Associations between Brief Resilience Scale scores and ageing-related domains in the Lothian Birth Cohort 1936

Adele M. Taylor
University of Edinburgh
Stuart J. Ritchie
King’s College London
Ciara Madden
University of Edinburgh
Ian J. Deary
University of Edinburgh

Adele M. Taylor, Department of Psychology, The University of Edinburgh, Edinburgh, United Kingdom;
Stuart J. Ritchie, Social, Genetic and Developmental Psychiatry Centre, King’s College London, London, United Kingdom;
Ciara Madden, Centre for Dementia Prevention, The University of Edinburgh, Edinburgh, United Kingdom;
Ian J. Deary, Centre for Cognitive Ageing and Cognitive Epidemiology, The University of Edinburgh, Edinburgh, United Kingdom

Correspondence to: Ms Adele Taylor, Department of Psychology, The University of Edinburgh, 7 George Square, Edinburgh, EH8 9JZ, Email: adele.taylor@ed.ac.uk.

We thank LBC1936 participants and members of the research team contributed to the study. The LBC1936 study is supported by Age UK (Disconnected Mind programme grant). The work was undertaken by The University of Edinburgh Centre for Cognitive Ageing and Cognitive Epidemiology, part of the cross council Lifelong Health and Wellbeing Initiative (MR/K026992/1). Funding from the UK Biotechnology and Biological Sciences Research Council (BBSRC) and the UK Medical Research Council (MRC) is gratefully acknowledged. The authors declare no conflict of interest.
Abstract

It is unclear how scores on self-report resilience scales relate to key ageing-related domains in older age, and if they truly measure resilience. We examined antecedents and outcomes of age-76 Brief Resilience Scale scores in participants of the Lothian Birth Cohort 1936 (n = 655). We found bivariate associations between age-76 BRS scores and ageing-relevant antecedent variables measured at least 3 years earlier, from domains of cognitive ability, physical fitness, and wellbeing, and, additionally, sociodemographics and personality (absolute r’s from .082 to .49). Biological health variables were associated with BRS scores. Age-73 cognitive ability (largest $\beta = 0.14$), physical fitness (largest $\beta = 0.084$), and wellbeing variables (largest $\beta = 0.26$) made positive independent contributions to age-76 BRS scores in multivariate models. In a conservative model including all variables as covariates, corrected for multiple comparisons, only emotional stability (neuroticism) significantly independently contributed to BRS score ($\beta = 0.33$). An exploratory backwards elimination model indicated more wellbeing and personality associates of BRS scores ($\beta$s from .087 to .32). We used latent difference score modelling to assess outcomes of BRS scores; we examined associations between age-76 BRS and change in latent factors of age-related domains between age 76 and 79. Whereas BRS scores were related cross-sectionally to levels of latent cognitive ability ($r = .19$), physical fitness ($r = .20$), and wellbeing ($r = .60$) factors, they were not related to declines in these domains. The independence of the BRS construct from established wellbeing and personality factors is unclear.

Keywords: brief resilience scale, cognitive ability, ageing, personality, wellbeing
BRS scores in older age

Older age is often characterised negatively due to the increase in poor health and other adverse events experienced by many older people. Mean declines in cognitive (Salthouse, 2004) and physical functions (Cooper et al., 2011) are seen in older age. Age-related decline is evident in biological and physiological processes (López-Otín, Blasco, Partridge, Serrano, & Kroemer, 2013). Mental health changes have also been reported, including greater prevalence of depression in older age (Steffens, Fisher, Langa, Potter, & Plassman, 2009). Changes in these key age-related domains have the potential to impact negatively upon an individual’s independence, health and wellbeing (Lara et al., 2013). Yet, even when health and mental function are found to be objectively poor, some older adults report having high levels of ‘successful ageing’ (Jeste et al., 2013), and happiness (Jopp & Rott, 2006). This suggests that some people may be better able to withstand age-related changes in health and functioning than others. What accounts for this variation between individuals is still to be determined, though it has recently been suggested that resilience - the ability to adapt positively to risk or adversity – might be important in withstanding the negative consequences of ageing (MacLeod, Musich, Hawkins, Alsgaard, & Wicker, 2016; Wild, Wiles, & Allen, 2013).

In what follows, we stress that it is important to keep in mind the possible difference between the construct of resilience, and the name given to the scores from a scale that purports to assess resilience. Studies that have examined so-called resilience in older age have found some evidence of associations with key age-related domains. Several have focused on relationships between scores on questionnaires that purport to assess resilience and wellbeing, and other psychological constructs. In a study of older adults (mean age 77 years; \(n=171\)), geographically and demographically similar to those investigated here, moderate associations were found between scores of the self-report Brief Resilience Scale (BRS; Smith et al., 2008) and better mental wellbeing \((r = .41, p < .001)\), and fewer symptoms of anxiety and depression \((r = -.46, p < .001)\) (Harris, Brett, Starr, Deary & McIntosh, 2016). Other studies, that used scores from the Connor-Davidson Resilience Scale (CD-RISC), found higher scores to be associated with: lower daily stress \((r = -.38, n = 27)\) (Ong, Bergeman, Bisconti, & Wallace, 2006); greater emotional wellbeing \((r = .49, n = 1,395)\) and optimism \((r = .44, n = 1,395)\) (Lamond et al., 2009); and lower levels of loneliness \((r = -.29, n = 2,025)\) (Kuwert, Knaevelsrud, & Pietrzak, 2014).
In addition to psychological health, physical health has also been related to various self-report measures purporting to assess resilience. Perna et al. (2016) examined differences in health behaviours between individuals with high and low scores on a short version of the Resilience Scale (RS). They found that, in individuals aged ≥ 65 years ($n = 3,347$), higher RS scores were associated with greater participation in physical activity (odds ratios (OR) from 1.9 to 2.2). Higher scores on other scales intended to measure resilience have also been linked to: better self-rated health (relative risk (RR) = 1.65) and greater grip strength (RR = 1.40, $n = 546$) (Hardy, Concato, & Gill, 2004); reduced risk of disability in activities of daily living (OR = 1.04, $n = 11,112$) (Yang & Wen, 2014); and increased longevity (OR = 1.43, $n = 1,528$) (Zeng & Shen, 2010).

Other domains affected by ageing have received less attention in the literature in relation to resilience. In a review and concept analysis of resilience, Windle (2011) noted that “neuroscience/biological approaches to resilience are notably missing … a major contribution to resilience research could be made through more multi-disciplinary studies that examine … its role in healthy ageing and managing loss, such as changes in cognitive functioning” (p. 155). There is limited evidence on the relationship between resilience and cognitive ability in older age. Research based on children and adolescents suggested that individuals with higher IQ tend to have higher resilience despite experiencing adversity, as evidenced by better developmental outcomes (Masten et al., 1999). Better performance on psychometric tests of executive function and processing speed in early adulthood were associated with higher scores on the Resilience Scale for Adults (RSA) (Stainton, Chisholm, Upthegrove, & Wood, 2018). Studies specific to older age are rarer, and, although there is some evidence to suggest that self-reported resilience scale scores relate to subjective ratings of cognitive ability in later life, support for an association with objective measures of cognitive ability is weaker. Lamond et al. (2009) found that higher CD-RISC scores were moderately negatively correlated with subjective cognitive function in a sample of 1395 older women aged 73 years ($r = -.40$). However, the association with an objective cognitive measure was null ($r = .065$). A smaller study of 129 individuals aged 77 found non-significant associations between self-reported BRS scores and objective measures of verbal ability ($r = .13$) and non-verbal reasoning ($r = .07$). Additionally, no
BRS scores in older age

relation was found between BRS scores in older age and individual differences in cognitive change between ages 11 and 77 years (Harris, Brett, Starr, Deary, & McIntosh, 2016).

There is also limited evidence on the relationship between resilience and biological processes. Many physiological systems are implicated in an individual’s response to stress and adversity (Feder, Nestler, & Charney, 2009). Furthermore, functional declines in several physiological systems are considered to be hallmarks of ageing (López Otín et al., 2013). However, few studies have investigated whether there is an association between resilience and physiological and biological markers of stress or ageing, and no studies have examined this association exclusively in older people. A study of diabetic patients aged between 18 and 75 years reported an interaction between a resilience factor (derived from self-reported optimism, self-esteem, self-efficacy and self-mastery measures) and psychological distress in predicting glycaemia levels one year later, such that, for those with low to moderate but not high resilience, increased distress related to worsening glycaemic levels over time (β = -0.52) (Yi, Vitaliano, Smith, Yi, & Weinger, 2008). In a small study examining resilience (derived from a subset of questions on the Defense Style Questionnaire) and the stress hormone cortisol in adults aged between 18 and 60, Simeon et al. (2007) found that self-reported resilience was positively correlated with urinary cortisol levels (r = .28). However, no association was found between RS scores and a range of psychopathology-related biological markers in either patients diagnosed with mental health conditions, or healthy controls (Mizuno et al., 2016).

As has been described, much of the literature on resilience in older age is based on scores from self-report resilience scales, or resilience factors derived from other scales. It is necessary to question whether they truly measure the construct of resilience. These various scales inherently treat resilience as a trait that exists on a continuum within all individuals. However, there is growing consensus that resilience is not an individual trait but should be understood as the capacity of dynamic systems to adapt to adversity. From a systems perspective, resilience changes over time and varies across different contexts (Masten, 2016; Southwick, Bonanno, Masten, Panter-Brick, & Yehuda, 2014), and cannot be measured directly, but rather is inferred through examining adversity and adaptive response (Cosco et al., 2017). Therefore, the resilience label given to these scales may be a misnomer, as they potentially represent some other construct. But, if they are not assessing true resilience in this sense, then it is important to ask what the
BRS scores in older age

scales measure, and to understand their nomological networks. This important theoretical job is partnered
by a practical one. So-called resilience scales are widely used and have produced many results. Therefore, it
is helpful to understand what they have assessed and part of that is by way of understanding the personal
variables to which they relate.

The question of the construct validity of self-reported, so-called resilience is difficult to answer, partly due to the broad range of self-report scales and factors that have been used to represent resilience in the field. Resilience scales vary in content but are typically composed of items relating to manifest characteristics or personality traits believed to enable individuals to thrive following adversity. The 25 items of the CD-RISC relate to constructs such as hardiness, control, self-esteem, coping style and stress resistance (Connor & Davidson, 2003). The RS consists of 25 items relating to equanimity, perseverance, self-reliance, meaningfulness, and existential aloneness (Wagnild & Young, 1993). The RSA includes social and familial components in addition to personal qualities (Friborg, Hjemdal, Rosenvinge, & Martinussen, 2003). The BRS stands apart from other scales by being the only one whose items directly address an individual’s capacity to ‘bounce back’, rather than the traits that make this possible. So-called resilience scales might also be an example of the jangle fallacy, whereby scales with different names in fact largely measure the same underlying construct (Kelley, 1927); i.e., resilience scales might actually measure a well-established construct, such as an aspect of the personality trait of emotional stability (the opposite of neuroticism).

More evidence on the convergent and discriminant validity of the resilience scales would help to address these concerns. Also helpful would be evidence of incremental predictive validity, showing that there is something unique about the construct measured by resilience scales that makes them a useful measurement tool in addition to, or in place of, other already-established measures of other constructs.

The current study is focused on the self-report BRS, which is reported to have good convergent validity. It has moderate to strong correlations with other self-report resilience scales ($r$’s up to .72), and moderate associations with related constructs that are in the appropriate direction; for example it has moderate positive correlations with optimism and positive affect, and moderate negative correlations with anxiety and depression (Chmitorz et al, 2018; Rodríguez-Rey, Alonso-Tapia, & Hernansaiz-Garrido, 2016; Smith,
BRS scores in older age

Tooley, Christopher, and Kay, 2010). Discriminant predictive validity was also reported based on significant partial correlations between BRS scores and a range of health outcomes following adjustment for optimism, Type D personality and social support (Smith et al., 2010). However, apart from the findings on Type D personality, there is little examination of how the BRS relates to personality traits, and therefore it is unclear if BRS scores are substantially independent of established personality factors. Moderate correlations have been reported between other resilience measures and personality traits (Oshio, Taku, Hirano, & Saeed, 2018). Of particular interest here is the relationship between BRS scores and emotional stability/neuroticism. Neuroticism (and its inverse, emotional stability), describes a tendency towards being sensitive and experiencing anxiety, depression, and other negative emotions. The BRS and some facets of neuroticism both relate to responses to stressful or upsetting circumstances. Only one study has reported on the association between neuroticism and scores on the BRS, and none specifically studied older adults. Navrady et al. (2017) found a moderate negative correlation between neuroticism and BRS score ($r = -0.48$, $p <.001$) in adults of mean age 56 years. In a recent meta-analysis based on 30 studies ($N = 15,609$), the estimated average correlation between neuroticism and various resilience measures was $r = -0.46$ (Oshio, Taku, & Saeed, 2018).

Direct comparison of the associates of the BRS scores and measures of neuroticism in older age are limited by there being very few studies that have examined BRS scores in this age group, and due to differences in methods of measuring associate variables. However, comparison of studies with samples of different ages shows a substantial overlap between the predictors and outcomes of neuroticism and BRS scores. In cross-sectional studies, lower resilience scale scores relate to more symptoms of ill health ($r$'s from -.28 to -.50; Smith et al., 2008), greater symptoms of anxiety and depression ($r = -0.46$), and greater loneliness ($r = -0.23$) (Harris et al., 2016). Higher resilience scores have been associated with greater optimism ($r = 0.44$) (Lamond et al., 2009). Similarly, higher emotional stability (inverse of neuroticism) has been associated with fewer symptoms of anxiety ($r = -0.31$) and depression ($r = -0.53$; Laukka, Dykiert, Allerhand, Starr, & Deary, 2018), and greater optimism ($r = 0.49$; Taylor, Ritchie, & Deary, 2017). Moreover, higher neuroticism has been linked to a greater number of medical conditions ($r = 0.19$; Neeleman, Bijl & Ormel, 2004) and greater loneliness ($r = 0.28$; Wang & Dong, 2018). The same is found when comparing
BRS scores in older age

results from studies of older adults but which used different resilience scales. As described earlier, older
age resilience scale scores have been associated with better subjective cognitive function, better physical
function, and they predict increased longevity (Hardy et al., 2004; Lamond et al., 2009; Zeng & Shen, 2010).
Similarly, associates of neuroticism in older age include poorer subjective cognitive function (Slavin et al.,
2010), and outcomes include declines in physical function (Buchman et al., 2013) and increased risk of
mortality (Wilson et al., 2005b). There is evidence, therefore, that makes it worth asking whether self-
reported resilience scale scores are, to a substantial extent, jangles of emotional stability (negative
neuroticism).

The aim of the present study was to understand more about key age-related antecedents and
outcomes of BRS scores in later life. Data are from the Lothian Birth Cohort 1936 (LBC1936), a community-
dwelling narrow-age cohort. The BRS was first administered to LBC1936 participants at age 76 years; here,
we examined associations between age-76 BRS scores and potential antecedents from a range of domains,
including cognitive ability, physical fitness, biological health, and wellbeing measured at age 73. A previous
study based on a geographically-similar but smaller and older sample showed that later-life BRS scores
were associated with childhood measures of personality and illness (Harris et al., 2016). As such, here we
also used life-course data to examine whether early-life and earlier adulthood sociodemographic factors
were antecedents to older age BRS scores. Furthermore, because personality traits are known to correlate
moderately with resilience scale scores, and as such represent a potential source of confounding (or
jangling), we examine the effect of the Big Five personality traits on these associations. We also investigate
outcomes of BRS scores, to find whether BRS scores had predictive capability in relation to some of the
common declines of older age. We examined associations between age-76 BRS scores and the trajectory of
change in the latent factors of the key age-related domains of cognitive ability, physical fitness, biological
health, and wellbeing between age 76 and 79 years. For reasons already described, this study does not
advocate for or against the BRS scores examined here being interpreted as a measure of true resilience; the
purpose of the study was to understand more about this scale which is commonly used in the field and has
previously been reported on in the literature in the context of resilience.
Methods

Participants

Participants were members of the Lothian Birth Cohort 1936 (LBC1936), a longitudinal cohort study of cognitive, brain, and general ageing. Recruitment and assessment procedures for the study have been described comprehensively (Deary et al., 2007; Deary, Gow, Pattie, & Starr, 2012; Taylor, Pattie, & Deary, 2018). Briefly, LBC1936 participants are mostly surviving participants of the Scottish Mental Survey of 1947 (SMS1947; Scottish Council for Research in Education, 1949). In the SMS1947, 70,805 children out of a possible 75,211 children born in 1936 and attending school in Scotland on 4th June 1947 completed the Moray House Test (MHT) No.12 test of general intelligence. Almost six decades later, the LBC research team identified individuals born in 1936, and thus potential surviving members of the SMS1947, currently residing in Edinburgh city and the surrounding Lothian area. Identification was carried out using the Community Health Index (CHI), which lists all individuals in a given area registered with a general medical practitioner (GP). The Lothian CHI identified 3,810 people born in 1936, and 3686 of those individuals were invited to participate in the LBC1936 study between 2004 and 2006. Additionally, some participants were made aware of the study through media advertisements. Overall, 2318 responses were received, and there were 1226 interested and eligible participants (97 from media advertisements). In total, 1091 were recruited to the LBC1936 study and were tested at Wave 1 (548 males, 543 females). See Figure 1 for more detail on recruitment.

Participants have since been followed-up on three further occasions in older age: Wave 2 testing occurred between 2007 and 2010 (n = 866; mean age = 72.5 years (SD = 0.71); Wave 3 testing occurred between 2011 and 2013 (n = 697; mean age = 76.3 years (SD = 0.68); Wave 4 testing occurred between 2014 and 2017 (n = 550; mean age = 79.3 years (SD = 0.62). Henceforth, we will refer to these waves of testing as age 70, 73, 76 and 79, respectively. Of the 225 participants who dropped out of the study following wave 1, 39 cases were due to death. The 169 participants who dropped out of the study following Wave 2, 38 cases were due to death. Of the 158 participants who dropped out of the study following Wave 3, 40 cases were due to death. Although reason for dropout is not collected systematically, from the data that are available we know that ill health is another major cause of attrition. Note that 11 participants who
BRS scores in older age

did not attend Wave 3 returned for testing at Wave 4, accounting for the mismatch between Wave 3 dropout and Wave 4 attended numbers.

Ethical permission for the LBC1936 study protocol was obtained from the Multi-Centre Research Ethics Committee for Scotland (Wave 1: MREC/01/0/56), the Lothian Research Ethics Committee (Wave 1: LREC/2003/2/29), and the Scotland A Research Ethics Committee (Waves 2, 3 & 4: 07/MRE00/58). The research was carried out in compliance with the Helsinki Declaration. Written, informed consent was given by all participants.

--Insert Figure 1 here--

Measures

Brief Resilience Scale scores

BRS scores were measured for the first time in older age at age 76 years (LBC1936 Wave 3) using the Brief Resilience Scale (Smith at al., 2008). The BRS is a short self-report psychometric measure that is described as assessing resilience in terms of the original meaning of the word: the ability to ‘bounce back’ or recover from stress and adversity. The scale has six items; three are worded positively (e.g., I tend to bounce back quickly after hard times) and three are worded negatively (e.g., I have a hard time making it through stressful events). Participants responded to each item on a 5-point Likert-type scale, ranging from strongly disagree (1) to strongly agree (5). Negatively-worded items were reverse scored, and the overall BRS score was the mean of the six items, with higher scores indicating greater resilience. The BRS was included in a booklet containing 15 different questionnaires that was mailed to participants prior to attending age-76 follow-up testing. Participants returned the completed booklet during their follow-up visit where it was checked by a trained researcher and any errors in types of response, such as giving two answers to a single question, or omissions, were corrected.

Key Ageing Domains.

All variables relating to the key ageing domains examined in the current study (cognitive ability, physical fitness, biological health, and wellbeing) were measured in the same way and using the same equipment during follow-up testing at ages 73, 76, and 79 years. Cognitive, physical and biological factors
BRS scores in older age

were measured on the same day as each other as part of the follow-up testing visit, and wellbeing variables were completed either in the days prior to the appointment or on the same day.

**Cognitive ability.** Participants were administered a wide-ranging battery of cognitive tests by trained researchers at each follow-up wave. For the purposes of the current study, we selected the Symbol Search, Digit Symbol Substitution, Matrix Reasoning, Letter Number Sequencing, and Block Design subtests from the Wechsler Adult Intelligence Scale, third UK Edition (WAIS-III-UK; Wechsler, 1998a, 1998b), and the Digit Span Backwards subtest from the Wechsler Memory Scale UK-III UK (Wechsler, 1998a, 1998b). For latent difference score analysis we derived a factor of general cognitive ability from the six subtests, as has been done in previous studies based on this cohort (e.g. Luciano et al., 2009).

**Physical fitness.** Trained research nurses measured three aspects of physical fitness during each follow-up wave. Grip strength in the right hand was recorded using a North Coast Hydraulic Hand Dynamometer. Lung function was measured as forced expiratory volume in one second (FEV1) assessed using a Micro Medical Spirometer. The current analyses used the best of three attempts on both the grip strength and lung function measures. Walk speed was recorded on a stopwatch and was the time taken (in seconds) for participants to walk 6 metres along a corridor. Higher walk speed scores reflect poorer (i.e. slower) performance. All three physical fitness measurements were adjusted for sex and height (measured on the day of the physical fitness assessment).

**Biological health.** We calculated three measures of biological health (allostatic load, DNA methylation age acceleration, telomere length) that have not previously examined in relation to resilience scale scores, from blood samples and other physiological indices. Allostatic load is a hypothesized trait representing developmental build-up of stress and ‘wear and tear’ on bodily subsystems (McEwen, 1998). The other two biological health measures have previously been proposed as ‘biological clocks’, used to examine differences in biological age between individuals of the same chronological age (Marioni et al., 2016): telomere length and DNA methylation. Telomeres are sections of DNA and protein that act as a protective cap at the end of chromosomes. Telomere length is considered to be a marker of biological age (López Otín et al., 2013). Telomere length decreases in response to cell division and various types of damage and with age, and has been related to disease and mortality in humans (Blackburn, Epel & Lin,
BRs scores in older age

DNA methylation is the chemical modification of the genome related to the regulation of genes. Due to the significant effect of chronological age on methylation levels, DNA methylation-based biological markers of ageing, so-called ‘epigenetic clocks’, have been developed as a measure of the difference between an individual’s chronological age and their methylation-indicated, ‘biological’ age. Accelerated ageing as predicted by a faster-running epigenetic clock has been related to multiple health outcomes including all-cause mortality (Marioni et al., 2015b).

The allostatic load variable used in the current study was calculated using the second-order multigroup confirmatory factor analytic method described by Booth, Starr, & Deary (2013; see Fig. 1 of that paper). This model included measurement of on 10 biomarkers identified to represent different contributing factors to allostatic load: body mass index (BMI), triglyceride, high-density (HDL) and low-density lipoprotein (LDL), glycated haemoglobin (HbA1c), fibrinogen, and mean systolic blood pressure (SBP) and mean diastolic blood pressure (DBP). The biomarkers triglyceride, HDL, LDL, HbA1c, and fibrinogen were analysed at the Department of Laboratory Medicine, Western General Hospital, Edinburgh. BMI was calculated as weight (in kilograms) over height (meters squared). SBP and DBP were calculated as the average of three seated readings taken using an Omron 705IT blood pressure monitor. A latent construct of allostatic load was calculated using the second-order multigroup confirmatory factor analytic method.

For measurement for telomere length, DNA was extracted from whole blood by standard procedures at the WTCRF Genetics Core, Western General Hospital, Edinburgh. Telomere length was measured using a quantitative real-time polymerase chain reaction (PCR) assay at the University of Newcastle. All PCRs were carried out on an Applied Biosystems (Pleasanton, CA, USA) 7900HT Fast Real Time PCR machine with 384-well plate capacity. Full details are reported in Matrin-Ruiz et al. (2004). Four internal control DNA samples were run within each plate to correct for plate-to-plate variation. These are internal controls of cell lines with known absolute telomere length who relative ratio values (telomere starting quantity/glyceraldehyde 3-phosphate dehydrogenase starting quantity) were used to generate a regression line by which values of relative telomere length for the actual samples were converted into absolute telomere lengths. The correlation between relative and absolute telomere lengths was 0.8.
To calculate DNA methylation age acceleration, DNA was extracted from whole blood samples and methylation typing was performed at the WTCRF Genetics Core at the Western General Hospital, Edinburgh. DNA methylation was measured at 485,512 sites using the Illumina HumanMethylation450 BeadChip array. Bisulphate-converted DNA samples were hybridised to the Infinium HumanMehtylation450 array using the Infinium HD Mehtylation protocol and Tecan robotics (Illumnia). Raw intensity data were background-corrected and normalised using internal controls, and methylation beta values were generated using R minfi package. Quality control (QC) was carried out on these data to remove: 1) low-quality samples; 2) probes with a low detection rate; 3) samples with a low call rate; 4) samples where there was a sex mismatch based on XY probes. Post-QC, there were 450,726 autosomal probes available for analysis.

Full details are reported in Shah et al. (2014). Seventy-one of these probes were used to calculate DNA methylation age using the regression weights supplied by Hannum et al. (2013). The DNA methylation-based age acceleration measure used in the current paper was calculated by regressing DNA methylation age on chronological age and saving the residual.

Wellbeing.

Psychological well-being was measured with three self-report scales. As with the BRS, two of these scales were included in a booklet of questionnaires mailed to participants prior to attending their follow-up visits. Questionnaires were checked by a trained researcher on the day of follow-up testing and any errors and omissions were corrected by the participant at this time.

Mental wellbeing was assessed using the Warwick-Edinburgh Mental Well-being Scale (WEMWBS; Tennant et al., 2007) which was developed to capture the affective-emotional, cognitive-evaluative, and psychological functioning aspects of subjective well-being. Participants responded to 14 items (e.g., *I’ve been feeling confident*) on a 5-point Likert scale from *none of the time* (1) to *all of the time* (5) by selecting the response that best described their experience in the previous two weeks. The overall WEMWBS score was the sum of responses to all 14 items, with higher scores indicating better mental wellbeing.

Satisfaction with life was measured using the Satisfaction with Life Scale (SWLS; Diener, Larsen, & Griffin, 1985), a 5-item measure of global cognitive judgements of life satisfaction, developed to measure...
the non-emotional component of subjective well-being. Participants responded to items (e.g., in most ways my life is close to ideal) on a 7-point Likert-type scale, ranging from strongly disagree (1) to strongly agree (7). Overall SWLS score is the sum of all five items, with higher scores representing greater satisfaction with life.

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was used to assess current and recent anxiety and depressive mood symptoms. Participants completed the HADS at their follow-up testing visit, on the same day as the cognitive, physical and biological tests. The scale has 14 items, seven of which address anxiety (e.g., worrying thoughts go through my mind) and seven address depression (e.g., I still enjoy the things I used to enjoy). The overall HADS score is calculated as the sum of responses to all anxiety and depression items, with higher scores reflecting increased symptom severity.

Sociodemographics.

During an interview with a trained psychologist at Wave 1 (age 70), participants retrospectively reported on socioeconomic status (SES) and education. Participant’s and their father’s occupational SES was calculated based on principal occupation before retirement, coded according to the Office of Population Censuses Surveys 1980 (Office of Population Censuses & Surveys, 1980), and General Register Office’s Census 1951 Classification of Occupations (Office General Register, 1956) respectively. For married women, their husband’s SES was used if higher than their own. SES codes ranged from 1 (professional) to 5 (unskilled labour), such that higher scores indicate lower occupational SES. Education was measured as the participant’s self-reported number of years of formal full-time education. A childhood environmental deprivation measure based on self-reported childhood living conditions was calculated according to methods reported previously (Johnson, Corley, Starr & Deary, 2011). This composite measure was the sum of the following standardized variables: number of people per room in the home, indoor or outdoor toilet facilities, and number of people sharing toilet facilities.

Personality traits.

The 50-item International Personality Item Pool (IPIP; Goldberg, 2001; Gow, Whiteman, Pattie & Deary, 2005) was used to measure the Big-Five personality factors: emotional stability (the inverse of neuroticism), extraversion, agreeableness, conscientiousness, and intellect. The IPIP contains 10 items for
BRS scores in older age
each personality factor, to which participants responded on a 5-point Likert-type scale, indicating how well
the item described them, from *very inaccurate* (0) to *very accurate* (4). This was included in the multi-
questionnaire booklet administered at each follow-up wave.

**Statistical analysis**
Statistical analyses were carried out using IBM SPSS Statistics v.22 (IBM, New York, USA), MPlus v7.3
(Muthén & Muthén, 2014), and R v3.5.1 (R Core Team, 2018). The current study was based on participants
with complete BRS data at age 76 (n = 679). Participants with a Mini Mental State Examination score of <24,
commonly used as a cut-off indicating possible dementia, were excluded (n=24), leaving a sample of 655 for
analyses. Outlying data points were capped at ±3.5SDs from the mean (Symbol Search, environmental
depression, grip strength, walk speed, lung function, WEMWBS, HADS, agreeableness, conscientiousness,
telomere length, DNA methylation). Principal components analysis of the BRS items confirmed there was a
single resilience component: the first unrotated principal component explained 59.7% of variance, with
item loadings ranging from 0.72 to 0.82 (mean = 0.77). Cronbach’s alpha for the BRS was 0.86. T-tests were
used to examine differences in age 73 (Wave 2) scores between those who dropped out following Wave 2
and those who returned for testing at Wave 3, and to examine differences in age 76 (Wave 3) scores
between those who dropped out following Wave 3 and those who returned for testing at Wave 4. No Wave
1 data were analysed in this report. We examined antecedents of age-76 BRS scores by testing associations
with early-life and earlier adulthood sociodemographics (retrospectively reported at age 70), and variables
from the key ageing domains (cognitive, physical, biological, wellbeing) and personality traits measured at
age 73. This included both bivariate correlations and multiple linear regression analyses. For the latter,
variables were entered consecutively in a priori-decided blocks to test relative importance of each variable
to BRS score and to adjust for potentially confounding variables. Six models adjusted for cognitive ability,
socio-demographic, physical fitness, biological health, wellbeing, and personality variables. All models were
adjusted for age and sex. Finally, we applied backwards elimination to all variables in the ‘fully adjusted’
model 6, except age and sex covariates, to retain a parsimonious model.

To examine the outcomes of BRS scores, we tested associations between age-76 BRS scores and
trajectories of change in key ageing domains. We used latent difference score models (McArdle, 2009) to
test whether BRS score at age 76 was associated with changes in the latent ageing domains of cognitive ability, physical fitness, biological health, and wellbeing between ages 76 and 79. Such models rely on the existence of correlations among each of the observed variables that make up the latent factor of that construct at each of two time points; from their results, we can examine the overall degree of change in the latent construct. Also, and crucially for the present study, we can add covariates (in this case BRS score) and examine the extent to which they correlate with the baseline levels of, and change in, each latent factor. Age (in days at time of testing) and sex were included as covariates in multivariate analyses. All latent constructs had strong measurement invariance imposed upon them over the two waves (see Widaman, Ferrer, & Conger, 2010). See Figure 2 for a graphical representation of the model estimated.

The number of significant tests in our analyses increased the chance of a type I error. To minimise the potential for a false positive result, we corrected the $p$-values for the results presented in Tables 1 (comparison of participant characteristics for those remaining in vs dropped out of the study), 2 and 3 (bivariate and multiple regression associations between antecedent variables recorded at age 73 or earlier and BRS score), and 5 (latent difference score models) according to the false discovery rate (FDR) method (Benjamini & Hochberg, 1995). Results surviving FDR correction are flagged in tables, and results both prior to and following FDR-correction are described in the Results section.

Results

Descriptive statistics for BRS scores, early-life and adulthood sociodemographics, key ageing domain variables (cognitive ability, physical fitness, biological health, and wellbeing), and personality are presented in Table 1. The mean BRS score at age 76 was 3.55 (SD = 0.64). There was no difference in BRS score between participants who remained in the study following age 76 testing and those who dropped out of the study after this wave ($p = .38$, $d = 0.085$). At age 73, compared to those who remained in the study, participants who subsequently dropped out had significantly lower occupational SES ($p =.043$, $d = 0.17$), lower cognitive ability ($ps$ from < .001 to .041, $ds$ from 0.18 to 0.46), poorer lung function ($p = .013$, $d =$
BRS scores in older age

0.22), slower walk speed \((p < .001, d = 0.49)\), lower mental wellbeing \((p = .003, d = 0.27)\), more anxiety and
depressive symptoms \((p = .006, d =0.25)\), and lower conscientiousness \((p = .035, d = 0.18)\). At age 76,
compared to those who remained in the study, participants who subsequently dropped out had
significantly lower occupational SES \((p <.001, d =0.34)\), fewer years of education \((p = .002, d = 0.27)\), lower
cognitive ability \((ps <.001 \text{ to } .01, ds \text{ from } 0.24 \text{ to } 0.52)\), poorer lung function \((p = .01, d = 0.24)\), slower
walk speed \((p <.001, d = 0.38)\), greater methylation age acceleration \((p = .005, d = 0.27)\), lower mental
wellbeing \((p = .022, d = 0.21 )\), and less satisfaction with life \((p = .026, d = 0.21)\). The majority of these
differences remained significant following correction for multiple comparisons. Only the following
differences between participants (which were close to the \(p < .05\) threshold for statistical significance) did
not survive FDR correction: participant social class, digit span backwards, and conscientiousness at age 73,
and mental wellbeing, satisfaction with life and intellect at age 76.

---Insert Table 1 here---

Bivariate analyses between life history variables and ageing-related domains at age 73 and Brief

Resilience Scale scores at age 76

The majority of sociodemographic, key ageing domain, and personality variables measured at age 73 or
earlier were correlated significantly with BRS score at age 76 (Table 2). The strongest bivariate associations
were between BRS score and wellbeing and personality variables (maximum \(r = .49\)). Better mental well-
being \((r = .41)\) greater satisfaction with life \((r =.29)\), fewer anxiety and depression symptoms \((r = -.41)\),
higher emotional stability \((r = .49)\), and higher extraversion, conscientiousness, agreeableness, and intellect
\((rs \text{ from } .17 \text{ to } .27)\) were all significantly associated with higher BRS score. Higher BRS scores were
associated with higher cognitive ability \((rs \text{ from } .089 \text{ to } .18)\), more years in formal education \((r = .10)\),
higher occupational SES \((r = -0.082)\), greater grip strength \((r = .088)\), and faster walk speed \((r = -.13)\). Being
female was associated with lower BRS score \((r = -.084)\). Only the association with participant social class did
not survive FDR correction. BRS score at age 76 was not significantly associated with father’s occupational
SES, childhood environmental deprivation, age 73 lung function, nor any of the age 73 biological health
variables (allostatic load, telomere length, methylation age acceleration); \(rs \text{ from } .012 \text{ to } .044\).

---Insert Table 2 here---
Regression analyses with life history variables and ageing-related domains at age 73 as predictors and
Brief Resilience Scale scores at age 76 as the outcome

Table 3 gives results of hierarchical linear regression models examining associations between socio-
demographics, key domains of ageing (cognitive ability, physical fitness, biological health, and wellbeing),
and personality measured at age 73 or earlier and BRS score at age 76. To test the relative importance of
each variable and to reduce the potential for confounding by other measured variables, all variables from
the bivariate analyses were entered consecutively in a priori-decided blocks. All models were adjusted for
age and sex. Model 1 included the six cognitive ability variables (Symbol Search, Digit Symbol Substitution,
Matrix Reasoning, Letter-Number Sequencing, Digit Span Backwards, Block Design). Socio-demographic
variables (father’s and participant’s SES, education, and childhood environmental deprivation) were added
in model 2. Models 3 and 4 further included physical fitness (grip strength, lung function, walk speed), and
biological health variables (allostatic load, telomere length, methylation age acceleration) respectively.
Wellbeing variables (mental wellbeing, satisfaction with life, anxiety and depression symptoms) were
added to model 5. In model 6 we adjusted for the Big Five personality factors (Emotional Stability,
Extraversion, Conscientiousness, Agreeableness, Intellect). As a final, exploratory step of the regression
analysis we applied backwards elimination to the ‘fully adjusted’ model 6, retaining only age and sex
covariates, and variables which significantly independently contributed to BRS score (p < .05).

There were small positive associations between BRS score and two cognitive ability measures: block
design (β = 0.14, p = .013) and digit symbol substitution scores (β = 0.12, p = .05) measured at age 73 were
positively associated with age 76 BRS score. Sociodemographic variables were added in model 2. Though
sex, education, and participant social class had significant bivariate associations with BRS score, no
sociodemographic variables (nor age and sex) were found to relate to BRS score in any of the multivariate
models. After further adjustment for physical fitness and biological health variables in models 3 and 4, the
associations with Digit Symbol Substitution and Block Design were only slightly attenuated, though the
association with Digit Symbol Substitution was no longer significant (β = 0.11, p = .071), and there was also a
small positive association between BRS score and grip strength (β = 0.078, p = .089) and a negative
association with walk speed (β = -0.084, p = .076), both non-significant. Models 1 to 4 explained a maximum
BRS scores in older age

of 2.7% of the variance in age 76 BRS score. The addition of wellbeing variables in model 5 explained a
further 18% of the variance, and all three variables were significantly associated with BRS score: greater
mental wellbeing (β = 0.26, p < .001) and satisfaction with life (β = 0.093, p = .042) were associated with
higher BRS scores, and higher anxiety and depression symptom severity were associated with lower BRS
score (β = -0.18, p < .001). Model 6 made final adjustment for personality factors, which accounted for an
additional 7.5% of variance in BRS score. In this ‘fully adjusted’ model, which accounted for 27% of the
variance in BRS score, the strongest association was between age 73 emotional stability and BRS score (β =
0.33, p < .001). Other independent contributions to BRS score were made by extraversion (β = 0.10, p =
.024), and satisfaction with life (β = 0.093, p = .034), but these did not survive FDR correction for multiple
comparisons. When backwards elimination was applied to model 6, the variables retained were satisfaction
with life (β = 0.10, p = .005), anxiety and depression symptoms (β = -0.10, p = .024), emotional stability (β =
0.32, p < .001), extraversion (β = 0.11, p = .003), conscientiousness (β = 0.087, p = .012), and intellect (β =
0.13, p = .001) (see Figure 3). Together the variables explained 30.6% of the variance in age 76 BRS score
and all survived FDR correction.

In summary, years of formal education reported at age 70, and cognitive ability, wellbeing, and
personality variables measured prospectively at age 73 had significant associations with BRS score at age 76
such that individuals with higher cognitive ability, better mental wellbeing and satisfaction with life, and
fewer anxiety and depression symptoms had higher BRS scores. However, following adjustment for other
covariates and personality in multivariate analysis, and following correction for multiple comparisons, only
wellbeing and personality variables made significant independent contributions to BRS score.

Latent difference score models of Brief Resilience Scale scores at age 76 and change in ageing-related
domains from 76 to 79

The final step of our analyses used latent difference score models to examine the relationship between age
76 BRS score and concurrent (baseline) levels of latent factors of key ageing domains (cognitive ability,
physical fitness, biological health and wellbeing), and between age 76 BRS score and trajectories of change
BRS scores in older age

in the latent factors between age 76 and 79. First, we examined correlations among each of the observed variables hypothesised to make up the latent factor of each construct at age 76 and age 79 (see supplementary tables 1 and 2). Next, we examined whether there was change over time in the latent factors, and the overall degree of this change. As a final step, to investigate associations between BRS score and baseline (age 76) levels of each latent construct and between BRS score and trajectory of change in each latent construct (age 76 to age 79), we added BRS score to the models as a covariate.

Examination of the correlations among the observed variables for each hypothesised latent ageing factor indicated that there were moderate correlations among the cognitive ability variables (rs from .28 to .62), physical fitness variables (absolute rs from .21 to .27), and wellbeing variables (absolute rs from .44 to .56) at age 76 (baseline) and age 79. As such, we produced separate latent variable models using the cognitive, physical fitness, and wellbeing variables. At ages 76 and 79, the intercepts of the observed variables loaded on the respective latent factors as follows: general cognitive ability (r = .61 to r = .70); physical fitness (r = .43 to r = .53); wellbeing (r = .61 and r = .83). All loadings were significant at p < .001.

Examination of the observed biological health variables showed that there were only small associations between them, that were not consistent across baseline and age 79 measurement time-points (maximum r = .14 for telomere length and methylation age acceleration at age 76 only), and were not consistently significant. As would be expected from this pattern of relations, the latent variable model was a poor fit to the data, and we thus did not produce a latent difference score model for biological health.

Table 2 shows correlations between age 76 BRS score and observed variables from each ageing domain measured at age 76 and 79. BRS score was significantly positively correlated with cognitive ability (rs from .082 to .16), physical fitness (absolute rs from .031 to .13), and wellbeing variables (absolute rs from .30 to .47) at age 76, with only the association between BRS score and lung function being non-significant. BRS score was also significantly and positively correlated with cognitive ability variables (rs from .057 to .12), and wellbeing variables (absolute rs from .39 to .46) measured at age 79. Associations with symbol search (r = .057), letter-number sequencing (r = .073), and physical fitness variables (absolute rs from .02 to .09) were of similar magnitude to those at baseline but were not significant.
Next, we used the latent difference score models to test whether each of the key ageing domains showed significant change in older age (note that these raw change estimates came from models that were not adjusted for age at testing or sex, whereas the estimates below are age- and sex-adjusted). There was significant decline across the three years in the general factors of cognitive ability (-0.311 SDs, z = -12.31, \( p < .001 \)) and physical fitness (-0.216 SDs, z = -9.05, \( p < .001 \)) between age 76 and 79. Wellbeing did not show significant change (0.03 SDs, z = 0.96, \( p = .34 \)); therefore, we did not examine the association between BRS score and change in wellbeing in the final stage of this analysis.

In order to address whether individual differences in BRS score are related to baseline levels and subsequent change in key domains of ageing, we used age 76 BRS score to separately predict the intercepts (baseline) of the general factors of cognitive ability, physical fitness, and wellbeing, and to predict difference scores (change) in the general factors of cognitive ability and physical fitness (that is, we included directed paths from the BRS score to the intercepts and difference scores). All models had adequate fit as indicated by the following absolute fit indices: Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR) indices (see Table 4). At baseline, BRS score was significantly and positively related to levels of general cognitive ability (\( r = .19 \)), physical fitness (\( r = .20 \)), and wellbeing (\( r = .60 \)), with all \( p \)-values <.001. These significant associations survived FDR correction. However, there were no significant associations between baseline level of BRS score and change in either cognitive ability or physical fitness (see Table 5). The association with the largest effect size was that between BRS score and change in physical fitness between age 76 and 79 (\( r = -.26 \)), but this did not reach statistical significance (\( p = .074 \)).

The association with change in cognitive ability was minimal (\( r = .019, p = .86 \)).
In a relatively large, well-characterised, narrow-age sample of community-dwelling older adults from the LBC1936, we aimed to investigate antecedent factors associated with age-76 scores on the Brief Resilience Scale (BRS), from a wide range of early- and later-life sociodemographic variables, and age-73 cognitive ability, physical fitness, biological health, wellbeing and personality variables. We also examined whether BRS score at age 76 related to baseline levels and trajectories of change in latent factors of general cognitive ability, physical fitness, biological health, and wellbeing between ages 76 and 79. Our results make substantial contributions to understanding the nomological network (Cronbach & Meehl, 1955) for the construct measured by the BRS, in older age. We found significant bivariate associations between age-76 BRS score and antecedent variables from the majority of domains investigated, including personality traits (especially emotional stability), education, and age-73 cognitive ability, physical fitness and wellbeing. When backwards elimination was applied to our multivariate linear regression model we found that age-73 satisfaction with life, anxiety and depression symptoms, emotional stability, extraversion, conscientiousness and intellect, but no other ageing-related variables, made significant independent contributions to BRS scores. Though age-76 BRS scores had significant contemporaneous relationships with baseline levels of the latent factors of general cognitive ability, physical fitness, and wellbeing, we found no evidence that declines in key domains of ageing between age 76 and 79 are meaning (or statistically significantly) outcomes of BRS scores.

Despite there being a growing literature on the associates of self-report resilience scales’ scores in older age, the relationship between these scales and some key age-related domains, including cognitive function and biological factors, remained underexplored. This study reported findings from a range of key domains known to be affected by ageing. Importantly, due to the breadth of phenotypic data collected in the LBC1936 sample, we were able to avoid problems relating to unexamined confounders that pose a risk to studies which only examine a small number of predictors. In addition to bivariate analyses, we conducted multivariate analyses in which the same set of variables were entered into regression models in consecutive blocks, thus reducing the potential for our results to be an artefact of intercorrelations.
Higher scores on six neuropsychological tests covering a range of cognitive abilities were significantly associated with higher BRS scores, and the associations between BRS score and digit symbol substitution and block design (tapping information processing speed and visuospatial reasoning abilities, respectively) survived adjustment for sociodemographic, physical fitness, and biological health variables included as covariates in linear regression models. Cognitive variables, adjusted for age in days at time of testing and sex, accounted for 2.5% of the variance in age-76 BRS score. There is little prior evidence on the relationship between cognitive ability and resilience scale scores in older age. Results from two previous studies of older adults were equivocal, but the our results are consistent with the direction of associations reported in those studies, which found small and mostly non-significant cross-sectional associations between higher BRS scores and better vocabulary and non-verbal reasoning (Harris et al., 2016), and between higher CD-RISC scores and higher mental status scores (Lamond et al., 2009). Our results also correspond with those of Stainton et al. (2018), who found in a sample of younger adults that performance on executive function and processing speed tests accounted for 4% of the variance in RSA scores.

Additionally, we found a small but highly significant association with between baseline levels of a latent general cognitive ability factor and BRS score ($r = .19; p < .001$), though there was no evidence that BRS score related to change in this latent factor within older age, despite there being significant cognitive decline between age 76 and 79 years. This extends the results of Harris et al., 2016, who found that BRS score was not related to the trajectory of change in cognitive ability across the life course between age 11 and 77.

By examining a comprehensive range of cognitive tests and including a latent-variable approach, our results provide the most robust evidence on a relationship between cognitive ability and resilience scale scores in older age to date. Methodological differences limit the comparison of results between studies, but our results add to the evidence for higher cognitive ability being linked to higher levels of the construct measured by self-report resilience scales. The BRS was designed to capture individual differences in the ability to ‘bounce back’ from adverse events. The relationship between higher cognitive ability and
higher BRS scores might be due to those with higher cognitive ability being better able to employ the
analytic and problem solving skills and coping mechanisms necessary to manage difficult life circumstances.  
However, it is important to note that, when adjustment was made for wellbeing factors in our multivariate
regression analysis, the associations between cognitive functions and BRS scores were attenuated, and they
were entirely diminished by adjustment for Big Five personality factors. Whereas it is unclear if a single
variable or a collection of wellbeing and personality variables explains the association between BRS score
and cognitive ability factors, there is evidence from previous studies that neuroticism is associated with
lower cognitive function and steeper cognitive decline in older age (Wilson et al., 2005a).
Null findings on the association between BRS scores and biological health measures in older age are
novel. No studies have reported on resilience scale scores and biological health exclusively in older people,
which is surprising given that resilience scores have been related to physical health symptoms and
mortality (Smith et al., 2008; Zeng & Shen, 2010), and that declining physiological integrity in older age is
known to represent a risk factor for illness and mortality (López-Otín, 2013). None of the three biological
markers investigated in the current study (allostatic load, telomere length, and DNA methylation) were
found to correlate with BRS score, indicating that this measure is not related to biological health. Because
there were no inter-correlations between the biological health variables we were unable to derive a
reliable biological health factor to include in our latent change score modelling. As such we are unable to
comment on whether resilience is prospectively linked to changes in general biological health. It should be
noted that the biological measures used in the current study represent only a very limited selection of
many possible measures related to physiological stress and ageing.

The bivariate association reported between higher age 76 BRS scores and higher grip strength
corroborates the findings of Hardy et al. (2004), and extends them by showing that faster walk speed is also
associated with higher BRS scores. Though BRS scores did not relate to lung function in this study, baseline
scores of a latent physical fitness factor derived from grip strength, walk speed and lung function was
significantly positively related at to BRS score, with a similar magnitude to the association found with
cognitive ability ($r = 0.20$). As with cognitive ability, BRS score was not related to prospective decline in
physical fitness between age 76 and 79 despite there being significant decline recorded. There are multiple
BRS scores in older age

psycnmical and biological advantages of being physically fit that could potentially account for the
association between physical fitness and BRS scores (see review by Silverman & Duester, 2014).

Furthermore, it is possible that subjective ratings of fitness inform the manner in which individuals respond
to the BRS. That is, individuals may take their physical status into consideration when completing the BRS,
leading those who feel physically fit relative to their peers to conclude that their fitness is evidence of a
good capacity to ‘bounce back’, while those who feel less physically fit might be more likely to respond
negatively to the BRS.

Some of the strongest and most consistently-reported associations in the literature are on the
wellbeing and personality correlates of resilience scale scores. Our results corroborate those of previous
studies which reported moderate associations between higher resilience scale scores and fewer anxiety
and depression symptoms, and greater emotional wellbeing (Harris et al., 2016; Ong et al., 2006). We also
found a positive association between greater satisfaction with life and higher BRS score, and between
higher scores on all of the Big Five factors of personality and higher BRS score. These were some of the
largest associations found in our bivariate analyses. There were r-values of up to .49 with emotional
stability from the IPIP questionnaire. Moreover, the latent wellbeing variable derived from emotional
wellbeing, satisfaction with life, and anxiety and depression symptom variables had the largest association
with BRS at baseline (r = .60). Notably, the inclusion of wellbeing and personality variables in the fully
adjusted multivariate regression model markedly attenuated the associations between BRS score and
cognitive ability and physical fitness variables. This suggests that the variance captured by the BRS is most
substantially related to wellbeing and personality traits (especially emotional stability/neuroticism), rather
than to cognitive or physical status. Though the results of the fully adjusted model may be overly
conservative, a more exploratory analysis applying backward elimination to the fully adjusted model
supports this conclusion by showing that, when non-significant predictors are removed from the regression
model, satisfaction with life, anxiety and depression symptoms, and the personality variables emotional
stability, extraversion, conscientiousness, and intellect alone contribute to BRS score. This is in agreement
with a study examining the convergent and discriminant validity of the RSA in relation to the ‘Big Five’
personality factors and intelligence, by Friborg, Barlaug, Martinussen, Rosenvinge & Hjemdal (2005). They
BRS scores in older age

and concluded that there was a moderate degree of redundancy between RSA scores and personality, and due to the significant loading of RSA factors onto the latent personality factors in principal component analysis, the RSA factors should not be viewed as independent of personality, but as variants of traits from the Big Five model of personality.

The close relationship between resilience scores and other positive psychological and personality factors reported by several studies, and strongly found in the present study, has led to some criticism regarding the lack of clarity on what distinguishes this construct from other similar constructs. The substantial overlap in scale content between resilience and personality scales - one facet of neuroticism on the NEO-PI relates vulnerability to stress, and neuroticism items on the IPIP Big Five inventory also relate to stress - raises the possibility that this is an example of the “jangle” fallacy (Kelley, 1927, p. 62). Emotional stability (the inverse of which is neuroticism) was the only variable significantly independently associated with BRS score in our regression model after adjustment for other covariates and for multiple comparisons, indicating that BRS scores are substantially accounted for by individual differences in this variable; however, as previously noted, less conservative results from our backwards elimination model suggest that differences in satisfaction with life, anxiety and depression symptoms, emotional stability, extraversion, conscientiousness and intellect are also captured by the BRS. The maximum variance in BRS score explained by any regression model was 30.6%, and future studies will be required to determine how much of this residual variance is unique to a construct labelled as resilience, and how much is accounted for by other facets of personality and wellbeing not measured in the current study. Though we intended to assess antecedents to BRS scores by examining associations between BRS score at age 76 and antecedent variables measured at least 3 years prior, the overlap in the constructs means that it is not possible in the current study to say whether personality and wellbeing factors are true antecedents to the construct captured by BRS scores, or whether the BRS is, to a substantial extent, a variant of these traits.

This study has some limitations. The degree of change that could be modelled in the key domains of ageing was limited by their being only one further wave of data available, which was collected three years after age-76 BRS scores. This might contribute to the null findings regarding associations between BRS score and change in the cognitive ability and physical fitness factors. Furthermore, because BRS scores
BRS scores in older age were measured for this first time at the third out of the four waves of available data, it precluded us from examining how within-person change in BRS scores relates to changes in key-ageing domains over longer periods of time. Future waves of data collection in the LBC1936 will allow us to better track within-person change in both BRS score and key ageing domains. It should also be noted that the LBC1936 are a self-selecting sample of community-dwelling older adults who are likely to be cognitively and physically fitter than the general population. As such, it is possible that participants who have experienced the greatest physical, cognitive, biological and wellbeing declines in older age have been lost to attrition. However importantly, because LBC1936 participants are surviving participants of the SMS1947 which assessed the cognitive ability of almost an entire population at age 11, access to historical data at population level makes it possible to understand the selected nature of the LBC1936 and to take into account restriction of range for some variables.

Conclusion

The present study examined antecedents and outcomes of Brief Resilience Scale scores in older age. We found that a range of antecedent age-related variables, including greater cognitive ability, physical fitness, and wellbeing at age 73 were associated with having a higher age-76 BRS score. Having more years of formal full-time education, a more professional SES, and higher levels of all Big Five personality variables also related to higher BRS scores at age 76. However, of all variables investigated, few made independent contributions to BRS score. Our most conservative linear regression model that included all variables simultaneously, found the personality trait of emotional stability to be the sole independent contributor to BRS score after adjustment for multiple comparisons; however, in a backwards elimination model, satisfaction with life, anxiety and depression symptoms, extraversion, conscientiousness, and intellect were also independent predictors of BRS score. Latent difference score models showed robust cross-sectional associations between BRS scores and latent general cognitive ability, physical fitness, and wellbeing factors when measured contemporaneously at baseline, but no evidence was found for associations between BRS score and future change in these key ageing domains. Our findings make novel contributions to the nomological network of the construct measured by the BRS, but we found little evidence to suggest that this construct is fully independent of other personality and wellbeing constructs.
References


BRS scores in older age


BRS scores in older age


BRS scores in older age


BRS scores in older age


BRS scores in older age


### BRS scores in older age

**Table 1. Characteristics of the Lothian Birth Cohort 1936 participants by wave of follow-up testing and comparison between completes and dropouts**

<table>
<thead>
<tr>
<th>Wave 2 Age</th>
<th>Completer vs Dropout</th>
<th>Cohen’s $d$</th>
<th>Wave 3 Age</th>
<th>Completer vs Dropout</th>
<th>Cohen’s $d$</th>
<th>Wave 4 Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td></td>
<td></td>
<td>76</td>
<td></td>
<td></td>
<td>79</td>
</tr>
<tr>
<td>N (completer/dropout)</td>
<td>866/697</td>
<td>0.62</td>
<td>550/158§</td>
<td>0.054</td>
<td>79.3 (0.63)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>72.5 (0.71)</td>
<td></td>
<td>76.2 (0.67)</td>
<td></td>
<td>76.2 (0.71)</td>
<td>0.14</td>
</tr>
<tr>
<td>Sex (Male)</td>
<td>51.1%</td>
<td>-</td>
<td>51.1%</td>
<td>-</td>
<td>49.6%</td>
<td></td>
</tr>
<tr>
<td>Brief Resilience Scale (BRS) score</td>
<td>-</td>
<td>-</td>
<td>3.55 (0.64)</td>
<td>0.38</td>
<td>4.05 (0.69)</td>
<td></td>
</tr>
</tbody>
</table>

**Socio-demographics**

| Father’s social class | 2.91 (0.95) |          | 2.89 (0.95) | 0.56 | 2.88 (0.96) |
| Participant’s social class | 2.25 (0.83) | 0.17 | 2.23 (0.84) | <.001<sup>a</sup> | 0.34 | 2.17 (0.83) |
| Education | 10.8 (1.14) | 0.10 | 10.8 (1.14) | <.001<sup>b</sup> | 0.27 | 10.9 (1.18) |
| Childhood environmental deprivation | -0.12 (2.22) | 0.13 | -0.18 (2.21) | .65 | -0.19 (2.27) |

**Cognitive ability**

| Symbol search | 24.8 (6.07) | <.001<sup>a</sup> | 37.0 | 0.37 | 24.9 (6.25) | <.001<sup>a</sup> | 0.44 | 23.0 (6.40) |
| Digit symbol substitution | 56.8 (12.2) | <.001<sup>a</sup> | 0.46 | 54.3 (12.7) | <.001<sup>a</sup> | 0.52 | 51.9 (12.5) |
| Matrix reasoning | 13.3 (4.95) | <.001<sup>a</sup> | 0.40 | 13.2 (4.85) | <.001<sup>a</sup> | 0.24 | 13.1 (5.00) |
| Letter-number sequencing | 11.0 (3.05) | <.001<sup>a</sup> | 0.43 | 10.6 (2.95) | <.001<sup>a</sup> | 0.33 | 10.2 (2.79) |
| Digit span backwards | 7.86 (2.28) | 0.18 | 7.84 (2.36) | <.001<sup>a</sup> | 0.27 | 7.63 (2.14) |
| Block design | 33.9 (10.1) | <.001<sup>a</sup> | 0.36 | 32.6 (9.79) | <.001<sup>a</sup> | 0.24 | 31.6 (9.36) |

**Physical fitness**

| Grip strength<sup>c</sup> | 28.7 (9.41) | 0.16 | 27.7 (9.76) | 0.45 | 0.069 | 26.2 (9.45) |
| Lung function | 2.30 (0.68) | 0.22 | 2.11 (0.62) | <.001<sup>a</sup> | 0.24 | 2.11 (0.64) |
| Walk speed | 4.30 (1.11) | <.001<sup>a</sup> | 0.49 | 4.65 (1.40) | <.001<sup>a</sup> | 0.38 | 5.14 (1.56) |

**Biological health**

| Allostatic load | 0 (1.53) | 0.86 | 0.015 | 0 (1.45) | 0.31 | 0.10 | 0 (1.54) |
| Telomere length | 3958 (688) | 0.95 | 0.005 | 3740 (668) | 0.32 | 0.090 | 3619 (566) |
| Methylation age acceleration | -1.53 (6.88) | 0.89 | 0.012 | 0.62 (6.82) | <.001<sup>a</sup> | 0.27 | 3.16 (6.20) |

**Wellbeing**

| WEMWBS | 51.5 (7.42) | 0.003<sup>a</sup> | 0.27 | 51.6 (7.88) | <.001<sup>a</sup> | 0.21 | 51.8 (8.27) |
BRS scores in older age

<table>
<thead>
<tr>
<th></th>
<th>Wave 2 (age 73)</th>
<th>Wave 3 (age 76)</th>
<th>Wave 4 (age 79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWLS</td>
<td>25.5 (5.93)</td>
<td>25.7 (5.92)</td>
<td>25.9 (5.80)</td>
</tr>
<tr>
<td>HADS</td>
<td>7.07 (4.38)</td>
<td>7.50 (4.45)</td>
<td>7.08 (4.45)</td>
</tr>
</tbody>
</table>

**Personality**

<table>
<thead>
<tr>
<th>Personality</th>
<th>Wave 2 (age 73)</th>
<th>Wave 3 (age 76)</th>
<th>Wave 4 (age 79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPIP Emotional Stability</td>
<td>25.0 (7.76)</td>
<td>25.3 (7.10)</td>
<td>25.4 (7.49)</td>
</tr>
<tr>
<td>IPIP Extraversion</td>
<td>21.6 (7.28)</td>
<td>21.7 (7.21)</td>
<td>21.4 (7.49)</td>
</tr>
<tr>
<td>IPIP Conscientiousness</td>
<td>27.8 (6.09)</td>
<td>28.0 (6.09)</td>
<td>27.6 (6.13)</td>
</tr>
<tr>
<td>IPIP Agreeableness</td>
<td>31.0 (5.45)</td>
<td>30.8 (5.39)</td>
<td>30.9 (5.46)</td>
</tr>
<tr>
<td>IPIP Intellect</td>
<td>23.8 (5.95)</td>
<td>24.0 (5.75)</td>
<td>24.1 (5.97)</td>
</tr>
</tbody>
</table>

Values given are mean and standard deviation. Social class (occupational) was categorised from professional (1) to unskilled labour (5); FEV1, forced expiratory volume in 1 second; walk speed, time to walk 6m in seconds; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scale, SWLS, Satisfaction with Life Scale; HADS, Hospital Anxiety and Depression Scale; IPIP, International Personality Item Pool.

* p-value for differences in Wave 2 (age 73) scores between those who dropped out following Wave 2 and those who returned for testing at Wave 3.

† Results significant at p < 0.05 after FDR adjustment

§ The mismatch between Wave 3 dropout and Wave 4 attended numbers is due to 11 participants who did not attend Wave 3, who did not dropout, returning to participate in Wave 4.
Table 2. Correlations between early-life and antecedent variables measured at age 73 and Brief Resilience Scale (BRS) score at age 76 in LBC1936 and between BRS score at age 76 and key ageing domain variables measured at ages 76 and 79

<table>
<thead>
<tr>
<th>Antecedent variables</th>
<th>r (age 73)</th>
<th>r (age 76)</th>
<th>r (age 79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in days)</td>
<td>-.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>-.084*†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sociodemographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father’s social class</td>
<td>-.021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant’s social class</td>
<td>-.082*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>.10**†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Childhood environmental deprivation</td>
<td>-.043</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbol search</td>
<td>.089**†</td>
<td>.16**†</td>
<td>.057</td>
</tr>
<tr>
<td>Digit symbol substitution</td>
<td>.14**†</td>
<td>.15**†</td>
<td>.11**†</td>
</tr>
<tr>
<td>Matrix reasoning</td>
<td>.092**†</td>
<td>.16**†</td>
<td>.12**†</td>
</tr>
<tr>
<td>Letter-number sequencing</td>
<td>.13**†</td>
<td>.090**†</td>
<td>.073</td>
</tr>
<tr>
<td>Digit span backwards</td>
<td>.12**†</td>
<td>.082*</td>
<td>.11**†</td>
</tr>
<tr>
<td>Block design</td>
<td>.18**†</td>
<td>.091*</td>
<td>.12**†</td>
</tr>
<tr>
<td>Physical fitness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grip strength</td>
<td>.088**†</td>
<td>.13**†</td>
<td>.086</td>
</tr>
<tr>
<td>Lung function</td>
<td>.018</td>
<td>.031</td>
<td>-.020</td>
</tr>
<tr>
<td>Walk speed</td>
<td>-.13**†</td>
<td>-.11**†</td>
<td>-.060</td>
</tr>
<tr>
<td>Biological health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allostatic load</td>
<td>.012</td>
<td>-.003</td>
<td>-.007</td>
</tr>
<tr>
<td>Telomere length</td>
<td>-.019</td>
<td>-.001</td>
<td>.002</td>
</tr>
<tr>
<td>Methylation age acceleration</td>
<td>.044</td>
<td>.027</td>
<td>.065</td>
</tr>
<tr>
<td>Wellbeing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEMWBS</td>
<td>.41**†</td>
<td>.47**†</td>
<td>.44**†</td>
</tr>
<tr>
<td>SWLS</td>
<td>.29**†</td>
<td>.30**†</td>
<td>.39**†</td>
</tr>
<tr>
<td>HADS</td>
<td>-.41**†</td>
<td>-.46**†</td>
<td>-.46**†</td>
</tr>
<tr>
<td>Personality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Emotional stability</td>
<td>.49**†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Extraversion</td>
<td>.27**†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Conscientiousness</td>
<td>.24**†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Agreeableness</td>
<td>.17**†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Intellectual</td>
<td>.24**†</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coding for binary variables was as follows: male = 0, female = 1. Social class (occupational) was categorised from professional (1) to unskilled labour (5). Education, number years in formal full-time education; Grip strength, best of three attempts from right hand (kg); Lung function, forced expiratory volume in 1 second; walk speed, time to walk 6m in seconds; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scale, SWLS, Satisfaction with Life Scale; HADS, Hospital Anxiety and Depression Scale. IPIP, International Personality Item Pool.

* All variables measured at age LBC1936 Wave 2 (mean age 73 years), except sociodemographics which were retrospectively reported at LBC1936 Wave 1 (mean age 70 years) as described in Methods. *significant at p-value < 0.05; ** significant at p-value < 0.01; †significant at p < 0.05 after FDR adjustment.
BRS scores in older age

Table 3. Multiple linear regression results (standardised betas) for antecedents of age 76 Brief Resilience Scale score.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.016</td>
<td>0.015</td>
<td>0.028</td>
<td>0.029</td>
<td>0.030</td>
<td>0.027</td>
</tr>
<tr>
<td>Sex</td>
<td>-0.061</td>
<td>-0.059</td>
<td>-0.065</td>
<td>-0.058</td>
<td>-0.066</td>
<td>-0.047</td>
</tr>
<tr>
<td>Cognitive ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbol Search</td>
<td>-0.077</td>
<td>-0.076</td>
<td>-0.079</td>
<td>-0.077</td>
<td>-0.039</td>
<td>-0.037</td>
</tr>
<tr>
<td>Digit Symbol Substitution</td>
<td>0.12*</td>
<td>0.12*</td>
<td>0.11</td>
<td>0.11</td>
<td>0.080</td>
<td>0.060</td>
</tr>
<tr>
<td>Matrix Reasoning</td>
<td>-0.051</td>
<td>-0.048</td>
<td>-0.058</td>
<td>-0.056</td>
<td>-0.035</td>
<td>-0.034</td>
</tr>
<tr>
<td>Letter-number sequencing</td>
<td>0.036</td>
<td>0.039</td>
<td>0.040</td>
<td>0.041</td>
<td>0.018</td>
<td>0.023</td>
</tr>
<tr>
<td>Digit span backwards</td>
<td>0.063</td>
<td>0.065</td>
<td>0.055</td>
<td>0.056</td>
<td>0.057</td>
<td>0.047</td>
</tr>
<tr>
<td>Block design</td>
<td>0.14*</td>
<td>0.14*</td>
<td>0.13*</td>
<td>0.12*</td>
<td>0.045</td>
<td>0.058</td>
</tr>
<tr>
<td>Socio-demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father’s social class</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>-0.005</td>
<td>-0.032</td>
<td>-0.014</td>
<td></td>
</tr>
<tr>
<td>Participant’s social class</td>
<td>0.003</td>
<td>0.002</td>
<td>&lt;0.001</td>
<td>-0.009</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>-0.037</td>
<td>-0.045</td>
<td>-0.042</td>
<td>-0.022</td>
<td>-0.004</td>
<td></td>
</tr>
<tr>
<td>Childhood Environmental deprivation</td>
<td>-0.019</td>
<td>-0.023</td>
<td>-0.023</td>
<td>0.035</td>
<td>0.036</td>
<td></td>
</tr>
<tr>
<td>Physical ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grip strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung function</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allostatic load</td>
<td>0.032</td>
<td>-0.009</td>
<td>0.018</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telomere length</td>
<td>0.007</td>
<td>0.003</td>
<td>0.015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methylation age acceleration</td>
<td>0.030</td>
<td>0.031</td>
<td>0.026</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wellbeing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEMWBS</td>
<td></td>
<td></td>
<td></td>
<td>0.26**</td>
<td>0.080</td>
<td></td>
</tr>
<tr>
<td>SWLS</td>
<td></td>
<td></td>
<td></td>
<td>0.093*</td>
<td>0.093*</td>
<td></td>
</tr>
<tr>
<td>HADS</td>
<td></td>
<td></td>
<td></td>
<td>-0.18**</td>
<td>-0.024</td>
<td></td>
</tr>
<tr>
<td>Personality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPIP Emotional Stability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.33***</td>
</tr>
<tr>
<td>IPIP Extraversion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.10*</td>
</tr>
<tr>
<td>IPIP Conscientiousness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.075</td>
</tr>
<tr>
<td>IPIP Agreeableness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.008</td>
</tr>
<tr>
<td>IPIP Intellect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.054</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>.025</td>
<td>.019</td>
<td>.027</td>
<td>.023</td>
<td>.20</td>
<td>.27</td>
</tr>
<tr>
<td>∆ R²</td>
<td>.038*</td>
<td>.001</td>
<td>.013</td>
<td>.002</td>
<td>.18*</td>
<td>.075*</td>
</tr>
</tbody>
</table>

N = 522. Coding for binary variables was as follows: male = 0, female = 1. Data are presented as standardised beta coefficients reflecting change in age 76 resilience score associated with an increase of 1 SD unit in predictor variable. Social class (occupational) was categorised from professional (1) to unskilled labour (5). Education, number years in formal full-time education; Grip strength, best of three attempts from right hand (kg); Lung function, forced expiratory volume in 1 second; walk speed, time to walk 6m in seconds; WEMWBS, Warwick-Edinburgh Mental Wellbeing Scale, SWLS, Satisfaction with Life Scale; HADS, Hospital Anxiety and Depression Scale. IPIP, International Personality Item Pool.
BRS scores in older age

*significant at $p$-value <0.05; ** significant at $p$-value <0.01; †significant at $p$ < 0.05 after FDR adjustment
(FDR adjustment applied to model 6 results only)
BRS scores in older age

Table 4. Model fit indices of latent difference score models predicting change in key ageing domains from Brief Resilience Scale score

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>df</th>
<th>$p$</th>
<th>RMSEA</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>General cognitive ability</td>
<td>220.39</td>
<td>46</td>
<td>&lt;.001</td>
<td>.076</td>
<td>.94</td>
<td>.93</td>
<td>.059</td>
</tr>
<tr>
<td>Physical fitness</td>
<td>12.71</td>
<td>14</td>
<td>.55</td>
<td>.000</td>
<td>1.00</td>
<td>1.00</td>
<td>.023</td>
</tr>
<tr>
<td>Wellbeing</td>
<td>37.58</td>
<td>14</td>
<td>.001</td>
<td>.051</td>
<td>.99</td>
<td>.98</td>
<td>.032</td>
</tr>
</tbody>
</table>

Table 5. Associations of age 76 Brief Resilience Scale score with key ageing domain levels and changes between age 76 and 79 years

<table>
<thead>
<tr>
<th>Ageing domain</th>
<th>Baseline level association with age 76 resilience</th>
<th>Change association with age 76 resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
<td>SE</td>
</tr>
<tr>
<td>General cognitive ability</td>
<td>.19</td>
<td>.043</td>
</tr>
<tr>
<td>Physical fitness</td>
<td>.20</td>
<td>.056</td>
</tr>
<tr>
<td>Wellbeing</td>
<td>.60</td>
<td>.031</td>
</tr>
</tbody>
</table>

†significant at $p < 0.05$ after FDR adjustment
Figure 1. Recruitment flowchart for the Lothian Birth Cohort 1936. Reproduced with permission from Deary et al., 2007.

Initial CHI list
3810 names

3686 mailed

1703 responses
46.2% of mailing

1351 interested
79.3% of response
1132 eligible
83 ineligible/medical reason
11 no MHT
125 no longer interested/withdrawal before appointment made

352 not interested or ineligible
20.7% of response

1741 re-mailed

615 responses
35.3% of mailing

216 interested
35.1% of response
94 eligible
45 ineligible/medical reason
15 no longer interested/withdrawal before appointment made
62 already participants

399 not interested or ineligible
64.9% of response

1226 interested and eligible

85 withdrawals
50 not tested

1091 tested
Figure 2. Simplified diagram of the latent difference score model. For illustration, we show the version for physical fitness: a latent factor at each of the two ages (circles) is indicated by scores on each of the three measured physical fitness variables (squares), and a latent difference score (Δ physical fitness) is derived from them. The score from the Brief Resilience Scale (rectangle) is then regressed on the baseline and the change factors (dashed lines).
BRS scores in older age

Figure 3. Standardised beta coefficients for linear regression (backwards elimination) with ageing-related domains at age 73 as predictors and Brief Resilience Scale scores at age 76 as the outcome.