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Childhood socio-economic circumstances, cognitive function and education and later-life economic activity

RESEARCH ARTICLE

Childhood socio–economic circumstances, cognitive function and education and later–life economic activity: linking the Scottish Mental Survey 1947 to administrative data

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As the population ages, older adults are expected to work for longer into the life course. However, older adults experience particular problems staying economically active, even prior to reaching statutory retirement. Recent work has suggested that economic activity in midlife can be predicted by the far-reaching effects of early life, such as childhood socio–economic circumstances, cognitive ability and education. The present study investigates whether these same early-life factors predict the odds of being economically active much later in life, from age 55 to age 75. We capitalise on data linkage conducted between a subsample of the Scottish Mental Survey 1947 cohort and the Scottish Longitudinal Study, which includes three waves of national census data (1991, 2001 and 2011). The structural association between early-life factors and later-life economic activity was assessed using latent growth curve analyses conducted for males and females separately. In both males and females, the odds of being economically active decreased non-linearly across the 20-year follow-up period. For males, greater odds of being economically active at age 55 were predicted by higher childhood cognitive ability and higher educational attainment. For females, greater odds of being economically active at age 55 were predicted by higher childhood socio–economic status and higher childhood cognitive ability. In contrast, early-life factors did not predict the odds of becoming inactive over the 20-year follow-up period. We suggest that early-life advantage may contribute to the capacity for work in later life, but that it does not necessarily protect from subsequent decline in this capacity.

Introduction

As the population ages, social policy has adapted in an attempt to balance the working and retired population and to cover the increasing costs of pension and healthcare arrangements. As a result, individuals are expected to work and function later into the life course. However, the rate of economic inactivity (not in employment and not looking for work) increases substantially beyond age 50 years (Office for National Statistics, 2016; Table A05). Remaining economically active in later life is particularly challenging. Older adults often face declines in physical ability and some cognitive skills (Wettstein et al, 2016), in addition to significant rates of ill health (Baltes and Baltes, 1993), which may result in a mismatch between their human capital and the demands of work (Ilmarinen, 2001). Furthermore, once unemployed, older adults experience particular problems finding and returning to work (Wanberg et al, 2016). The result is a mostly one-way, steep trajectory leading older adults out of the workforce. Despite this, it has been suggested that economic activity in later life can sometimes be protective for health and well-being (Brunner, 2005; Then et al, 2013). Understanding the determinants of later-life economic activity, and the factors protecting individuals from age-related transitions to inactivity, is an important step for informing social policy in an ageing society.

Previous work has predominantly focused on predicting midlife (around ages 25–49) economic activity, and has highlighted the importance of early-life circumstances, such as childhood socio-economic status (SES; Caspi et al, 1998; Elman and O'Rand, 2004; Anyadike-Danes and McVicar, 2005; Currie, 2009; Brandt and Hank, 2014) and childhood cognitive ability (Caspi et al, 1998; Fergusson et al, 2005). These early-life factors have been frequently associated with mortality (Galobardes et al, 2004; Lager et al, 2009; Iveson et al, 2017), morbidity (Batty et al, 2006; Cohen et al, 2010; Hagger-Johnson et al, 2010), and physical function in later life (Guralnik et al, 2006; Kuh et al, 2009). Their long-term associations are thought to represent their role in building human capital (Becker, 1993; Kanfer et al, 2001; Sterns and Dawson, 2012) – skills, knowledge and ability – and cognitive and physical reserve (Stern, 2009) – the ability to resist the damaging effects of morbidity and ageing. For economic activity, better early-life circumstances may result in the capacity and resilience required to remain active for longer.

Importantly, early-life factors appear to be structured in their association with economic activity. Richards and Sacker (2003) observed that occupational attainment at age 43 years was predicted by childhood SES (indicated by the father's occupation), cognitive ability at age 8, and educational achievement at age 26. Each of these predictors had direct associations with occupational attainment. Childhood SES also

exhibited an indirect effect through cognitive ability and education, and cognitive ability had an indirect effect through education. A similar structure, whereby education mediates the association from early–life cognitive ability, has been shown in models predicting early–adulthood occupational social class (Paterson et al, 2010), midlife social position (Deary et al, 2005), midlife wages (Elman and O'Rand, 2004), and highest occupational social class (Johnson et al, 2010a, 2010b; Paterson et al, 2014). Indeed, educational attainment itself has been shown to be partly determined by both early–life SES (Lynch et al, 1997; Sirin, 2005) and early–life cognitive ability (Jencks et al, 1983; Deary et al, 2007; Deary and Johnson, 2010), with those from more advantaged socio–economic backgrounds or with higher cognitive abilities more likely to achieve higher levels of education. Importantly, previous work has demonstrated various mechanisms by which socio–economic origins affect childhood cognitive ability, and how both socio–economic origins and childhood cognitive ability affect educational attainment. Early–life SES has been shown to act on cognitive development through economic conditions and material deprivation (Duncan et al, 1994), maternal health (Weinberg and Tronick, 1998), childhood nutrition (Koletzko et al, 1998) and childhood health (Kramer et al, 1995), among other pathways. Early–life SES has been shown to act on education through similar mechanisms, with the addition of parental involvement and aspirations and the social composition of the educational environment (Sacker et al, 2002). Early–life cognitive ability, on the other hand, contributes directly to educational attainment by indicating one's ability to meet the intellectual demands of higher educational qualifications (Strenze, 2007). In addition to the phenotypic association, there is a strong genetic correlation between cognitive ability and education (Bartels et al, 2002; Hagenaars et al, 2016).

Notably, little work has been done to examine the importance of early–life factors for later–life economic activity specifically. By focusing on midlife occupation, previous studies (Richards and Sacker, 2003; Deary et al, 2005; Elman and O'Rand, 2004) miss the final decade or so of employment, in which adults are particularly at risk of becoming inactive and unemployment rates are particularly high (Wanberg et al, 2016). It is therefore unclear whether these early–life factors play a role in later–life economic activity, and what structure may underlie any association. Furthermore, it is unclear whether early–life factors predict the capacity to be economically active in later life, as it does in midlife, or the subsequent resilience to economic inactivity (due to age–related declines in ability, for example) among those initially active, or both.

The present study aimed to address this gap by investigating the association between early–life factors (cognitive ability, SES and education) and economic activity across a 20–year period of later–life (ages 55–75). It examined the structure underlying these early–life factors and their association with both the odds of being economically active in later–life and the change in these odds over time. Individuals with higher childhood SES, higher childhood cognitive ability, and more education may be more likely to be economically active in later life (age 55), but may also be more resilient to declines in working ability as age increases. Importantly, we did not assume that the factors predicting economic activity odds at age 55 would be the same as those predicting change in odds over time. To achieve this, we utilised recent linkage of administrative data between the Scottish Mental Survey 1947 and the Scottish Longitudinal Study (Huang et al, 2017). This linkage marries measures of general cognitive ability at age 11 years with measures of socio–economic circumstances at age 3, education across the life course, and economic activity at ages 55, 65 and 75.

Methods

The methods and analyses of the present study were preregistered prior to the data being accessed (https://osf.io/hkbtc). The only change to the planned methods was a reduction in the number of variables involved in the analyses; the preregistered analyses included additional measures of childhood SES that were not included in the present analyses due to poor model fit.

Sample

The sample was selected from the Scottish Longitudinal Study – a standing data set covering around 274,000 individuals, chosen as a 5.3% sample of the Scottish population. The initial sample consisted of 4,162 individuals who were born in 1936 and had taken part in the Scottish Mental Survey 1947 (The Scottish Council for Research in Education, 1949). As part of this survey, almost all children aged 11 and attending a Scottish school on 4 June 1947 completed the Moray House Test No. 12, which was designed to assess their general cognitive ability.

As part of the Scottish Longitudinal Study, cognitive ability records from 1947 have been linked backwards to administrative records from 1939, and forwards to Scottish Census records from 1991, 2001 and 2011. The total sample consisted of 2,374 individuals from the Scottish Longitudinal Study who took part in the Scottish Mental Survey and who were present for at least the 1991 Scottish Census. Note that individuals not present at the 1991 census may have died or emigrated between 1947 and 1991 (see Huang et al, 2017).

Of the 2,374 individuals who appeared at the 1991 census, 1,971 individuals were present at the 2001 census ($N = 267$ died between 1991 and 2001), and 1,534 individuals were present at the 2011 census ($N = 475$ died between 2001 and 2011). Of the total sample, 448 men and 423 women had complete early-life records (administrative records from 1939, and Scottish Mental Survey 1947 records) linked with data from all three censuses.

Assessments

Childhood socio-economic status

Age three SES was taken from 1939 National Register records of cohabitants, including the parents and grandparents of sample members. A Historical CAMSIS (HISCAM) score (Lambert et al, 2013) was derived from the Historical International Classification of Occupation (HISCO) code of each cohabitant. The highest HISCAM score for a given household was taken as the measure of childhood SES.

Childhood cognitive ability

Age 11 cognitive ability was taken from Scottish Mental Survey 1947 records of each individual. Raw Moray House Test No. 12 (MHT) scores (The Scottish Council for Research in Education, 1949), were used as a measure of childhood cognitive ability. The MHT has previously been shown to have good criterion and concurrent validity against other tests of general cognitive ability (Deary et al, 2004).

The MHT is a paper and pencil test, with a time limit of 45 minutes, consisting of verbal reasoning, numerical reasoning and other similar problems. Scores could range from 0 to a maximum possible 76. Note that, as it was collected relatively early in the educational career of individuals, when there was no difference in the number of years spent in education, the impact of education itself to Moray House Test scores will be minimal.

Education

Life-course educational attainment was taken from the most recent census in which an individual appeared (2011, 2001 or 1991 respectively). This was done because the 2011 and 2001 censuses captured more detailed educational qualification information than the 1991 census. In line with Scottish Census guidelines, we categorised highest educational qualification into several levels: no qualifications, Level 1 (Senior certificate and so on), Level 2 (Advanced senior certificate), Level 3 (Higher national certificate and so on), and Level 4. However, we further separated Level 4 qualifications into professional and degree-level (and above) qualifications due to historical differences in the role of professional courses in Scottish education. The resulting educational attainment variable used in the analyses consisted of ordered categories ranging from 'no qualifications' to 'degree or above'.

Adult occupational social class

Age 55 occupational social class was taken from the 1991 Scottish Census, in which individuals reported their present or most recent occupation. These occupations were converted into Standard Occupational Classification 2010 classes, before being assigned a corresponding National Statistics Socio-economic Classification (NSSEC) code (Office for National Statistics, 2010). The NSSEC is a socio-economic classification in which occupations are classified according to their position, employment relations and conditions (Goldthorpe, 2007). NSSEC classifications were reduced to the three-class version: (1) higher managerial, administrative and professional occupations; (2) intermediate occupations; (3) routine and manual occupations. NSSEC class was coded as missing for those who had never worked. This classification by reduced NSSEC code allowed for a stratified analysis, as described later.

Later-life economic activity

Age 55, 65 and 75 economic activity was taken from the 1991, 2001 and 2011 Scottish Censuses respectively. At each census, individuals reported the type of economic activity (or otherwise) that they were undertaking in the prior week. A binary economically active versus economically inactive variable was created from these responses. Being economically active was defined as working as an employee (full-time or part-time), working as self-employed, attending a government training scheme, waiting to start work, or unemployed but looking for work. Being economically inactive was defined as not currently in employment and not currently looking for work or waiting to start work (that is, those in full-time education,

those unable to work due to sickness or disability, those retired, those looking after the home or family).

Statistical analyses

The analyses were designed to assess the odds of an individual being economically active at a given census, and the change in these odds over time. We first described the sample in terms of their early-life characteristics (childhood SES, childhood cognitive ability, education), adult occupational social class and their odds of being economically active. We then described the univariate associations between each of the predictors and the economically active versus inactive binary variable at age 55, 65 and 75 separately. We then entered the variables into a series of latent growth curve models, with economic activity at 1991, 2001 and 2011 as binary outcome measures. The gap between outcome measurements was roughly ten years (3,661 days between 1991 and 2001, and 3,619 days between 2001 and 2011). Such an analysis separates the variance associated with starting conditions (the odds of economic activity at age 55) from that associated with change over time (the odds of becoming inactive after age 55). For each model, the growth curve for the odds of being economically active over time was estimated by creating two latent factors representing the

Figure 1: Hierarchical latent growth curve model.
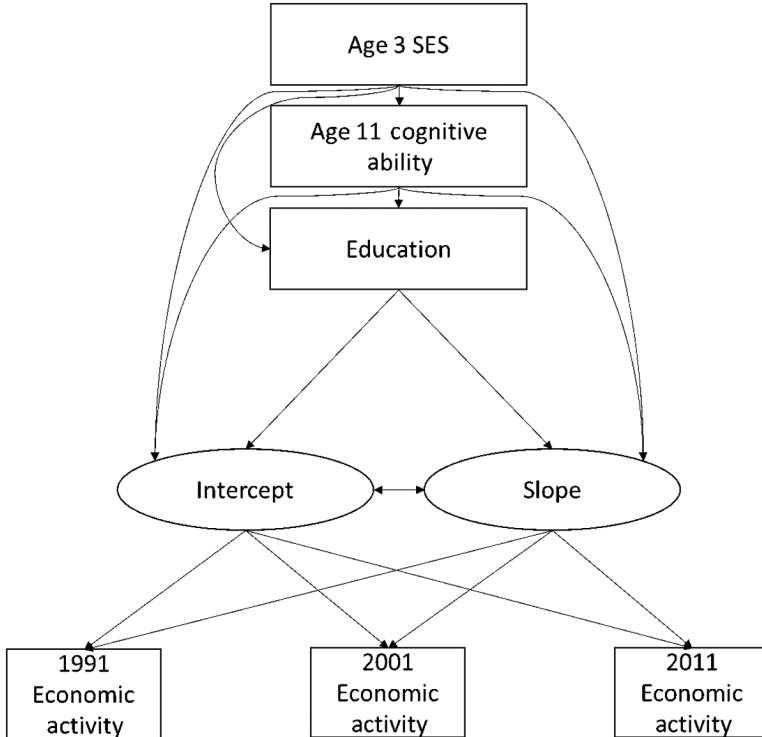
Note: Standard structural modelling conventions apply: observed variables are indicated by rectangles, and latent variables are indicated by ellipses.

intercept and the slope of the curve. Each outcome measure loaded equally on the latent intercept. The latent slope was freely estimated by specifying only the loadings of the first two outcome observations (0 and 1 respectively), and not the third (see Burant, 2016).

In the first stage of the analyses, we examined the associations between childhood SES, childhood cognitive ability, educational attainment and the latent intercept and slope terms by using structural equation modelling to create hierarchical latent growth curve models. This was designed to test the hypothesis that, in addition to direct associations with the odds of being economically active, the associations from earlier predictors are mediated by later ones. The model tested whether the association with childhood SES was mediated by childhood cognitive ability and education, and whether the association with childhood cognitive ability was mediated by education. The full model tested is shown in Figure 1. HISCAM scores and MHT scores were standardised ($M = 0$, $SD = 1$) prior to entry into the analyses. Separate models were calculated for men ($N = 1,153$) and women ($N = 1,221$) in order to account for potential differences in the baseline odds of being economically active, and because of sex differences in the age of statutory retirement (60 for women, 65 for men).

In the second stage of the analyses, we examined potential moderation of early-life associations by further stratifying the hierarchical latent growth curve models by adult occupation type (three-class NSSEC). This analysis allowed us to assess how the odds of being economically active differed across occupations, and whether particular types of occupation could protect individuals from the risk associated with poorer early-life circumstances. Note that stratifying the analyses in this way necessitated the removal of individuals with missing or unclassified NSSEC codes (see Table 1), such as those who had never worked by the time of the 1991 census or those who had not completed the relevant question of the 1991 census sufficiently. As such, the stratified models were calculated for 1,030 men and 876 women. In order to formally assess moderation by adult occupation we constrained specific model paths to be equal across NSSEC groups and compared the resulting model fit to a corresponding unconstrained model using a Satorra–Bentler scaled chi-square test. This was done for both direct and indirect effects of each predictor included in the growth curve model. The full NSSEC-stratification analyses are presented in the Supplementary Material (see https://osf.io/ejxzu/). A similar method was used for examining sex differences, with a series of constrained sex-stratified models each contrasted with an unconstrained sex-stratified model using Satorra–Bentler scaled chi–square tests.

Models were estimated using maximum likelihood with robust standard errors. Covariance coverage was generally good, with a minimum covariance coverage value of 0.471 (see Supplementary Material). Missing values were imputed using full information maximum likelihood. Missing data were assumed to be missing at random. The pattern of missing data is reflected in Table 1, and is described in more detail in the Supplementary Material. Model fit was assessed using the established cut-offs of: RMSEA (Root Mean Square Error of Approximation) = 0.06, SRMR (Standardised Root Mean Square Residual) = 0.08, NNFI (Non-Normed Fit Index) = 0.95, and CFI (Comparative Fit Index) = 0.95 (Hu and Bentler, 1999; for further discussion see Wu et al, 2009). Model fit was assessed, and parameter weights were estimated for each of the associations included in the model. Coefficients are reported after standardising the two latent variables; unstandardised coefficients are presented in

Table 1: Descriptive statistics for the full sample, split by sex. The pattern of missing data is also reported

	Male (N = 1,153)			Female (N = 1,221)		
	Mean	SD	N Missing	Mean	SD	N Missing
Age 3 HISCAM score (max = 99)	47.27	10.15	254 (22%)	47.57	10.33	251 (21%)
Age 11 MHT score (max = 76)	35.46	16.09	63 (5%)	37.67	14.54	81 (7%)
Life-course educational attainment (N)			15 (1%)			19 (2%)
None	722 (63%)			773 (63%)		
Level 1	166 (14%)			213 (17%)		
Level 2	86 (8%)			79 (7%)		
Level 3	43 (4%)			30 (2%)		
Level 4 – professional	72 (6%)			84 (7%)		
Level 4 – degree	49 (4%)			23 (2%)		
Age 55 NSSEC Class (N)			123 (11%)			345 (28%)
Routine & Manual	566 (49%)			483 (39%)		
Intermediate	188 (16%)			264 (22%)		
Higher	276 (24%)			129 (11%)		
Age 55 economic activity		0.27	0 (0%)		0.34	0 (0%)
Active (N)	944 (82%)			733 (60%)		
Inactive (N)	209 (18%)			488 (40%)		
Log odds of being active	0.57	0.30		0.42	0.20	
Age 65 economic activity			274 (24%)			241 (20%)
Active (N)	209 (18%)			92 (7%)		

Table 1: Continued

	Male (N = 1,153)			Female (N = 1,221)		
	Mean	SD	N Missing	Mean	SD	N Missing
Inactive (N)	670 (58%)			888 (73%)		
Log odds of being active	0.16			0.07		
Age 75 economic activity		0.15	466 (40%)		0.12	374 (31%)
Active (N)	36 (3%)			26 (2%)		
Inactive (N)	651 (57%)			821 (67%)		
Log odds of being active	0.04			0.02		

Note: HISCAM = Historical CAMSIS; MHT = Moray House Test No. 12; NSSEC = National Statistics Socio-economic Classification. Source: Scottish Longitudinal Study.

Supplementary Material. *P*-values were not corrected for multiple comparisons. Analyses were conducted in R (v3.3.3; R Core Team, 2017) using the 'psych' (v1.6.6; Revelle, 2016) and 'lavaan' packages (v0.5–23.1097; Rosseel, 2012).

Results

Sample description

We first described the sample in terms of their early–life characteristics. Table 1 shows the 1939 HISCAM scores (childhood SES), MHT scores (childhood cognitive ability), level of educational attainment (education), and NSSEC class (adult occupational social class) for males and females separately. Around a fifth of males and females had missing 1939 HISCAM scores. As this score was taken at the household-level, it is likely to have been affected by absent males leaving the household to join the armed forces (prior to the Second World War). Furthermore, as HISCAM scores are based on occupational prestige, missing values may indicate households reporting only economically inactive roles (such as child-rearing). Note also that the majority of males and females reported having no further education beyond schooling, and that degree-level education was uncommon, particularly among females (see Table 1). However, the distribution of NSSEC classes was different for men and women. Whereas the majority of both men and women reported having routine occupations at the 1991 census, having higher (managerial) occupations was much more common among men. In contrast, more women than men reported having intermediate occupations. Furthermore, over a quarter of women had missing or unclassifiable NSSEC codes at the 1991 census, compared to only a tenth of men. This was predominantly driven by more women ($N = 342$) than men ($N = 112$) reporting no codeable NSSEC class. As with HISCAM scores, this preponderance of uncodeable responses likely represents individuals who have worked but not within the last ten years, and individuals who do not work due to family and care commitments.

The correlations between the key predictors are shown in Supplementary Material. Briefly, HISCAM scores, MHT scores, educational attainment level and NSSEC classes were all significantly and positively correlated with each other, for both males and females. Correlations between HISCAM scores and other variables were all around 0.2. Correlations among MHT scores, educational attainment and NSSEC class were larger, between about 0.3 and 0.6.

In terms of the outcome measure, we characterised the common sequences of economic activity and inactivity across the three censuses (Supplementary Material). Among the most common trajectories for both males and females was one of transitioning out of economic activity; individuals tended to be economically active at age 55 and then report inactivity at either ages 65 or 75. In contrast, remaining economically active across all three time points was much more uncommon. However, being economically inactive at all three censuses was the second-most common sequence among females.

Consistent with these sequences, the log odds of being economically active reduced substantially across the three census dates for both men and women (see Table 1). Similarly, the proportion of individuals with missing economic activity measures increased with each census date. The majority of these individuals with missing data died between the census dates ($N = 267$ died between 1991 and 2001; $N = 475$ died

Table 2: Fit statistics for the hierarchical growth curve models fit for men and women separately

Fit Index	Males	Females
X^2 (df)	3.429 (3)	8.008 (3)
RMSEA [95% CI]	0.011 [< 0.001, 0.052]	0.037 [0.005, 0.069]
SRMR	0.011	0.016
NNFI	0.994	0.938
CFI	0.999	0.988

Note: RMSEA = Root Mean Square Error of Approximation; SRMR = Standardised Root Mean Square Residual; NNFI = Non-Normed Fit Index; CFI = Comparative Fit Index. Source: Scottish Longitudinal Study.

between 2001 and 2011). The co-occurrence of these trends may indicate the dropout of those most likely to be economically active. In contrast with those who were present at all censuses (that is, those who contributed to all time points), those who dropped out (those who contributed to only one or two time points) demonstrated significantly lower HISCAM scores (among females only), lower MHT scores, lower levels of educational attainment, and lower NSSEC classes (Supplementary Material).

We next examined the univariate associations between each predictor and economic activity (versus inactivity) at ages 55, 65 and 75 separately (Supplementary Material Tables 5 and 6). At age 55, higher HISCAM scores (Male Odds Ratio (OR) = 1.237; Female OR = 1.257), higher MHT scores (Male OR = 1.385; Female OR = 1.485), higher levels of educational attainment (relative to none; Male ORs = 2.455 to 6.744; Female ORs = 1.287 to 2.717), and intermediate NSSEC class (relative to Routine & Manual; Male OR = 3.612; Female OR = 2.068) were each associated greater odds of being economically active for both males and females. At age 65, higher HISCAM scores (OR = 1.201) and degree-level educational attainment (OR = 2.949) were associated with greater odds of being active among males, whereas higher HISCAM scores (OR = 1.414) and higher MHT scores (OR = 1.336) were associated with greater odds of being active among females. At age 75, greater odds of being economically active among males was significantly associated with higher MHT scores (OR = 1.461), degree-level educational attainment (OR = 3.592) and intermediate NSSEC class (OR = 3.450). Among females, greater odds of being economically active at age 75 was significantly associated with only level 3 educational attainment (Higher National Certificate, and so on; OR = 4.610).

Hierarchical growth curve analyses split by sex

Fit statistics indicated that the latent growth curve model including early-life predictors had very good fit for both males and females (see Table 2). Model misfit was low for both males and females, as indicated by RMSEA values (*p* = .937 and *p* = .707 respectively). Similarly, the covariance structure appeared to fit well for both men and women, as indicated by SRMR values. Model fit was better than that of a null model, as indicated by NNFI and CFI for both men and women.

Figure 2: Structural equation model for males showing the associations between childhood SES, childhood cognitive ability, education, and the latent intercept and slope of later-life economic activity.
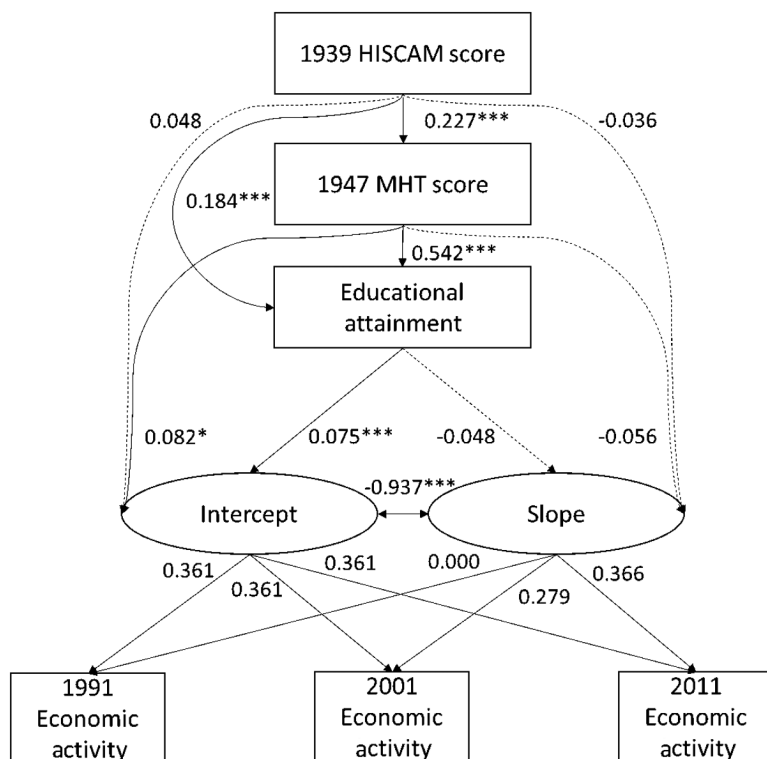
Source: Scottish Longitudinal Study.

Note: Single-headed arrows represent regression paths (non-significant paths are dashed), and double-headed arrows represent covariance between the latent variables. Beside the arrows are coefficients after standardising the latent variables. $*p < .05$, $**p < .01$, $***p < .001$ Total direct and total mediated effects are described in the main text.

Males

The direct and indirect associations between early-life factors and the latent intercept and slope factors are shown in Figure 2. In the initial part of the model, we imposed a temporal order on the early-life predictors. The set paths between these predictors were significant, such that age three HISCAM scores (childhood SES) predicted both age 11 MHT scores (childhood cognitive ability; $\beta = 0.227$, Standard Error (SE) = 0.035, $p < .001$) and educational attainment ($\beta = 0.184$, SE = 0.048, $p < .001$), and age 11 MHT scores significantly predicted educational attainment ($\beta = 0.542$, SE = 0.039, $p < .001$).

The estimated slope indicated a significant but non–linear change in the odds of being economically active over time (see Figure 2), with the odds of being active reducing mostly in 2001 and then further in 2011. This likely represents the effect of statutory retirement, with males in the sample reaching statutory retirement age around the 2001 census (age 65). There was significant negative covariance between the latent intercept and slope factors, indicating convergence over time; those with

lower odds of being economically active at 1991 had much flatter negative slopes, and those with higher odds had much steeper negative slopes. Given that individuals rarely transitioned from inactive to active (see Supplementary Material), only those who began as economically active could transition to economically inactive over the following 20 years.

We first examined the total association between each predictor and the latent intercept and slope by summing their direct and indirect associations (see Supplementary Material Table 11). Where significant, we broke down total associations into direct associations (Figure 2) and indirect associations (see Supplementary Material Table 11) and further examined potential moderation by adult NSSEC category. Together, life–course predictors accounted for only a small amount of variance in the latent intercept ($R^2 = 0.034$). There was no significant total association between HISCAM scores and the odds of being economically active at 1991 ($\beta = 0.048$, SE $= 0.014$, $p = .198$; Supplementary Material Table 11); although there were significant indirect associations mediated by the combination of MHT score ($p = .035$) and education ($p = .018$). NSSEC category did not appear to moderate these indirect effects (ps > 0.083).

Figure 3: Structural equation model for females showing the associations between childhood SES, childhood cognitive ability, education, and the latent intercept and slope of later-life economic activity.
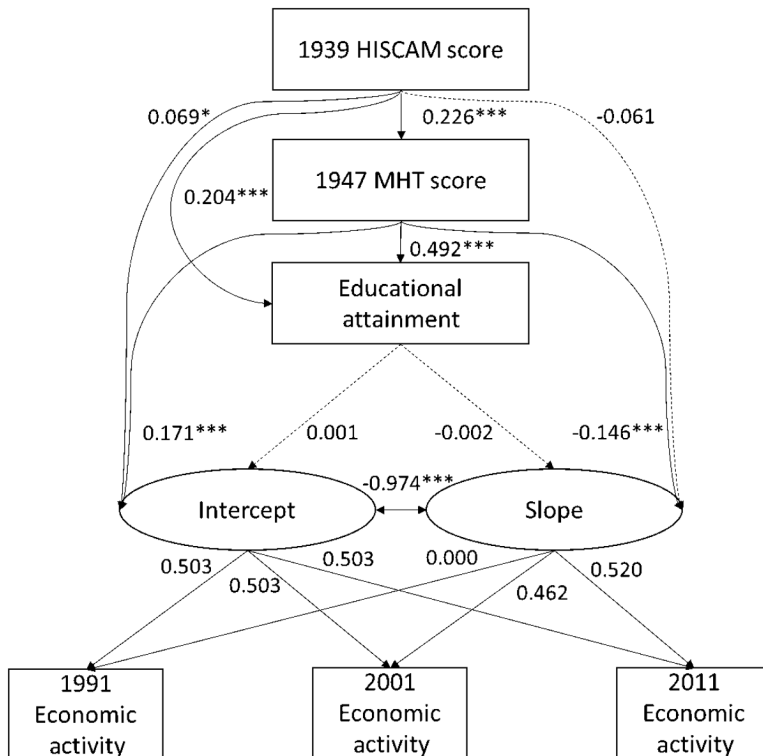
Source: Scottish Longitudinal Study.

Notes: Single-headed arrows represent regression paths (non-significant paths are dashed), and double-headed arrows represent covariance between the latent variables. Beside the arrows are coefficients after standardising the latent variables. $*p < .05$, $**p < .01$, $***p < .001$. Total direct and total mediated effects are described in the main text.

A 1 Standard Deviation (SD) advantage in MHT score was significantly associated with a 5% increase in the odds of being economically active at 1991 ($\beta = 0.123$, SE = 0.012, $p < .001$; Supplementary Material Table 11). This association was only partly mediated by educational attainment ($p = .001$); there remained a significant direct association between MHT score and economic activity at 1991 ($\beta = 0.082$, SE = 0.013, $p = .027$). Neither the direct or indirect associations between childhood cognitive ability and economic activity at 1991 were significantly moderated by NSSEC class (ps > 0.102). A 1-level advantage in educational attainment was directly associated with a 3% increase in the odds of being economically active at 1991 ($\beta = 0.075$, SE = 0.008; $p < .001$), and this association was not moderated by NSSEC category (X^2 difference = 0.168, df difference = 2, $p = .919$).

As with the latent intercept, life-course predictors together accounted for only a small amount of variance in the latent slope ($R^2 = 0.015$). Notably, neither HISCAM scores ($\beta = -0.035$, SE = 0.013, $p = .429$; Supplementary Material Table 11) or educational attainment ($\beta = -0.048$, SE = 0.008, $p = .086$; Supplementary Material Table 11) were associated with a change in the odds of being economically active over the 20-year follow-up period (about age 55 to 75). Whereas, in total, a 1SD advantage in MHT score was significantly associated with a 2% decrease in the odds of becoming economically inactive over time ($\beta = -0.083$, SE = 0.011, $p = .031$; Supplementary Material Table 11), neither the direct ($\beta = -0.056$, SE = 0.012, $p = .192$) or indirect ($p = .088$) associations were themselves significant.

Females

The direct and indirect associations among early-life predictors and the latent intercept and slope are shown in Figure 3. As with males, the specified paths among the three early-life predictors were all significant. That is, age 11 MHT scores (childhood cognitive ability) was significantly predicted by age three HISCAM scores (childhood SES; $\beta = 0.226$, SE = 0.029, $p < .001$), and educational attainment was significantly predicted by both age three HISCAM scores ($\beta = 0.204$, SE = 0.043, $p < .001$) and age 11 MHT scores ($\beta = 0.492$, SE = 0.040, $p < .001$).

The estimated slope indicated a significant non-linear change in the odds of being economically active over the three censuses (see Figure 3). As with males, the odds of being economically active dropped most between 1991 and 2001, with a shallower slope in 2011. Again, this probably indicates the effect of statutory retirement, for which women in the sample became eligible between the 1991 and 2001 censuses (age 60). There was significant negative covariance between the latent intercept and slope, such that those with lower odds of being economically active at 1991 had flatter negative slopes, and those with higher odds had steeper negative slopes. Again, this probably represents the tendency for those beginning as economically active to transition to economically inactive, and those beginning as economically inactive to remain inactive over time (see Supplementary Material); only those who began as economically active could transition to inactive over the following 20 years.

As with males, we estimated the total association between each predictor and the latent intercept and slope (see Supplementary Material Table 12), before breaking these down into direct (Figure 3) and indirect (see Supplementary Material Table 12) associations and further testing for moderation by adult NSSEC category. Together,

the life-course predictors accounted for only a small amount of the variance in the latent intercept ($R^2 = 0.037$). A 1SD advantage in HISCAM score was associated with a 4% increase in the odds of being economically active at 1991 ($\beta = 0.069$, SE = 0.016, $p = .028$; Supplementary Material Table 12). This association was driven by both a direct association ($\beta = 0.069$, SE = 0.016, $p = .028$) and an indirect association through MHT score ($p < .001$), neither of which were significantly moderated by NSSEC category at adulthood (ps > 0.051). Unlike in males, the association between HISCAM score and economic activity at 1991 was not significantly mediated by educational attainment ($p = .970$). A 1SD advantage in MHT score was associated with a 9% increase in the odds of being economically active at 1991 ($\beta = 0.172$, SE = 0.015, $p < 0.001$; Supplementary Material Table 12). This association was predominantly direct ($\beta = 0.171$; SE = 0.016, $p < .001$), as there was no significant indirect association through educational attainment ($p = .970$). This direct association was not significantly moderated by adult NSSEC class (X^2 difference = 0.462, df difference = 2, $p = .794$). There was no significant direct association between educational attainment and the odds of being economically active at 1991 ($\beta = 0.001$, SE = 0.012, $p = .970$).

Taken together, only a small proportion of the variance in the latent slope was accounted for by the life-course predictors ($R^2 = 0.027$). Neither HISCAM scores ($\beta = -0.061$, SE = 0.015, $p = .061$; Supplementary Material Table 12) or educational attainment ($\beta = -0.002$, SE = 0.012, $p = .949$; Supplementary Material Table 12) were significantly associated with the change in odds of being economically active over the 20-year period. However, as in males, a 1SD advantage in MHT score was associated with a 7% reduction in the odds of becoming economically inactive over time ($\beta = -0.147$, SE = 0.015, $p < .001$; Supplementary Material Table 12). This association was driven by a direct association between MHT score and the latent slope ($\beta = -0.146$, SE = 0.043, $p < .001$); there was no significant mediation by educational attainment ($p = .949$) and no significant moderation by NSSEC category (X^2 difference = 1.478, df difference = 2, $p = .478$).

Sex differences

Given that the pattern of associations between early-life predictors and both the latent intercept and slope differed between males and females, we explicitly assessed sex differences in each significant path. We began by testing sex differences in the association between early-life predictors and the odds of being economically active at 1991. While the direct association between HISCAM score and the odds of being economically active did not significantly differ between males and females (X^2 difference = 0.677, df difference = 1, $p = .411$), the indirect association through MHT score was significantly stronger among females than males (X^2 difference = 5.564, df difference = 1, $p = .018$). There was no significant difference between males and females in regard to the indirect association through educational attainment (X^2 difference = 2.922, df difference = 1, $p = .087$). The direct association between MHT score and the odds of being economically active at 1991 was significantly stronger among females than males (X^2 difference = 6.929, df difference = 1, $p = .008$). In contrast, the indirect association between MHT score and the odds of being economically active at 1991 through educational attainment was stronger among males than females (X^2 difference = 4.071, df difference = 1, $p = .044$). The direct

association between educational attainment and the odds of being economically active at 1991 did not significantly differ between males and females (X^2 difference = 3.623, df difference = 1, p = .057).

The direct association between MHT score and the change in the odds of being economically active over time was significantly stronger among females than males (X^2 difference = 6.499, df difference = 1, p = .011).

Discussion

The present study examined the association between early-life circumstances and the odds of being economically active from age 55 to 75. In both males and females, a temporally ordered association was observed between life-course predictors, such that age-3 SES predicted age-11 cognitive ability and lifetime educational attainment, and age-11 cognitive ability in turn predicted lifetime educational attainment. These associations are consistent with previous work (see, for example, Richards and Sacker, 2003; Deary et al, 2005; Paterson et al, 2010), and reiterate that those with social and cognitive advantage in childhood tend to achieve higher levels of education (Deary et al, 2007). However, the use of contemporaneously collected measures in the present study strengthens the argument for a causal association between life-course predictors. Despite the strong association between predictors, there was evidence for relatively weak but significant direct and mediated associations with economic activity in later life. Notably, the association between life-course advantage and better odds of being economically active was not moderated by the type of occupation at adulthood, suggesting that adult occupation did not compensate for early-life disadvantage. However, the pattern of associations between life-course predictors and the odds of being economically active at age 55 was very different to the pattern of associations between the same life-course predictors and subsequent change in odds over 20 years. Furthermore, the pattern of associations observed in males was very different to the pattern of associations observed in females.

Economic activity at age 55

In line with national estimates of economic inactivity (Office for National Statistics, 2016; Table A05), the present study observed that being economically inactive was common at age 55. Notably, at age 55, individuals had not yet reached statutory retirement age, and so inactivity likely reflects those who were unable or unwilling to remain in the workforce. In the present study, the odds of being economically active at age 55 were predicted by early-life circumstances, with higher childhood SES, higher childhood cognitive ability and higher educational attainment all associated with higher odds of being economically active. This is broadly in line with the findings of Richards and Sacker (2003), who observed that childhood SES, childhood cognitive ability and educational attainment all predicted midlife occupation (see also Deary et al, 2005; Paterson et al, 2010).

Consistent with previous work (such as Deary et al, 2005; Paterson et al, 2010), the strongest predictor of being economically active at age 55, for both males and females, was childhood cognitive ability. In the present study, a 1SD advantage in age-11 MHT scores was associated with a 5% and 9% increase in the odds of being economically active at age 55 for men and women respectively. In contrast

to Richards and Sacker (2003), however, the association from childhood cognitive ability was not wholly mediated by educational attainment (see Deary et al, 2005). This direct association among both males and females may represent the role of childhood cognitive ability in building human capital across the life course (Becker, 1993; Kanfer et al, 2001; Sterns and Dawson, 2012). Given the association between cognitive ability and employment prospects in early and midlife (Deary et al, 2005), those with higher childhood cognitive ability may be better at developing the skills and resources – including health – that are necessary for employment, particularly in older age. Educational attainment may similarly, albeit weakly, contribute to the development of human capital that results in greater employment odds at age 55. The weaker direct association from childhood SES, on the other hand, may represent the contribution of cultural factors – such as expectations of employment and retirement, and access to financial aid (Snow and Yalow, 1982; Richards and Sacker, 2003) – to human capital and age–55 economic activity.

Although childhood cognitive ability proved to be the strongest predictor of economic activity at age 55, the direct association was significantly stronger for females than males. For males, the association from childhood cognitive ability was partly mediated by educational attainment, and this indirect association was significantly stronger than for females. Unlike childhood cognitive ability, the associations between other early-life predictors and the odds of being economically active at age 55 did not significantly differ between males and females when formally tested. The stronger direct association from cognitive ability among women but stronger mediated association among men may relate to historic inequalities in access to education. Using the Labour Force Survey and British Household Panel Survey, Campbell (1999) observed an association between higher qualifications and higher odds of employment in later life (age 45+) among men but not women. In the present sample, limited access to education – as indicated by the lower proportion of women reporting degree-level education – may have resulted in a weaker mediating effect of education, and thus a stronger direct association with childhood cognitive ability. However, Campbell (1999) suggested that, as women become more involved in the labour market and gain better access to qualifications and higher status employment, the importance of education for later-life employment should emerge as in men. As such, in more contemporary cohorts the contributions of childhood cognitive ability and the mediating role of education may converge between men and women.

It is worth noting that the associations between early-life advantage, including childhood cognitive ability, and the odds of being economically active were much weaker in the present study than in similar life-course studies. For example, Deary et al (2005) reported a direct association between higher age-11 cognitive ability and higher midlife social status that was at least twice the strength of the association with age-55 economic activity reported here ($\beta = 0.43$ vs $\beta = 0.17$, respectively). Similarly, Richards and Sacker (2003) reported much larger direct associations between higher midlife occupational status and both higher childhood SES and higher educational attainment ($\beta = 0.11$ and $\beta = 0.36$, respectively) than were noted using age-55 economic activity in the present study ($\beta = 0.07$, $\beta = 0.07$, respectively). These weaker associations probably result from the use of very different outcome measures; where previous work focuses primarily on occupational attainment, the present study focuses on whether individuals are

economically active or not, regardless of their occupation. Indeed, in the present study, the association between higher childhood cognitive ability and higher odds of being economically active at age 55 was not moderated by the type of occupation at adulthood. The difference in outcome measures also likely explains the relatively small amount of variance captured by early-life circumstances. In the present study, early-life circumstances together accounted for only 3% of the variance in age–55 economic activity. Unlike the level or type of occupation, factors beyond early-life circumstances – such as financial circumstances and health – may be much more important for predicting economic activity at age 55 (see McNair et al, 2004).

Economic activity across later life

As well as the odds of being economically active at age 55, the present study examined the change in the odds of being economically active across later life. Notably, both males and females in the sample tended to transition out of economic activity, and the odds of being economically active decreased non-linearly over time, with a marked drop between age 55 and age 65. This rapid decrease probably represents the contribution of statutory retirement age, as most individuals would have reached this age (in the UK, 60 for women and 65 for men) before or around the 2001 census date. In contrast, the decrease in the odds of being economically active was much shallower between age 65 and age 75. As individuals had already reached statutory retirement age, this later decrease may represent those who had initially chosen to continue working, but who eventually transition out of the workforce. In this sense, the intercept (the odds of being economically active at age 55) and the slope (the change in these odds across time) prbably represent very different outcomes.

Whereas early-life advantage predicted higher odds of being economically active at age 55, albeit weakly, the same life-course factors appeared to have very little association with the subsequent change in these odds over the 20-year follow-up. As with the latent intercept, childhood SES, childhood cognitive ability and educational attainment together accounted for only 2% and 3% of the variance in the latent slope for men and women, respectively. The strongest and only significant predictor of the change in economic activity odds over time was childhood cognitive ability, with higher childhood cognitive ability directly predicting lower odds of transitioning to economically inactive. This suggests that, just as it plays a role in building human capital, childhood cognitive ability may help build resilience and prevent the decline of human capital with age. Note, however, that this association was relatively weak, particularly among men, with a 1SD advantage in MHT scores predicting a 2% and 7% decrease in the odds of becoming inactive among males and females respectively. As with the odds of being economically active at age 55, this suggests that other, more proximal factors may be important for predicting transitions to being economically inactive (McNair et al, 2004).

Notably, the association between childhood cognitive ability and the odds of becoming economically inactive over time was significantly stronger in women than in men. This sex difference may partly result from uneven dropout, as a higher proportion of males presented with missing data across the censuses than did females. Selective mortality of males from disadvantaged backgrounds (see, for example, Galobardes et al, 2004) may limit any association between childhood cognitive

ability and the odds of becoming economically inactive over time. However, sex differences may also emerge due to inequalities regarding state pension eligibility. As women in the present sample could claim state pension at age 60, versus age 65 for men, the contribution of childhood cognitive ability may represent a protective effect for economically active women who otherwise do not need to be active. One possibility is that childhood cognitive ability supports the ability to adapt and transition into new roles in order to continue to be economically active. Note, however, that for women the association between childhood cognitive ability and the odds of becoming inactive over time was not mediated by education, and was not moderated by the type of occupation reported. Another possibility is that the protective role of early–life cognitive ability may emerge due to its associations with less severe age–related reduction in physical (Singh–Manoux et al, 2005; Kuh et al, 2009; Poranen–Clark et al, 2016) and mental (Hatch et al, 2007; Gale et al, 2008; Koenen et al, 2009) health, and with the ability to endure morbidity without being impaired (Stern, 2009). This role may be particularly important among women, given that females experience a higher risk of ill health and functional impairment (Merrill et al, 1997; Ostchega et al, 2000; Rockwood et al, 2004; Helzner et al, 2005). Notably, the association between childhood cognitive ability and later–life health has been demonstrated in the present cohort (Deary et al, 2006; Iveson et al, 2017). By reducing the risk of such impairment, childhood cognitive ability may help females to maintain the ability to be economically active in later life.

Limitations

Whereas the present study identifies the association between several life–course factors and the odds of being economically active in later life, it does so for a cohort of individuals affected by the social and labour market conditions of their time (see Elder, 1994). The types of occupation available has qualitatively changed since the mid–20th century, and the wider labour market conditions continue to shift. As access to education and occupations has broadened, particularly for women, it is unclear whether the same life–course factors will predict the economic activity of more contemporary cohorts. Notably, only three early–life measures were included as predictors, with only one indicating a given factor. However, each is an established measure of their respective factor and all have been shown to have good criterion validity. For example, the MHT score has been shown to correlate well with other measures of cognitive ability, and has been used extensively in previous work (for example, Deary et al, 2000, 2004). Furthermore, by contrasting only economically active and inactive, the present study does not account for different types of exit from the workforce. Individuals may become economically inactive by choosing to retire with adequate pension provisions and savings, or by being forced out of employment due to ill health (Campbell, 1999; Scales and Scase, 2000). Similarly, individuals may remain active out of choice or out of necessity, such as to avoid post–retirement poverty (Adnett, 1996; Beck, 2000; Disney and Hawkes, 2003). Indeed, for older adults, working choices are constrained by their material circumstances (finances, housing tenure and so forth), available skills, health, caring responsibilities and pension availability (McNair et al, 2004). The data utilised here does not provide sufficient means to explore how early–life circumstances impact on these mechanisms, as many of the necessary covariate measures (adult occupational social class, self–rated health and

so on) are either temporally confounded with the outcome measure or not available from routinely collected data. Future work should aim for more detailed measures of these factors – particularly income, pension value and functional ability – across several time points to help distinguish positive and negative economic trajectories in later life.

The present study replicates and extends previous work by demonstrating the association between life-course factors – including childhood SES, childhood cognitive ability and lifetime educational attainment – and economic activity in later life. In particular, it highlights the potential role of childhood cognitive ability in building the human capital necessary to support the ability to be economically active at age 55, and in maintaining human capital beyond retirement age. However, the associations between life-course factors and economic activity were relatively weak, suggesting that other, more proximal factors may be important for predicting whether an individual is economically active later in life, and whether they become inactive over time.

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Note

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Supplementary material link: https://osf.io/ejxzu/

Conflict of interest

The authors declare that there is no conflict of interest.

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