 1685

00/00/00

«TITLE» «FORENAMES» «SURNAME»
«ADDRESS1»
«ADDRESS2»
«CITY»
«POSTCODE»

Dear «TITLE» «SURNAME» «STUDYNO»

LOTHIAN BIRTH COHORT 1921 STUDY

We are very grateful to you for completing the questionnaire we sent to you recently, and apologise for bothering you again. We are sorry it has taken so long to get back to you, but we have been overwhelmed by the response. You filled out the questionnaire very well, but omitted a few of the questions and we were hoping that you would not mind completing these and sending this letter back in the pre-paid envelope provided. The questions were:

Please contact me if you have any queries about completing these questions or if you have any problems.

Thank you for all your help with the LBC1921 Study, the information you provide is very important to us.

Yours sincerely,

Alan Gow
LBC1921 Study

Appendix VII

Retrospective Self-report – Correction reminder letter

LOTHIAN BIRTH COHORT 1921
Department of Psychology
The University of Edinburgh
7 George Square
Edinburgh EH8 9JZ
Telephone 0131 651 1685

00/00/00

«TITLE» «FORENAMES» «SURNAME»
«ADDRESS1»
«ADDRESS2»
«CITY»
«POSTCODE»

Dear «TITLE» «SURNAME» «STUDYNO»

LOTHIAN BIRTH COHORT 1921 STUDY

You may remember we sent you a letter a few weeks ago asking if you would be willing to complete a few of the questions you may have omitted from the main questionnaire booklet we sent you as part of the LBC1921 Study. We would be very grateful if you could complete these and return this letter if you are able to and wish to do so. If you have already done this, then we do apologise for bothering you again.

The questions are below and a prepaid envelope is enclosed in case the first letter never arrived or was mislaid. We would appreciate it if you are able to spend some time to complete these questions, as it will be very helpful indeed for our research. As ever though, you are under no obligation to complete the questions, or to give a reason for not doing so.

If you have already replied to our earlier letter, or are in the process of doing so, we would like to thank you. In that case please return this letter, in the prepaid envelope. If you feel you are unable to complete the questions, or do not wish to, please just return this letter in the envelope provided.

The questions are:

Please feel free to contact me (0131 651 1685) if you have any queries about completing these questions or if you have any problems.

Thank you once again for all your help with the LBC1921 Study. The information you provide is very important to us.

Yours sincerely,

Alan Gow BSc MSc
LBC1921 Study

Appendix VIII Automatic correction of Retrospective Self-report responses

The responses contained within each Retrospective Self-report booklet were checked upon return. In the case of missing items, and multiple or incompatible responses, a correction letter detailing these was mailed to participants (described in Chapter 5). However, it was not deemed appropriate to send such letters for certain atypical or clearly erroneous responses: for example, the inappropriate completion of the full-time work section by an individual employed mostly part-time, or not at all; or the entry of something other than a standard tick or check for items requiring a forced choice response. Such responses, where detected, were automatically corrected, with each of these changes detailed below (the sections correspond to those in the Retrospective Self-report, Appendix III).

Section I: Work
Part A: Your Employment
In your adult life, was your main job...full-time, part-time, was not in paid employment?
Two participants left this item blank, and 2 participants ticked both full-time and part-time. For these, full-time was entered as the response because later answers referred to full-time employment. One participant responded that they were not in paid employment, but this was entered as full-time, as later answers referred to 20 years of full-time work. Two participants ticked full-time but were both entered as not in paid employment due to incompatible correction letter responses suggesting this was the most appropriate category. One final participant ticked all 3 responses; this was not entered as it was not possible to determine the appropriate response.

The response to this first item determined completion of the remaining questions in Part A, which were only to be completed by participants employed mainly full-time. However, 14 participants who stated that their main employment was part-time, and the participant who ticked all 3 choices, responded to the remaining questions, including the Job Content Questionnaire (5 fully and 10 partially); these responses were therefore not entered.

What was the full title of your main job (the job you had for the longest time)?
One participant failed to record the title of their main job, however, this was entered as Plasterer from information contained within an accompanying letter.

How many years did you do this job?
In the 3 cases where participants responded to this item with a range (for example, 12-15), the midpoint was entered (i.e. 13.5). When the numerical value entered was qualified with something such as approximately, "+" or "~", only the numerical value was entered (so 50+ was entered as 50), which occurred on 3 occasions. One participant recorded "36 (20 in named job)", therefore 20 was entered; one participant recorded 45, but recorded in a later item working for 41 years full-time in total, therefore 41 was entered; one participant recorded 50, but worked for 45 years full-time in total therefore 45 was entered; a final participant recorded 60, though they retired at 65 and their total number of years in full time employment was 49, thus 49 was entered.

How many hours did you work at this job in an average week?
For the 14 participants who responded to this item with a range, the midpoint was entered, and for the 8 participants qualifying their response in some way (i.e. ?42), only the number was entered. One participant entered "48 before 1945, 40 after 1946"; this was treated as a range, and so the midpoint (44) was entered. Ten participants entered a value for this item which did not correspond to the number of weekly hours expected in a full-time position, ranging from 8 to 9.5 hours (1 participant entered 7 for this item, 6 entered 8, 1 entered 8 hours 20 minutes, 1 entered 9 and 1 entered 9.5). These responses seemed to refer to daily working hours, and so were accordingly multiplied by 5 to produce a total for a working week (in each case, full-time employment was specified by the answers to other items). Finally, 1 participant entered "12 hour shifts (over 6/7 days)", which referred to a job done for 6½ years as war work. Due to the problems of estimating the hours in an average week intended by this, no value was entered.

Considering your whole working life, how many years did you work full-time altogether?
For the 4 participants who qualified their answers to this item, only the number was entered. One participant recorded 66 years for this item, but reported they retired at the age of 65 to a later item. From previous records, this participant completed 9 years of education and therefore left school at 14. Working full-time from this age to 65 would amount to 51 years, which was entered.

What age did you retire?
Only the numerical value was entered for the 2 participants who qualified their answers to this item. For the participants who entered "22 from PO [Post Office], 61 self-employed" and "60 FT – 65 PT", the latter figure was entered as this refers to their final retirement from the work environment.

In the Job Content Questionnaire (JCQ), 1 participant ticked both agree and disagree for 2 items and another ticked both agree and strongly agree for 1 item; the midpoint was entered in these cases as it is likely they were unable to choose one response only. One participant ticked both strongly disagree and strongly agree for one item; this was left blank as it is more likely this was an error on the part of the participant. Twelve participants marked the items of the JCQ concerning supervisors or co-workers as not applicable (due to working alone or being self-employed with no supervisor, for example). Whilst these were left blank Section I was considered complete overall (and included in the completed numbers accordingly) if all other responses were present, as the items were marked as not applicable by the participants.

Part B: Household Work
What level of household work did you mainly do between X and Y years old? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)
One participant left the item for 20-35 years old blank and marked "army 21-26 then lodgings"; this was entered as "I did no household work or helped very rarely". Three participants circled more than one response for one of these items, and the midpoint was entered in each case (one participant circled 2 responses for 20-35, one circled 2 responses for 20-35 and 3 for 60-75, and one circled 2 responses for 40-55 and 60-75).

Section II: Support from others

How many years did you live alone between X and Y years old? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)
One participant wrote "never alone" for 20-35 years old, and 3 participants left this item blank (one for 40-55 years old, one for 60-75, and one for 40-55 and 60-75). In each case, however, they recorded living with a spouse or partner for 15 years during the particular age period in a later item; these individuals were therefore counted as having lived alone for 0 years in the appropriate age groups.

Seventeen participants provided responses to this item which were incompatible with the number of years they reported living with a spouse or a partner in a given age period (the maximum of these summed responses is 15 years). In 10 participants whose responses to these 2 items summed to 16 or 17 years, their responses were entered as given due to possible minor errors in rounding to a complete number of years in each item. For the 7 remaining participants, the number of years they were living with their spouse or partner was taken as correct, and the answer to this item was therefore computed as the sum to 15 from this.

*At any time between X and Y years old, were you living with a spouse or a partne*r? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)
One participant recorded "wife" for 20-35 years old and another participant marked no for 20-35, but recorded "married at 32" and that they lived together for 3 years; these were therefore was entered as yes. One participant wrote "mother" for 20-35 and that they lived with this person for 15 years in later item. No was entered as later items showed they were never married (the 15 years was disregarded). Another participant ticked both yes and no for 60-75, but wrote "daughter"; this was entered as no, and the 10 years were disregarded. One final participant scored out spouse and partner at 20-35, marked yes and wrote "mother" at this item. This was entered as no, and the 7 years with spouse/partner was disregarded.

When you were X to Y years old, what was the highest number of children you had living at home? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)
For this item, any mark or score through of any sort indicating that this item was not applicable to the participant was entered as 0 children. This occurred on 28 occasions with 19 participants. One participant recorded "1 from 1970 + 2 1969", thus 2 was entered. For 5 participants, blanks were entered as 0: one participant was never married and always lived alone (0 was entered in 3 the age periods); one was never married (0 entered in the 3 age periods); one had recorded "none" at 20-35, "some q. not relevant" at 40-55 and was never married (0 entered for 40-55 and 60-75); one had entered 0 for 20-35 and 60-75 and was never married (0 entered for 40-55); one was never married and had entered a dash in 20-35 (0 entered for 40-55 and 60-75).

When you were aged X to Y, about how many 'close' friends and 'close' relatives did you have ('close' meaning people that you felt at ease with, could talk to about what was on your mind, and could call on for help)? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)
For the 8 participants who responded to this item with a range (on a total of 11 occasions), the midpoint was entered. Twelve participants (on the 31 occasions) qualified the numerical value; only the number was entered. Finally, 17 participants did not provide a number for this item in one or more of the age periods (38 occurrences in total), but wrote "many", "a few", "lots" or "many dozens" for

example. Such entries were entered at a default of 50. On 5 occasions a number greater than this default had been recorded; these were also entered as 50.

Section III: Activities

From X to Y years old, what level of physical activity did you mainly do? (Where X = 20, 40 or 60, and Y = 35, 55 or 75 respectively.)

One participant circled more than one response for 20-35 and 40-55 years old, and so the highest value was entered.

In the activity tables, 6 participants indicated that they did not have a television or that the "watching television" item was not applicable between the ages of 20-35; these responses were therefore entered as less than once a year/never. One participant scored out "church or religious activities" and "going to pubs or social clubs" in each of the 3 age periods, which were also entered as less than once a year/never. One participant entered "4/5" in the several times a month response box for one item, which was entered as several times a month. One participant wrote 'never' for one item rather than ticking the appropriate box, which was therefore entered as less than once a year/never, and wrote "freq" in the several times a year box, which was entered as several times a year. Three participants entered age or year ranges as their response, for example "20-25" was entered in the several times a month box and "26-35" was in the several times a year box for an item. In these cases, the midpoint was entered.

For 32 participants, multiple blanks were left in the activity tables in one or more of the age periods. These were assumed to have been left intentionally blank (that is, that the participant did not do the activity, but had not checked the less than once a year/never box) if consistent evidence was available to suggest they had only marked the activities they participated in. The consistent evidence necessary to allow automatic entry of the once a year/never response included:

when 3 or more activities had been left blank in any one age period, they were entered as less than once a year/never, occurring for 31 participants;

if fewer than 3 items were left blank, but these were consistently omitted across the 3 age periods, they were entered as less than once a year/never, occurring for 4 participants;

one final participant omitted 2 items from the 20-35 age period, but did not respond to a correction or correction reminder letter, and so these responses were entered as less than once a year/never.

(Note the participants in the latter 2 categories could also be counted in the former, giving the total number of participants affected as 32.)

Under the extra activities, 12 participants listed more than 2 activities in one or more of the age periods. Only the first 2 with full frequency information were entered. Two participants entered "summer" and "winter" in different response boxes for one extra activity, and so the midpoint was entered each time. For the 3 participants who wrote "2/3/several times/days per week" for the frequency of their listed extra activity, several times a week was entered (this occurred twice for one participant). One participant also recorded "once a week each" which was entered as several times a month. Finally, one participant recorded "once a week for 4 sessions of 10 weeks", which was entered as several times a year.

Appendix IX Job Content Questionnaire permission

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DEPARTMENT OF WORK ENVIRONMENT

December 2, 2003

Alan J. Gow
Dept of Psychology
University of Edinburgh
7 George Square
Edinburgh, EH8 9JZ
Scotland, UK

Dear Mr. Gow:

Thank you for your interest concerning the "Job Content Instrument: Questionnaire and User's Guide." We have received your "JCQ Data Base Form" and your signed permission form.

I hereby send our questionnaire and validation report and research literature as requested. We look forward to supplying you with information that may assist in your research.

You may find more references and information in our book, Robert Karasek and Tores Theorell: Healthy Work, published by Basic Books, 1990.

Sincerely,

Robert A. Karasek, Ph.D.
Professor, Work Environment

Enclosures: JCQ User's Guide and Questionnaire
w/Global Economy and new Psychological Strain Scales
w/Karasek, et al, NIOSH, 1982
Karasek, et al (1983/ U.S., QES 1970's) Validation Report
Karasek and Thorell (1990 Healthy Work, Appendix 1)
Karasek, Schwartz, Theorell, Final NIOSH Report (1982)
Kristenssen (1995) Stress Med.
Kristenssen (1996) J Occ Hlth Psych
Schnall, Landsbergis, Baker (1994) Annual of Pub. Health.
Kawakami (1996), Industrial Health
Karasek (1979), Administrative Science Quarterly

Appendix X **Table i** Intercorrelations among Job Content Questionnaire scales (N = 318-344)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Skill Discretion	-												
2. Decision Authority	.73***	-											
3. Decision Latitude	*.90****	*.95****	-										
4. Psychological Job Demands	.20***	.10	.16**	-									
5. Coworker Support	.25***	.21***	.24***	-.03	-								
6. Supervisor Support	.13*	.07	.10	-.17**	.39***	-							
7. Social Support	.21***	.15**	.18**	-.14*	*.80****	*.86****	-						
8. Physical Exertion	-.09	-.10	-.10	.34***	-.11*	-.16**	-.18**	-					
9. Physical Isometric Loads	-.14**	-.17**	-.16**	.34***	-.20***	-.18**	-.22***	.54***	-				
10. Hazardous Conditions	.02	-.02	.01	.20***	-.07	-.14*	-.13*	.46***	.40***	-			
11. Toxic Exposures	.13*	.11*	.13*	.19***	-.05	-.08	-.07	.43***	.34***	.71***	-		
12. Total Physical Hazards	.08	.05	.07	.21***	-.06	-.12*	-.11	.48***	.41***	*.93****	*.93****	-	
13. Total Physical Stressors	-.00	-.02	-.01	.32***	-.10	-.16**	-.16**	.86***	.55***	*.81****	*.79****	*.86****	-

Note. Decision Latitude = Skill Discretion + Decision Authority; Social Support = Coworker Support + Supervisor Support; Total Physical Hazards = addition of z-scored Hazardous Conditions + z-scored Toxic Exposures; Total Physical Stressors = addition of z-scored Physical Exertion + z-scored Total Physical Hazards. For the variables produced by summing scales, the correlations with their constituent parts are shown in italics.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Appendix XI Typical Intellectual Engagement questionnaire

The Typical Intellectual Engagement (TIE: Goff & Ackerman, 1992) questionnaire was adapted for use with the LBC1921. The items and format are reproduced on the next 3 pages, which were included as part of a larger booklet distributed to participants when aged 80 (Chapters 7 and 9 of this thesis; Gow, 2003; Gow, Whiteman, Pattie, & Deary, 2005).

INTERESTS QUESTIONNAIRE

For each of the following questions, you will be asked to tick the answer that is right for you.

Do you:
STRONGLY DISAGREE with the statement? If you do, tick **SD.**
MODERATELY DISAGREE with the statement? If you do, tick **MD.**
SLIGHTLY DISAGREE with the statement? If you do, tick **sd.**
SLIGHTLY AGREE with the statement? If you do, tick **sa.**
MODERATELY AGREE with the statement? If you do, tick **MA.**
STRONGLY AGREE with the statement? If you do, tick **SA.**

No	Statement	SD	MD	sd	sa	MA	SA
1.	Almost every section of the newspaper has something in it which interest me.						
2.	Thinking about my life is really important.						
3.	I think deeply about things.						
4.	I keep myself busy with several activities.						
5.	I often take time to mull things over.						
6.	I don't feel the need to know the reasons for everything.						
7.	As long as a job gets done, I don't care how or why it's done.						
8.	When I get interested in something I have to read everything on the subject.						
9.	I tend to think about issues even if they do not affect me personally.						
10.	I would enjoy hearing the details about discoveries in any field.						
11.	Thinking is not my idea of fun.						
12.	I tend to avoid complicated things that require a lot of thinking.						
13.	I like to set aside time to think about things that interest me.						
14.	Thinking about theories or abstract ideas is not appealing to me.						
15.	I am not really bothered if I don't learn everything about a subject.						
16.	I prefer watching educational to entertainment programmes.						
17.	I prefer my life to be filled with puzzles I must solve.						

No	Statement	SD	MD	sd	sa	MA	SA
18.	We have enough to think about without trying to predict the future.						
19.	The most useful principles are those which are easy to understand.						
20.	I enjoy listening to news stories on a wide variety of topics.						
21.	I have only one or two real hobbies.						
22.	I read a great deal.						
23.	Other people think of me as being very serious minded.						
24.	I don't let ideas run my life; I wouldn't go out of my way to write them down or tell others about them.						
25.	I would rather read about my interests than watch television.						
26.	At times I have been so entertained by the cleverness of a crook that I hoped he would get away with it.						
27.	There are very few topics that bore me.						
28.	I prefer dealing with problems that have clear-cut solutions.						
29.	I enjoy the challenge of reading a complicated novel.						
30.	Sometimes I like to consider concepts or ideas even if they have no practical consequences.						
31.	I feel really good when I finally understand something I had to try hard to understand.						
32.	There are many news stories about things that are not important to me.						
33.	I rarely read widely on any one subject.						
34.	I prefer to find things out for myself rather than be told about them.						
35.	The reasons that people do things are usually complex.						
36.	I feel mentally sharpest when I'm deeply involved in a problem.						
37.	I enjoy solving complicated problems.						
38.	I prefer just to let things happen rather than try to understand why they turned out that way.						

STRONGLY DISAGREE **SD** MODERATELY DISAGREE **MD**
SLIGTLY DISAGREE **sd** SLIGHTLY AGREE **sa**
MODERATELY AGREE **MA** STRONGLY AGREE **SA**

No	Statement	SD	MD	sd	sa	MA	SA
39.	When I was a child, I read every book in my house.						
40.	Usually, I read several books at a time.						
41.	I don't like dealing with a situation that needs a lot of thinking.						
42.	I like to think about things even if my thoughts cannot change anything.						
43.	I always feel that I must look into all sides of a problem.						
44.	I maintain a lively interest in reading books on a wide variety of topics.						
45.	I have no great desire to learn new things.						
46.	I prefer complex to simple problems.						
47.	I don't like to waste time thinking about problems that can't be solved.						
48.	Most of my life, I have enjoyed studying so I could learn as many things as possible.						
49.	Ignorance is bliss.						
50.	The main reason I studied in school was because I had to.						
51.	Usually, too much thinking just leads to more errors.						
52.	I read at least ten books a year.						
53.	I have difficulty thinking in new and unfamiliar situations.						
54.	I usually look at a wide variety of newspapers or magazines each month.						
55.	I think it does no good to spend time on ideas that have no practical purpose.						
56.	I really enjoy a task that involves coming up with new solutions to problems.						
57.	I am more interested in sport than intellectual things.						
58.	I am always thinking of ways to improve myself.						
59.	I am an intellectual.						

Please check you have answered all the questions

THANK YOU FOR YOUR HELP

STRONGLY DISAGREE **SD** MODERATELY DISAGREE **MD**
SLIGTLY DISAGREE **sd** SLIGHTLY AGREE **sa**
MODERATELY AGREE **MA** STRONGLY AGREE **SA**

Appendix XII Activity Lifestyle questionnaire

The Activity Lifestyle (AL: Glass, de Leon, Marottoli, & Berkman, 1999) questionnaire was adapted for use with the LBC1921 and included as part of a larger booklet distributed to participants when aged 80 (Chapters 7 and 9 of this thesis; Gow, 2003). The version used is reproduced on the following page.

ACTIVITY LIFESTYLE

This questionnaire asks how often you participate in a variety of everyday activities such as walking and seeing friends. For each of the following questions, you will be asked to tick the answer that is right for you. Please answer all the questions. If you are unsure about what response to give to a question, please choose the one that appears most appropriate.

Please tick the box that most applies for each activity.

Social

Detail of activity	*Never participate*	*Rarely participate*	*Sometimes participate*	*Frequently participate*
Attending church				
Visits to cinema, sporting events, restaurants				
Day or overnight trips				
Playing cards, games, bingo				
Participation in social groups				
Visiting friends				
Talking to friends				
Talking to relatives				
Visiting relatives				
Listening to the radio				
Learning a language				

Fitness

Detail of activity	*Never participate*	*Rarely participate*	*Sometimes participate*	*Frequently participate*
Active sports or swimming				
Walking				
Other physical exercise				

Productive

Detail of activity	*Never participate*	*Rarely participate*	*Sometimes participate*	*Frequently participate*
Gardening				
Paid community work				
Unpaid community work				

Please check you have answered all the questions

THANK YOU FOR YOUR HELP

Appendix XIII Age-80 physical activity questions

The items below were used to assess physical activity in the LBC1921. They were included as part of a larger booklet distributed to participants when aged 80 (Chapters 7 and 9 of this thesis).

Lifestyles

In this section we would like to find out aspects of people's lifestyles which may affect their health.

23 On how many days in an average month (4 weeks) do you do any sport or physical exercise (e.g. dancing or brisk walking) that makes you out of breath and sweat, and that you do for more than 20 minutes at a time?

Please WRITE the number of days a month in the box.

[ ] days in an average month

24 During the last year have you done any walks of 2 miles or more? *These are walks which would usually take about an hour or so. We are interested both in walks you took for pleasure and in walking for other reasons, like to and from the shops.*

Yes 1

No......... 2

Please could you just look back to check that you haven't missed any questions by mistake or turned two pages at once.

THANK YOU VERY MUCH FOR COMPLETING THESE QUESTIONNAIRES. We could not do this study without your help.

Please could you now send the booklet back to us in the envelope provided.

Appendix XIV Alternative factor solutions of lifetime activity participation items

The scree plot produced from the PCA of the 45 items assessing activity participation across the lifespan (Figure 9.1) suggested the extraction of either 4, 6 or 8 factors. Extraction of each of these solutions was carried out with direct oblimin rotation. The 4-factor solution is shown in Table 9.1, and was used to create lifetime activity factors which were examined in relation to lifetime cognitive change in Chapter 9. The 6- and 8-factor solutions are shown in Tables ii and iii respectively. They were not, however, analysed further. The factors produced in these analyses were limited by their specificity, particularly in the 8-factor solution where often only 1 or 2 activities (albeit in the 3 age periods) defined a factor. The 4-factor solution was preferred for its parsimony (producing fewer factors) and clarity (the factors produced were broader but well-defined).

Table ii PCA of lifetime activity participation items: 6-factor solution

		Rotated component					
		1	2	3	4	5	6
Visits to the library	20-35	.12	.02	.08	**-.73**	.01	-.03
	40-55	.13	-.01	.06	**-.77**	-.02	-.04
	60-75	.22	-.08	-.01	**-.65**	.01	-.03
Reading a newspaper or magazine	20-35	.05	-.04	**.78**	.02	.07	-.11
	40-55	-.03	-.00	**.78**	.02	.12	-.02
	60-75	-.05	.01	**.71**	.01	.05	-.04
Reading a book	20-35	.04	-.09	.01	**-.83**	.12	-.05
	40-55	-.03	-.12	.03	**-.88**	.13	-.03
	60-75	-.01	-.16	-.03	**-.82**	.12	-.09
Writing	20-35	.26	-.03	.29	-.16	-.27	.23
	40-55	.28	-.01	**.32**	-.18	-.28	.24
	60-75	.23	-.05	.24	-.13	**-.30**	.27
Playing games (like cards, chess, bingo or crosswords)	20-35	-.08	.29	.10	-.25	**.73**	.13
	40-55	-.05	.26	.09	-.29	**.72**	.18
	60-75	-.15	.26	.09	-.28	**.70**	.17
Watching television	20-35	**.30**	-.16	.03	.18	.23	-.05
	40-55	.24	-.12	**.31**	.21	**.41**	-.06
	60-75	.15	-.09	.22	.12	.24	-.15
Listening to the radio	20-35	-.10	.02	**.73**	-.03	-.01	.09
	40-55	-.05	-.02	**.75**	-.03	-.07	.05
	60-75	-.04	.04	**.69**	-.04	-.09	.04
Visits to friends or family	20-35	**.36**	-.22	-.04	-.03	.26	**.34**
	40-55	**.41**	-.23	-.06	-.01	.26	**.37**
	60-75	**.36**	-.13	-.02	-.02	.21	**.37**
Study course at work or evening classes	20-35	-.07	.14	.11	-.08	**-.40**	.22
	40-55	.01	.12	-.01	-.23	**-.41**	.14
	60-75	.01	.18	-.02	-.22	-.23	.22
Going to the cinema or restaurants	20-35	**.65**	-.00	.03	-.01	.05	-.04
	40-55	**.69**	.11	.00	-.06	.10	-.07
	60-75	**.66**	-.02	-.12	-.12	.00	.07
Going to sporting events or concerts	20-35	**.56**	**.43**	.01	.02	-.13	.02
	40-55	**.62**	**.34**	.01	.02	-.10	.10
	60-75	**.50**	**.34**	.02	-.03	-.15	.13
Trips to the theatre, galleries or museums	20-35	**.60**	.03	.11	-.17	-.14	-.03
	40-55	**.66**	.00	.11	-.21	-.13	-.05
	60-75	**.53**	.03	.08	-.25	-.16	.05
Participation in social groups	20-35	.07	.17	.04	.02	-.03	**.63**
	40-55	.06	.22	.09	-.08	-.06	**.62**
	60-75	-.08	.20	-.01	-.03	-.02	**.65**
Church or religious activities	20-35	-.03	-.22	.01	.06	.10	**.82**
	40-55	-.03	-.24	.02	.06	.04	**.84**
	60-75	-.01	-.21	.01	.10	.03	**.82**
Going to pubs or social clubs	20-35	.06	**.77**	.03	.08	.14	-.13
	40-55	.09	**.81**	.02	.14	.19	-.11
	60-75	.14	**.78**	-.01	.16	.12	.01

Note. Loadings over .30 are highlighted in bold.

Table iii PCA of lifetime activity participation items: 8-factor solution

		Rotated factor							
		1	2	3	4	5	6	7	8
Visits to the library	20-35	.02	.11	.01	**-.77**	-.03	.02	.09	.05
	40-55	.08	.04	.03	**-.78**	-.02	-.01	.08	-.04
	60-75	.20	-.04	.01	**-.67**	-.03	.03	-.05	-.04
Reading a newspaper or magazine	20-35	-.02	.02	**.62**	-.04	.03	-.09	.15	**.40**
	40-55	-.09	.05	**.62**	-.03	.10	-.02	.16	**.37**
	60-75	-.16	.08	**.52**	-.05	.03	-.04	.24	**.40**
Reading a book	20-35	-.05	.01	-.02	**-.89**	.01	.03	-.04	.04
	40-55	-.10	-.05	-.01	**-.89**	.07	.01	-.02	-.01
	60-75	-.07	-.09	-.04	**-.85**	.03	-.03	-.07	-.01
Writing	20-35	.09	-.04	.03	-.08	-.02	.05	**.74**	.24
	40-55	.14	-.04	.08	-.07	-.00	.06	**.72**	.19
	60-75	.10	-.09	.01	-.02	-.01	.07	**.73**	.16
Playing games (like cards, chess, bingo or crosswords)	20-35	-.01	.10	.05	-.01	**.91**	-.05	-.04	-.05
	40-55	.02	.06	.03	-.02	**.93**	-.02	-.00	-.06
	60-75	-.09	.08	.04	-.03	**.89**	-.02	-.01	-.07
Watching television	20-35	.11	.02	-.09	.02	-.06	.04	-.12	**.54**
	40-55	.04	.06	.15	.03	.08	.03	-.15	**.67**
	60-75	-.07	.08	.03	-.02	.00	-.09	.02	**.59**
Listening to the radio	20-35	.06	-.04	**.80**	-.02	.06	.13	-.09	-.10
	40-55	.15	-.08	**.85**	-.00	.02	.09	-.11	-.14
	60-75	.14	-.05	**.78**	-.00	.02	.07	-.07	-.17
Visits to friends or family	20-35	.24	-.19	-.13	-.03	.19	.29	.05	**.32**
	40-55	.28	-.20	-.15	-.02	.17	**.33**	.03	**.32**
	60-75	**.30**	-.14	-.09	.02	.21	**.30**	.07	.19
Study course at work or evening classes	20-35	-.07	.04	.01	.06	-.06	.05	**.60**	-.19
	40-55	.02	.00	-.09	-.05	-.03	-.04	**.61**	-.24
	60-75	.05	.03	-.07	-.02	.14	.03	**.49**	-.28
Going to the cinema or restaurants	20-35	**.61**	-.02	-.00	.01	.04	-.05	.03	.20
	40-55	**.65**	.10	-.02	-.05	.06	-.06	-.03	.19
	60-75	**.66**	-.06	-.10	-.08	.02	.05	-.01	.04
Going to sporting events or concerts	20-35	**.59**	**.40**	.05	-.01	-.10	.06	.02	-.05
	40-55	**.62**	**.32**	.02	-.00	-.07	.12	.06	.02
	60-75	**.56**	.28	.07	-.01	-.06	.14	.05	-.13
Trips to the theatre, galleries or museums	20-35	**.69**	-.08	.16	-.07	.00	-.07	.06	-.11
	40-55	**.72**	-.10	.13	-.10	.02	-.11	.13	-.05
	60-75	**.65**	-.12	.14	-.09	.07	-.03	.14	-.21
Participation in social groups	20-35	.02	.22	.04	-.08	-.06	**.66**	.05	-.01
	40-55	.03	.25	.09	-.08	-.04	**.63**	.11	-.06
	60-75	-.06	.21	.04	-.07	.02	**.65**	.04	-.17
Church or religious activities	20-35	-.09	-.16	.01	-.01	.03	**.81**	.01	.08
	40-55	-.06	-.21	.04	.01	.01	**.83**	.03	.01
	60-75	-.02	-.17	.05	.03	-.02	**.82**	-.03	-.01
Going to pubs or social clubs	20-35	-.01	**.83**	-.02	-.04	.05	-.05	-.04	.07
	40-55	.02	**.86**	-.04	.04	.12	-.05	-.03	.09
	60-75	.09	**.80**	-.05	.08	.09	.05	.01	.02

Note. Loadings over .30 are highlighted in bold.

Appendix XV PCA of Typical Intellectual Engagement questionnaire

The distribution and analysis of the Typical Intellectual Engagement (TIE) questionnaire (adapted from Goff & Ackerman, 1992) has been described previously (Chapters 7 and 9 of this thesis; Gow, 2003; Gow et al., 2005). In summary, a PCA was conducted on the 59 TIE items (Table iv). The 1st unrotated principal component was described by 40 items which were summed to produce an age-80 Typical Intellectual Engagement score (Cronbach's alpha = .88). The PCA suggested that the data could also be described by a 3-factor solution: the 1st component was described by 16 items (Positive Intellectual Engagement, Cronbach's alpha = .84); the 2nd component was also described by 16 items (Negative Intellectual Engagement, Cronbach's alpha =.82); the 3rd factor was described by 6 items (Wide Reading, Cronbach's alpha = .81). The item loadings on the 1st unrotated component and the 3-factor solution are shown in Table iv. For current purposes, only the overall age-80 Typical Intellectual Engagement score will be used.

Table iv Typical Intellectual Engagement questionnaire factor loadings

	1st unrotated	Rotated components		
	component	1	2	3
I like to set aside time to think about things that interest me	**.44**	**.62**	.08	-.02
When I get interested in something I have to read everything on the subject	**.51**	**.61**	-.01	.09
I feel really good when I finally understand something I had to try hard to understand	**.49**	**.59**	-.01	.08
I think deeply about things	**.49**	**.57**	-.09	.03
I often take time to mull things over	**.45**	**.57**	-.05	-.02
Thinking about my life is really important	**.36**	**.56**	.09	-.08
I feel mentally sharpest when I'm deeply involved in a problem	**.50**	**.56**	-.03	.12
I tend to think about issues even if they do not affect me personally	**.51**	**.55**	-.01	.17
I really enjoy a task that involves coming up with new solutions to problems	**.53**	**.53**	-.15	.14
I am always thinking of ways to improve myself	**.35**	**.52**	.12	-.07
I would enjoy hearing about the discoveries in any field	**.50**	**.52**	-.09	.12
I enjoy solving complicated problems	**.55**	**.52**	-.13	.20
I always feel that I must look into all sides of a problem	**.52**	**.50**	-.13	.16
I keep myself busy with several activities	**.41**	**.44**	-.13	.03
I enjoy listening to news stories on a wide variety of topics	**.36**	**.43**	.08	.11
I like to think about things even if my thoughts cannot change anything	**.44**	**.41**	-.12	.16
Most of my life, I have enjoyed studying so I could learn as many things as possible	**.56**	.39	-.22	.35
I prefer my life to be filled with puzzles I must solve	**.34**	.37	-.02	.09
I prefer dealing with problems that have clear-cut solutions	.14	.36	.29	-.04
I prefer watching educational to entertainment programmes	**.37**	.36	-.09	.14
I prefer to find things out for myself rather than be told about them	.27	.35	.11	.08
Other people think of me as being very serious minded	**.34**	.34	-.06	.12
I usually look at a wide variety of newspapers or magazines each month	**.34**	.32	.09	.26
I tend to avoid complicated things that require a lot of thinking	**-.36**	-.13	**.62**	-.03
I don't like dealing with a situation that needs a lot of thinking	**-.34**	-.11	**.61**	-.04
Thinking is not my idea of fun	**-.31**	-.11	**.59**	.02
Thinking about theories or abstract ideas is not appealing to me	-.29	-.11	**.55**	.01
We have enough to think about without trying to predict the future	-.19	.04	**.55**	-.01
I have no great desire to learn new things	**-.44**	-.29	**.53**	-.02
I am not really bothered if I don't learn everything about a subject	-.29	-.16	**.53**	.08
I prefer just to let things happen rather than try to understand why they turned out that way	**-.33**	-.16	**.52**	-.02

I think it does no good to spend time on ideas that have no practical purpose	-.23	.09	**.52**	-.18
Usually, too much thinking just leads to more errors	**-.33**	-.02	**.50**	-.23
The most useful principles are those which are easy to understand	-.03	.25	**.49**	-.05
Ignorance is bliss	-.25	.02	**.47**	-.15
I don't feel the need to know the reasons for everything	-.03	.09	**.42**	.13
I have difficulty thinking in new and unfamiliar situations	-.25	-.02	**.41**	-.14
As long as a job gets done, I don't care how or why it's done	-.11	.03	**.41**	.06
I don't like to waste time thinking about problems that can't be solved	-.12	-.01	**.41**	.10
The main reason I studied in school was because I had to	-.25	-.02	.35	-.21
I rarely read widely on any one subject	**-.30**	-.13	.34	-.14
I don't let ideas run my life; I wouldn't go out of my way to write them down or tell others about them	-.18	-.02	.34	-.05
I am more interested in sport than intellectual things	-.19	.06	.33	-.20
I have only one or two real hobbies	-.05	.04	.30	.08
There are many news stories about things that are not important to me	-.03	.00	.19	.09
I maintain a lively interest in reading books on a wide variety of topics	**.60**	.21	-.11	**.77**
I read a great deal	**.46**	.10	-.01	**.75**
I read at least ten books a year	**.39**	-.02	-.11	**.71**
I enjoy the challenge of reading a complicated novel	**.56**	.25	-.06	**.67**
Usually, I read several books at a time	**.35**	.00	-.05	**.64**
When I was a child, I read every book in my house	**.38**	.07	-.09	**.57**
I prefer complex to simple problems	**.49**	.34	-.10	.38
Sometimes I like to consider concepts or ideas even if they have no practical consequences	**.51**	.32	-.17	.37
I would rather read about my interests than watch television	**.35**	.25	.04	.33
There are very few topics that bore me	**.39**	.29	.01	.33
Almost every section of the newspaper has something in it which interest me	**.30**	.21	.02	.28
The reasons that people do things are usually complex	.19	.11	.09	.27
I am an intellectual	**.40**	.24	-.23	.26
At times I have been so entertained by the cleverness of a crook that I hoped he would get away with it	.09	.02	.01	.15
Percentage variance explained	13.7	10.8	8.9	7.3
Cronbach's alpha	.88	.84	.82	.81

Note. For the 1st unrotated principal component, loadings over .3 are shown in bold. For the rotated factors, loadings over .4 are shown in bold.

Appendix XVI PCA of Activity Lifestyle questionnaire

The distribution and analysis of the Activity Lifestyle (AL) questionnaire (adapted from Glass, de Leon, Marottoli, & Berkman, 1999) has been described previously (Chapters 7 and 9 of this thesis; Gow, 2003). A PCA was conducted on the 17 AL items (Table v). The overall MSA was .73 with the lowest individual value being .53 for paid community work. The 1st unrotated principal component explained 19.9% of the variance and was described by 12 items loading over .30 (shown in Table v). These were summed to give an overall age-80 Activity Lifestyle score (Cronbach's alpha = .72). The scree plot produced (Figure i) suggested the extraction of 2 factors. In the earlier analysis (Gow, 2003) this was conducted with varimax rotation which may not have been appropriate as the factor scores were not independent. The analysis was therefore re-run using an oblique rotation method (direct oblimin rotation). Rotated factor 1 is defined by 6 items (such as visiting friends or talking to relatives) and is labelled Socialising/Visiting. Eleven items loaded over .30 on the 2nd rotated factor although 2 of these had higher cross-loadings on the 1st rotated factor. The factor was therefore defined by 9 items (such as unpaid community work or participation in social groups). The activities defining this factor are quite varied, but may be labelled Outside Participation. The item loadings on these factors are shown in Table v. Scores for the 2 rotated factors were computed by summing the responses to the appropriate items.

Table v Activity Lifestyle questionnaire factor loadings

	1st unrotated component	Rotated components 1	Rotated components 2
Attending church	**.41**	.24	**.30**
Visits to cinema, sporting events, restaurants	**.53**	**.46**	.19
Day or overnight trips	**.57**	**.41**	**.32**
Playing cards, games, bingo	.18	-.01	.27
Participation in social groups	**.47**	.10	**.57**
Visiting friends	**.73**	**.72**	.15
Talking to friends	**.62**	**.69**	.04
Talking to relatives	**.45**	**.78**	**-.32**
Visiting relatives	**.62**	**.77**	-.08
Listening to the radio	.27	.28	.04
Learning a language	.24	-.01	**.35**
Active sports or swimming	**.39**	-.04	**.40**
Walking	**.39**	.15	**.39**
Other physical exercise	**.42**	.05	**.56**
Gardening	.28	.09	**.30**
Paid community work	.06	-.16	**.30**
Unpaid community work	**.40**	-.02	**.61**
Percentage variance explained	19.9	19.9	10.1
Cronbach's alpha	.72	.74	.59

Note. Loadings over .3 are shown in bold. Scores were produced by summing the highlighted items for each factor (unless an item loaded on more than one rotated factor; in these cases, only the highest loading was considered).

Figure i Activity Lifestyle scree plot