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Poverty and Children's Cognitive Trajectories: Evidence from the United Kingdom Millennium Cohort Study

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POVERTY AND CHILDREN'S COGNITIVE TRAJECTORIES: EVIDENCE FROM THE UNITED KINGDOM MILLENNIUM COHORT STUDY

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Abstract: Existing evidence is inconclusive on whether a socio-economic gradient in children's cognitive ability widens, narrows or remains stable over time and there is little research on the extent of 'cognitive mobility' of children who had a poor start in life compared to their peers. Using data from five sweeps of the United Kingdom (UK) Millennium Cohort Study (MCS) at the ages of 9 months, 3 years, 5 years, 7 years and 11 years, this paper explores the cognitive ability trajectory of children in the bottom decile of the distribution at a given age, and the factors that drive or hinder their progress relative to their peers. Using discrete-time event history analysis methods, the paper analyses children's risks of moving in and out of the bottom decile of the cognitive ability distribution. The findings indicate a relatively high level of cognitive mobility between ages 3 and 11, especially in the pre-school period (between ages 3 and 5), with children from income-poor households more likely to get 'trapped' in the bottom of the age-specific cognitive ability distribution. Parental education plays a dual buffer role: it protects children from falling behind their peers as well as increasing the chances of moving up the ability distribution. Parental involvement, such as reading to a child and regular bedtimes at the age of 3, was found to protect children from falling into the bottom group of cognitive distribution but not necessarily helping lower scoring children to move up.

Keywords: poverty, cognitive ability, transitions, Millennium Cohort Study, social class.

Acknowledgements: The Millennium Cohort Study (MCS) is a multi-disciplinary research project following the lives of around 19,000 children born in the UK in 2000-01. It is based at the Centre for Longitudinal Studies (CLS) at University College London, Institute of Education. The authors would like to thank the CLS and the UK Data Service for providing the data, as well as Professor Heather Joshi and Professor Jonathan Bradshaw for their helpful comments and suggestions on an earlier draft of this paper.

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1. INTRODUCTION

Educational success, as measured by educational attainment, current or future earnings, can be a catalyst for social mobility both within and across generations. But for children with low cognitive attainment levels, the chances of educational success can be limited due to the multiple disadvantage and persistent socio-economic gradient (McKnight 2015). The educational system has to enable all children to achieve academic success despite socio-economic adversity, race or ethnicity (Coleman 1966). Thus the question of cognitive trajectory is a question of the extent to which a child can move up or down the age-appropriate developmental ladder compared to their peers. It is also a question of factors, such as family circumstances beyond the child's control, which explain the variation in cognitive mobility and can represent either risks or opportunities for academic achievement. This paper seeks to address these questions using data from the five latest available sweeps of the United Kingdom (UK) Millennium Cohort Study (MCS).[1] It focuses on children with the lowest cognitive test scores and socio-economic factors associated with the likelihood of their mobility along the cognitive development distribution by age 11, such as household income.

Children's inherited cognitive abilities are only one of the components that help explain their developmental trajectories (Becker and Tomes 1986). Other factors, such as parental investments, family socio-economic background and the quality of educational provision can impede or stimulate academic progress. There is a vast inter-disciplinary literature on the effects of family background or positive socio-economic 'gradient' in education. Higher socio-economic status (SES) is associated with better educational outcomes whether SES is measured using household income (Machin and Vignoles 2004), parental social class (Erikson et al. 2005), or a composite indicator of income and class (Caro et al. 2009). Parental education also has an independent effect, net of occupation and income (Bukodi and Goldthorpe 2012; Sullivan et al. 2013).

Evidence to date strongly suggests that, as a proxy for educational attainment, children's cognitive development trajectories are highly correlated with family SES (Feinstein 2003) including low-income or poverty (Dickerson and Popli 2016; Feinstein 2003). Evidence from the UK cohort studies, which follow the same group of children as they grow up, shows that those from more affluent backgrounds tend to do better in cognitive tests from as early as the age of 2 or 3 years (Feinstein 2003; Hansen and Joshi 2007; Blanden and Machin 2010; Washbrook and Waldfogel 2010; Hansen et al. 2010; Waldfogel 2013; Platt et al. 2014). Evidence from cohort studies in the United States (US) (Brooks-Gunn and Duncan 1997; Lee and Burkam 2002) and in lower income country settings (Dornan and Woodhead 2015) produces similar findings.

Meanwhile, existing evidence is inconclusive on the extent of mobility across the observed cognitive distribution for children who had a poor start in life. Based on MCS data, Blanden and Machin (2010) find that between ages 3 and 5 low vocabulary achievers from high income families move further up than those from low income families. Using data from a cohort of British children born in 1970, Feinstein (2003) shows that lower SES children who performed better than

[1] This analysis will be updated when the 2015/2016 MCS data (on children aged 14) become publicly available.

their higher SES peers on cognitive tests at 22 months old go on to perform less well at 42 months, i.e. even before starting school, while their less able high-SES peers catch up. This widely cited finding has influenced public policy and discourse in the UK and beyond (Millar 2011), but its reliability was questioned due to the possibility of measurement error leading to 'regression to the mean'[2] (Jerrim and Vignoles 2013). A recent study of a cohort of British children born in 1991-92, which sought to address this measurement error, finds that children from most disadvantaged backgrounds who attained high cognitive test scores at age 7 performed worse than their lower achieving counterparts from the least disadvantaged families by age 14-16 (McKnight 2015). This suggests that 'convergence' in test performance between more able low-SES and less able high-SES students may happen later than previously thought.

As a contribution to this debate, the present study analyses the effect of poverty (in the context of other SES characteristics) on the extent of cognitive mobility across deciles of the age-specific distribution between ages 3 and 11. The analytical focus is on the group of children at the lower end of cognitive ability distribution (scoring in the bottom decile),[3] i.e. those who had a poor educational start. This is an important distinction from most other studies which have focused on the comparison of mean test score outcomes between SES groups. The paper addresses the following research questions:

Q1*:* what is the extent of cognitive mobility in and out of the bottom decile of the measured cognitive ability distribution between ages 3 and 11, i.e. between the pre-school years and the start of secondary schooling?

Q2: How does the effect of income, independent of other SES characteristics and early parental inputs, differ for the risks of exiting from the bottom decile (for children who had scored in the bottom decile) and entering the bottom decile (for children who had scored higher up the ability distribution)?

Understanding the extent of developmental mobility for children who started well below most of their peers and the role of poverty in hindering their progress will help stimulate further debate on the effectiveness of pre-school and early school provisions. The UK is an interesting case study because since 1997 successive governments have placed early years education and social mobility high on the political agenda (Cabinet Office Strategy Unit 2008; Cameron 2015; Field 2010; HM Government 2011). Since the MCS follows a cohort of children born in 2000-2001 until they are 11 years old, it sheds light on the situation of a contemporary cohort of children, who at an early age would have benefited from the Labour government's investments in early education and care (e.g. the Sure Start programme) and in family benefits (e.g. child tax credits) but before the cuts in family benefits and services introduced by the Conservative Liberal-Democrat Coalition government came into force.

[2] "Extremely high (and low) values affected by measurement error are likely to be closer to the sample mean at repeat assessments." (Flouri et al. 2014, p. 1054)

[3] We focus on mobility across decile rather than, for example, quintiles, because we are interested in the lowest scoring children (hence, bottom decile) and because longer range mobility is more rare.

To our knowledge, no other studies have examined the effects of income poverty on children's transitions in and out of the bottom-end of the cognitive ability distribution as they grow older. Studies that examined trajectories of cognitive outcomes from an early age focused on mean group differences (e.g. Blanden and Machin 2010), rather than the risks of 'entry' into and 'exits' from the lowest cognitive decile as studied here. If children living in poverty are more likely to fall into and get 'trapped' at the bottom of the age-specific distribution, this has direct implications for programmes and interventions targeted at low academic achievement.

The paper is structured as follows: Section 2 highlights the relevant evidence, conceptual framework and hypotheses of the study. Section 3 presents the data, measures and methods applied. Section 4 underlines the key empirical findings and Section 5 discusses the main findings and concludes.

2. FRAMEWORK, EVIDENCE AND HYPOTHESES

A growing body of evidence from neurobiology, developmental psychology and economics emphasises the early years of childhood as a cornerstone for later outcomes (see Phillips and Shonkoff 2000). The experiences and environment in the first three to five years of a child's life are critical in shaping the brain architecture that underpins future development (Fox et al. 2010; E. Knudsen 2004). According to a cumulative skill formation model, investments in early skills reinforce the returns of later human capital investments (Cunha et al. 2010; Cunha and Heckman 2008; Heckman 2006, 2008; Heckman and Masterov 2007). This framework informs the present study as it emphasises the evolution and dynamic nature of cognitive skills formation over the life-course, with a particular focus on the family environment and the importance of experiences in early childhood. Indeed, numerous intervention studies with disadvantaged children show that adverse experiences in the early years can have lasting negative impacts on important later life outcomes and vice versa, positive experiences are associated with better cognitive and socio-emotional outcomes (see Shonkoff and Meisels 2000; Schweinhart et al. 2005). Economists stress the importance of investing in the early years of disadvantaged children as the most efficient strategy to build a productive future workforce (Heckman 2006; Knudsen et al. 2006).

In a seminal review of evidence from several longitudinal studies in the US, Brooks-Gunn and Duncan (1997) cite the negative impact of childhood poverty, particularly in the earliest years, on a range of medium and longer term outcomes, such as cognitive ability, educational achievement, school completion and income in adulthood. Using the US Panel Study of Income Dynamics, Duncan et al (2010) document large adverse effects of poverty experienced in early childhood on adult earnings and hours worked. Persistent, rather than transient, poverty was found to be especially harmful for a child's cognitive development (also see Dickerson and Popli 2016). Poverty is "a multifaceted phenomenon of a considerable complexity" (Tomlinson and Walker 2009), which goes beyond a lack of income or deprivation in specific household items. Poverty can manifest in poor housing, limited access to services or the stress experienced by parents unable to make ends meet, their mental health and sense of worth. Thus, one can expect numerous interlinked pathways through which childhood poverty affects current and future cognitive outcomes. The 'pathways' are understood as a transmission mechanism between poverty and child outcomes (Brooks-Gunn and Duncan 1997) and can include health and nutrition, home environment, parental interactions, parental health or neighbourhood (Dickerson and Popli 2016). According to the family stress model and its extensions (K.J. Conger et al. 2000; R.D. Conger and Elder 1994), economic disadvantage exerts pressure on parental mental health, adversely affecting parental investment in children and, in turn, child outcomes.

Income poverty can affect child cognitive outcomes through parental input of time (care and activities with a child) and money (purchased goods and services). From the point of view of economic theory, limited material resources lead to lower parental investment in children (Lord 2001). Studies from other disciplines stress that socio-economic disadvantage is likely to determine a poor pattern of parental investment behaviour through a link to parental beliefs and aspirations (Stafford and Yeung 2004; Wentzel 1998). With a variety of possible measures used in the literature to proxy 'parental input', the question of what input really matters and how much of it is necessary is still an ongoing scholarly debate (Kalil and Mayer 2016; Waldfogel 2016).

Parenting behaviour as a mediating factor between economic deprivation and child outcomes has been confirmed in numerous studies (Kiernan and Huerta 2008; Kiernan and Mensah 2011). Moreover, parenting styles were found to reflect broader family social and cultural capital (Sullivan et al. 2013) or other unobserved parental characteristics (Ermisch 2008). However, over-emphasizing the role of parenting may backfire: although parenting practices can be amenable to interventions (see Cunha et al. 2006), policy makers increasingly use the language of parental behaviour to blame parents, rather than inadequate social protection and services provision, for adverse child outcomes (Hartas 2015; Main and Bradshaw 2016).

Demographic characteristics such as gender, ethnicity and race have long been found to be associated with income poverty. In the UK, black, Pakistani and Bangladeshi minority groups are more likely to be income poor (Fisher and Nandi 2015; Palmer and Kenway 2007). Moreover, the observed cognitive delay of infants (9 months old) found among these two minority groups, disappears when factors of socio-economic deprivation are taken into account (Kelly et al. 2006).

As poverty is the product of multiple individual and structural causes, a broader conceptualisation of socio-economic disadvantage is often applied to examine the effects of 'environmental factors' on child cognitive development. Here there is a clear disciplinary divide: while economists tend to use income as a proxy for SES, sociologists employ social classes as "categories defined not just by income, but by labour market position, power and status" (Sullivan et al. 2013, p. 5). Social class is often measured using broad occupational categories to reflect differential positions within employment relations (Goldthorpe 1997, 2004). Although the exact causal mechanism is somewhat obscure, Sullivan et al (2013) find an independent effect of parental social class on cognitive outcomes at age 7, even after controlling for parental education, income, and parenting practices, as well as children's cognitive scores at age 5, using data from the MCS. Parental occupational status is also found to explain the differences in academic achievement of 15-year-olds cross-nationally after taking into account a child's gender and immigrant status (Jerrim 2012).

Drawing on this body of research, the present study tests the following hypotheses.

H1: If income poverty has a direct independent effect on children's cognitive mobility over time, children who scored in the bottom decile of the cognitive ability distribution at age 3, 5, or 7 are significantly more likely to remain in the bottom decile the next time they were tested (at age 5, 7 or 11) if they come from a low income household, even after controlling for parental education, occupational class, and parental practices.

H2: Children who scored above the bottom decile of the ability distribution in one year are more likely fall into the bottom decile the following year if they come from income poor households, ceteris paribus.

3. DATA AND METHODS

This paper uses data from four cycles of the UK Millennium Cohort Study (MCS), a longitudinal study of around 19,000 children born at the turn of the century across the UK. From the age of 9 months (MCS1), children are followed up at ages 3 (MCS2), 5 (MCS3), 7 (MCS4) and 11 (MCS5) and will be surveyed into early adulthood. The MCS was designed to provide rich information on socio-economic and demographic characteristics of the family with a particular focus on parental endowments, practices and input from the pre-natal period onwards. Data on children's cognitive development are collected from the age of 3. The study's sample design allowed disproportional representation of families living in areas with high child poverty rates and high concentration of ethnic minorities at the time the sample was drawn.[4] Therefore sampling weights are applied in the analysis of the data.

18,552 families were interviewed in MCS1. Many of them (79 per cent) were re-interviewed in MCS2 and 692 additional eligible families were interviewed for the first time (Hansen and Joshi 2007). These 'new families' are not included in the multivariate analyses in this paper because they lack key predictors from MCS1. There were 13,287 families with valid responses in MCS5 – 69 per cent of all MCS families who have ever responded, including the 'new families'. See Hansen (2014) for more information about response rates across the first five surveys. Although attrition is a an issue for any longitudinal study, it is encouraging that "there is little evidence of strong differential attrition by family background" over the first five cycles of the study (Platt et al. 2014, p. 9).

For consistency with most other MCS research, we exclude cohort members who are second or third children in families with twins or triplets. Thus we count each family just once and avoid having to account for 'clustering' within families.

3.1 Outcome measures of cognitive development

MCS children received age-appropriate standard cognitive tests from the age of 3. The raw scores are standardised to take account of the age of the child at interview (to the nearest 3 months) and the difficulty of the item set completed.

[4] See Plewis (2007) for detailed information about the MCS sampling design, Hansen (2012) for data on attrition across the first four sweeps and Mostafa (2014) on attrition in the first five sweeps.

Table 1 shows the specific types of cognitive assessment administered to MCS children at ages 3, 5, 7 and 11 (Hansen 2014, p. 62). Different age-appropriate British Ability Scales (BAS) tests were used in all four surveys. The Naming Vocabulary scale measures young children's verbal ability, while Word Reading and Verbal Similarity are typically used to assess older children's (5 to 17 years) reading ability and verbal reasoning/knowledge, respectively. The Picture Similarity scale assesses children's problem-solving ability and the Pattern Construction scale tests their spatial awareness. The MCS user database reports three types of BAS test scores: raw scores, ability scores and t-scores. This study uses the t-scores because they are adjusted both for the specific items administered and for children's age at the time of testing.

The Bracken School Readiness test carried out in MCS2 at age 3 assesses the comprehension of diverse educational concepts in young children. The following concept categories were used in MCS2: colours, letters, numbers/counting, sizes, comparisons, and shapes. These concepts are meant to be related to children's readiness for formal education. The total number of correct answers in all categories is transformed into a standard age-adjusted score. The NFER Number Skills tests administered in MCS4 assess children's knowledge of mathematical concepts and skills. We use the standardised age-adjusted scores provided in the MCS dataset (see Hansen 2014).

The two CANTAB tests administered in MCS5 are not used here because they are not comparable to the rest of the tests in the way they are scaled and standardised and they do not measure the same aspects of cognitive ability as the other tests.

Table 1 – ***Assessments by Sweep Collected***

Assessment	MCS Sweep			
	MCS2	MCS3	MCS4	MCS5
BAS Naming Vocabulary	■	■		
Bracken School Readiness	■			
BAS Picture Similarity		■		
BAS Pattern Construction		■	■	
BAS Word Reading			■	
BAS Verbal Similarities				■
NFER Number Skills			■	
CANTAB Spatial Working Memory Task				■
CANTAB – Cambridge Gambling Task				■

Source: Hansen (2014, p. 62).

Although the MCS cognitive ability tests do not measure innate intelligence and are merely "tests of attainment based on the capability and motivation to complete a particular task under given conditions" (Platt et al. 2014, p. 52), they are typically used as indicators of age-specific cognitive development (Waldfogel 2013). In practice, scores from different tests administered in the same wave are often combined, using factor analysis or related techniques, to estimate an underlying latent dimension of cognitive ability. Using multiple scales helps attenuate (but not necessarily eliminate) the measurement error associated with the test scores and, therefore, minimise the risk of detecting spurious changes in the observed test scores over time due to 'regression to the mean' (Jerrim & Vignoles, 2013). Following Jones and Schoon (2008), we use principal component factor analysis to derive latent cognitive ability scores based on correlations between the observed standardised test scores at ages 3, 5 and 7. Cases with missing values on at least one of the scales in a given wave are excluded from factor analysis. Since at least two variables are necessary for the estimation, we have to use the observed BAS Verbal Similarity standardised score as a proxy for latent cognitive ability at age 11 (as we cannot combine it with either of the two CANTAB measures). Thus, cognitive ability at age 11 may be measured with more error than at earlier ages. Table A1 in the Annex reports the estimates of factor loadings (i.e. the Pearson correlations between the latent factor and observed indicator) at ages 3, 5 and 7. The underlying factor accounted for 79 per cent of the underlying variance at age 3, 56 per cent at age 5 and 63 per cent at age 7. The predicted factor scores are subsequently standardised to a mean of 100 and a standard deviation of 15.

3.2 Socio-economic status

Income poverty is our main SES variable of interest, but we also control for highest parental occupational status (based on the current or last known job) and highest parental level of education at the time of the survey, as well as for parental work status and family structure (i.e. couple family vs. lone parent). This is to distinguish the effects of current 'flow' of family material resources (i.e. income) from the 'stock' of social and human capital (e.g. occupational status). Current income poverty can be regarded as a proxy for current liquidity constraints.

Households are classified as poor if their total disposable incomes (after taxes and transfers, adjusted for size and composition) before housing costs, are below 60 per cent of the national contemporary median. To estimate the effects of household income across the distribution (rather than simply below and above the poverty line), we use disposable income quintiles in alternative specifications. The poverty threshold tends to fall in the second quintile. We use contemporary income rather than income averaged over the preceding surveys (e.g. Blanden and Machin 2010) because we are interested in the effects of the socio-economic circumstances prevailing at the time of testing on children's test scores. Since income poverty is quite volatile from wave to wave (Bradshaw and Holmes 2010), the effects of poverty measured contemporaneously with cognitive ability are likely to be smaller than the effects of persistent poverty (see Dickerson and Popli 2016).

The highest ranked occupational status of the current or last known job of the mother or father is used as a measure of social class. It is based on the five categories of the widely used NS-SEC schema (Goldthorpe 1997). Households where both parents have never worked are classed in a separate category. Meanwhile, the highest level of education of the mother or father, whichever is higher, is used to measure household educational attainment based on five National Vocational Qualification (NVQ) equivalent categories.[5]

Unless stated otherwise, all predictors are time-varying, i.e. measured in the same sweep of the MCS as cognitive ability.

[5] The lowest NVQ (Level 1) is equivalent to one GCSE at grade D-G, while the highest NVQ (Level 5) is equivalent to a post-graduate degree. https://www.gov.uk/what-different-qualification-levels-mean/compare-different-qualification-levels.

3.3 Covariates

■ *Parental involvement*

We control for three measures of parental involvement measured at age 3: a) frequency of reading to the child, b) how often the child watches television/video; c) whether the child has a regular bedtime. Frequency of reading is coded on a 6-point scale from 0 "never" to 5 "every day" and it is entered in the model as a continuous variable. Frequency of watching TV has four response options: "3 or more hours", "1-3 hours", "less than 1 hour" and "not at all" and it is used as a categorical predictor (i.e. set of three dummies). Not watching TV at all does not imply that this time is substituted with interaction with parents or other play/learning activities, and there is no agreed optimal frequency of watching TV at age 3. Like watching TV, regular bedtime is used in the literature as an indicator of parental style in regulating children's behaviour – setting routines, rules and discipline (see Kelly et al. 2013). It is used here as a categorical predictor coded as "never", "sometimes", "usually" and "always".

We do not control for parental inputs, such as help with reading, at later ages because frequency of helping the child with reading[6] at age 7 is negatively associated with cognitive scores at ages 7 and 11 (estimates are available on request), suggesting that parents tend to focus on children who lag behind in verbal ability at that age.[7] At age 5, the relationship between help with reading and cognitive ability is still positive, but not as strong as at age 3. Meanwhile, other indicators of parental cognitive stimulation at age 3 (e.g. helping with counting/maths and helping with alphabet) are not as highly associated with cognitive outcomes at 3 and later ages as reading. This is likely because many of the cognitive outcomes measured here refer specifically to verbal ability, which may be influenced differently compared to other aspects of cognitive development (Washbrook and Waldfogel 2010).

■ *'Initial conditions': characteristics at birth and MCS1*

Although there is no cognitive ability measure at the age of 9 months, children's physical and psychological functioning was assessed using the Denver Developmental Screening Tests (DDST) (Frankenburg and Dodds 1967). The main respondent (usually the mother) was asked whether the cohort child had already achieved several age-specific 'developmental milestones'.
The MCS uses a set of DDST items covering three areas: fine motor function (putting hands together, grabbing objects, holding small objects, and passing a toy); gross motor function (sitting up, standing up, and walking a few steps) and communicative gestures (smiling, giving a toy, waving good-bye, extending arms, and nodding for yes). Following Dickerson

[6] Note that at the age-3 wave, parents are asked how often they read to the child, but at later interviews they are asked about helping the child with reading.
[7] However, Dickerson and Popli (2016) find no evidence of current parental inputs being endogenous to current cognitive ability, using instrumental variables methods.

and Popli (2016), we classify a child as having a delay in an item if they cannot accomplish a task that 90 per cent of children of a specific age (6-8 months, 9 months, 10 months and 11-12 months) can perform.[8] If they have a delay in at least one item in a particular DDST area, they have a delay in that area.[9]

We also control for conditions and characteristics at the time of birth of the cohort child: mother's age, low birth weight (under 2.5kg), whether the child had been breastfed for at least 6 months and whether the child is the first born. These indicators are meant to account for some of the variation in genetic endowments relevant to growth and development.

Demographic controls include the child's sex and ethnicity, as well as the number of siblings in the household (which can vary over time) and the language spoken at home.

The means of all predictors are reported in Table A2 in the Annex.

■ *Methods*

To estimate independent associations between household income and the probability of scoring in the bottom of the cognitive ability distribution at different ages, the SES indicators are entered in a logistic regression model together with an expanded set of covariates: demographics, parental inputs and the conditions prevalent around the time of the child's birth. The results are reported as average marginal effects: the predicted effects of a one unit change in the covariate, everything else being equal, on the probability of scoring in the bottom decile of the cognitive ability distribution, averaged across the values of all other predictors. This helps compare the effects of the predictors across the four waves of MCS (MCS2-MCS5).

Children's mobility across the deciles of the cognitive ability distribution is analysed using two methods. The data are transformed into a person-period file so that each row refers to a child i in period t. First, transition matrixes are estimated, separately by contemporary income poverty status. This shows the raw (transition) probabilities of moving up or down from a particular decile, or remaining in that decile, between any two successive sweeps of the study from MCS2 onwards. This method summarises the cognitive ability trajectories observed in the data and sheds light on the relationship between income poverty and cognitive mobility, but it does not provide estimates of the effects of poverty on the probability of moving in or out of a particular decile.

Second, discrete time event history analysis models are used to estimate the probability of exiting from the bottom decile or entering the bottom decile between any two successive sweeps, conditional on scoring in or out of the bottom decile in the current sweep, respectively. Thus, the dependent variable in the 'exit' model is the change from a cognitive ability score in

8 There are three original response categories: "often", "once or twice" and "not yet". The latter two categories are classified as a delay.

9 6.8 per cent of MCS children had a fine motor function delay in MCS1, 4.3 per cent a gross motor function delay and 0.6 per cent a delay in communicative gestures. While 9.7 per cent had a delay in at least one of these three areas, almost no one (0.1 per cent) had a delay in all three.

the bottom decile at time t to any higher decile at time $t+1$, and the dependent variable in the 'entry' model is the change from any higher decile at time t to the bottom decile at time $t+1$. In the 'exit' model, for each time period t when a child has scored in the bottom decile and is, therefore, *at risk* of moving out of the bottom decile in the following period $t+1$ (by scoring in a higher decile of the age-specific distribution at that time), there is a binary response y_{it} showing whether in the ensuing period (with a valid cognitive ability score) the child still scores in the bottom of the ability distribution (0) or exits (1). If a child does not have a valid score between two or more waves, information from the next available wave is used, but if the child no longer appears in the study (i.e. it is a 'censored' observation), y_{it} is set to zero. Only the first transitions are modelled: children who exit from the bottom decile by the next period no longer return to the risk set. Since cognitive scores are only available in four periods and few children leave the bottom decile and re-enter it again during the study, this is a reasonable simplification. However, children who exit from the bottom decile do end up in the risk set of the 'entry' model in the following period, so little information is lost in practice. Since all observations are censored at MCS5, this period is only used to construct the response variable but is not entered in the model itself. The majority of the original sample (54 per cent) of children appear in all five sweeps of the MCS, another 7 per cent appear in the first four sweeps only and 5 per cent in the first three sweeps only.

4. RESULTS

4.1 Differential risks of scoring in the bottom decile of the cognitive ability distribution at ages 3, 5, 7 and 11

Table 2 (page 16) shows that unadjusted differentials in the probability of being in the bottom decile of the cognitive ability distribution by income poverty and other socio-economic characteristics are large and persistent, but there is evidence that they get somewhat smaller between the ages of 3 and 11. This is consistent with the literature on the importance of SES in early years and also suggests that formal schooling may play an equalising role. At age 3, children from income-poor families are nearly 4 times more likely to score in the bottom 10 per cent of the cognitive ability distribution than their peers from non-poor families, but the differential drops to the factor of 3 at ages 5, 7 and 11. The equalisation effect for children with out-of-work parents is stronger. Children whose parents are not in paid employment are nearly 5 times and 3 times more likely to score in the bottom decile than their counterparts with both parents in work at ages 3 and 11, respectively. However, differences by parental occupational status (e.g. between managerial/professional and semi-routine/routine occupations) are in fact largest at age 7, indicating that the effects of social class do not necessarily narrow in a linear fashion over time.

Differences by gender and ethnicity have narrowed over time, while socio-economic differences have remained stable. At ages 3, 5 and 7, boys are significantly more likely to score in the bottom decile of the cognitive ability distribution, but the gender gap is no longer statistically significant at age 11. In fact, boys have a significantly higher mean verbal skills score than girls at age 11, although the difference is not substantively large (less than one standardized score point). This is the first MCS sweep where boys catch up with girls in measured verbal ability (Platt et al. 2014).

Table 2 – ***Per cent of children in the bottom decile of cognitive ability, by demographic and socio-economic characteristics***

		MCS2 Age 3	MCS3 Age 5	MCS4 Age 7	MCS5 Age 11
Child's gender	Boy	12.7	12.5	12.0	*9.9*
	Girl	7.9	7.4	7.9	*10.7*
Child's ethnicity	White	7.7	8.3	9.1	9.7
	Mixed	13.4	11.0	10.9	7.7
	Indian	23.0	12.1	7.6	7.0
	Pakistani and Bangladeshi	50.8	34.1	21.2	22.2
	Black	29.7	20.5	17.0	9.0
	Other	25.1	19.4	9.2	11.7
Parental relationship	Married	8.5	8.2	7.0	8.5
	Cohabiting	10.6	11.0	11.4	12.0
	Lone parent	16.7	14.8	15.4	12.5
Parental work status	Both working	5.0	6.1	6.1	6.8
	One working	11.6	11.5	11.7	13.4
	None working	23.2	21.0	21.5	18.7
Parental occupational class	Managerial and professional	3.8	4.4	3.5	4.7
	Intermediate	4.8	6.8	7.5	7.2
	Small employers and self employed	10.2	9.9	8.6	9.9
	Lower supervisory and technical	11.7	11.6	12.5	12.9
	Semi-routine and routine	14.2	14.0	16.1	14.7
	Not in work or missing	21.5	20.0	19.6	18.6
Parental qualification	None	30.6	27.2	26.2	25.2
	NVQ1	21.5	21.6	21.3	16.5
	NVQ2	12.3	11.5	12.6	13.2
	NVQ3	8.7	9.3	9.2	9.0
	NVQ4	4.3	5.0	5.0	6.1
	NVQ5	3.7	3.7	3.2	3.9
Family poverty status (current)	Non-poor	5.6	6.2	6.6	7.3
	Poor	21.6	18.5	18.4	21.1
Family poverty status (Wave 1)	Non-poor	5.7	6.2	6.0	6.5
	Poor	20.7	18.7	18.2	16.9
Country	England	11.0	*10.1*	*10.1*	*10.1*
	Wales	7.6	*8.3*	*10.3*	*10.3*
	Scotland	5.7	*10.3*	*9.7*	*12.4*
	Northern Ireland	8.4	*8.7*	*9.0*	*8.7*
Special educational needs at age 7	No			7.8	8
	Yes			34.3	24.3
	N (unweighted)	13,557	14,863	13,103	12,994

Source: MCS2-MCS5. Sample weights, clustering and stratification accounted for.

Meanwhile, the gaps between ethnic groups have narrowed steadily. At age 3, white cohort members were by far the least likely to fall in the bottom decile, but at age 11 they were just as likely to score in the bottom decile as any other ethnic group except Pakistani and Bangladeshi children. All non-white children made progress over time. Although Bangladeshi and Pakistani cohort members are still the most likely of all ethnic groups to place in the bottom decile at age 11, they have made the biggest gains since age 3 in absolute terms: the share of those in the bottom decile fell from one in two (51 per cent) at age 3 to one in five (22 per cent) at age 11. However, they have made no progress between 7 and 11 years of age and, in fact, got left further behind their peers from mixed, Indian and black ethnic backgrounds. Indeed, black and Indian children made the biggest relative gains: the share of children in the bottom decile is 3.3 times lower at age 11 than at age 3. Indian children have the highest mean verbal ability scores of any other ethnic group at age 11. Convergence in cognitive scores by ethnicity is a real trend rather than an artefact of unequal of attrition, as the ethnic composition of the working sample is very stable over time (see Annex).

At age 7, parents were asked if the cohort child's school had informed them that the child had special educational needs (SEN). Perhaps not surprisingly, children with a SEN notice are substantially over-represented in the bottom decile of the measured cognitive ability distribution at ages 7 and 11. However, not all children in the bottom decile have SEN and not all SEN children are in the bottom decile. At age 7, just over one-quarter (27 per cent) of bottom decile children and 6 per cent of those in the second and higher deciles have SEN.[10] It is likely that children with the most severe SEN were not able to complete the tests and are thus excluded from the study, as 15 per cent of SEN children did not have a valid latent cognitive test score at age 7, compared with just 3 per cent of non-SEN children. As SEN status is correlated with socio-economic and demographic characteristics, it would be important to control for SEN in multivariate analyses, but because the information is only available from age 7 and is not supposed to refer backward to ages 3 and 5, we leave SEN status out of the regressions. Our tests show that developmental delays at the age of 9 months (especially in gross motor function) are significantly correlated with SEN status at age 7. Therefore, controlling for early developmental delays in our main models helps account for SEN at least in part. When we do control for SEN status at age 7 as a robustness check, the effects of the socio-economic and demographic predictors[11] are somewhat attenuated, but the findings remain qualitatively the same (estimates available on request). The share of children who would receive a SEN notice at age 7 is the same in all waves (8 per cent), suggesting no significant differential attrition by SEN status.

Table 3 (page 18) shows the estimated average marginal effects of demographic and socio-economic characteristics on the probability of an MCS child falling in the bottom decile of the age-specific cognitive ability distribution at ages 3, 5, 7 and 11 from multivariate logistic regression models. To leverage the variation in household income, quintiles of disposable household income are used instead of the binary poverty status.[12] Additional time-varying covariates (not included in Table 1) cover demographics, such as number of cohort child's siblings in the household and language spoken at home, as well as a set of predictors measuring parental inputs at age 3 and baseline characteristics around the time of the child's birth.

[10] This ranges from 13 per cent in the second decile to 4 per cent in the top decile.

[11] Boys (12 per cent) are more likely to have SEN than girls (5 per cent); white children (9 per cent) more than non-white (7 per cent); higher birth order children (10 per cent) than first born children (8 per cent).

[12] Differences by poverty status are as predicted but the explanatory power of the model is lower than when income quintiles are used (estimates available from the authors on request). All households in the bottom quintile are below the relative poverty line, as well as some of those in the second quintile.

Table 3 – ***Differences in the probability of scoring in the bottom decile of the cognitive ability distribution at ages 3, 5, 7 and 11 by demographic and socio-economic characteristics (average marginal effects from logistic regression models)***

		MCS2 Age 3	MCS3 Age 5	MCS4 Age 7	MCS5 Age 11
Girl (ref: boy)		-0.05***	-0.05***	-0.04***	0.01
Child's ethnicity (ref: white)	Mixed	0.03	0.02	-0.01	-0.03
	Indian	0.10***	0.01	-0.03	-0.05**
	Pakistani and Bangladeshi	0.20***	0.07***	0.03	0.01
	Black	0.12***	0.06**	0.03	-0.03
	Other	0.12**	0.04	-0.05*	0.01
Number of siblings in the household (ref: none)	One	-0.002	-0.01	-0.01	0.004
	Two	0.01	-0.003	-0.01	-0.003
	Three or more	0.02	-0.0002	0.01	-0.004
Current income quintile (ref: bottom)	Second	-0.02*	-0.01	-0.004	-0.02
	Third	-0.04**	-0.02	0.01	-0.05***
	Fourth	-0.05***	-0.03*	-0.01	-0.05**
	Top	-0.07***	-0.03*	-0.03*	-0.07***
Parental occupational class (ref: managerial and professional)	Intermediate	-0.02	0.01	0.02	0.003
	Small employers and self employed	0.01	0.02*	0.03*	0.01
	Lower supervisory and technical	0.04**	0.03**	0.05***	0.03*
	Semi-routine and routine	0.02*	0.03**	0.05***	0.04***
	Never been in work	0.04*	0.05*	0.06*	0.05
Parental qualification (ref: none)	NVQ1	0.004	0.01	0.0004	-0.05**
	NVQ2	-0.01	-0.03**	-0.03*	-0.03
	NVQ3	-0.02	-0.03*	-0.04**	-0.05**
	NVQ4	-0.04***	-0.05***	-0.05***	-0.05**
	NVQ5	-0.04**	-0.07***	-0.07***	-0.07***
Parental work status (ref: both in work)	One working	0.02*	0.02*	0.03***	0.01
	None working	0.03**	0.04**	0.03**	0.0
	Lone parent (ref: married or cohabiting)	-0.01	-0.01	0.01	-0.01
	English is the only/main languages poken at home	-0.06**	-0.04*	0.02	-0.003
	Mother's age at birth of child	-0.001	-0.001*	-0.002**	-0.0003
	Low birthweight child	0.03*	0.03**	0.04***	0.01
	Child breastfed for at least 6 months	-0.01	-0.01	-0.02**	-0.04***
	First born child	-0.02	-0.01	-0.01	-0.02*
	Fine motor function delay at MCS1	0.01	0.02	-0.01	0.01
	Gross motor function delay at MCS1	0.07***	0.05***	0.05***	0.03*
	Communication gestures delay at MCS1	0.01	0.02	0.0001	0.05
TV watching at MCS2 (ref: 3 or more hours a day)	1-3 hours a day	-0.01	0.002	-0.002	0.002
	Under 1 hour a day	0.03**	0.02*	0.02	0.02
	None at all	0.06	0.07*	0.06	0.05
Regular bedtime at MCS2 (ref: never)	Sometimes	0.02	-0.03	-0.01	-0.03
	Usually	-0.01	-0.05***	-0.05***	-0.04*
	Always	-0.02*	-0.06***	-0.05***	-0.06***
Frequency of reading to the child at MCS2		-0.02***	-0.01**	-0.01*	-0.01**
Country (ref: England)	Wales	-0.02**	-0.01	-0.001	-0.003
	Scotland	-0.03**	0.03**	0.01	0.03*
	Northern Ireland	-0.01	-0.001	-0.02*	-0.03***
Observations		12,830	12,786	11,419	10,881
Pseudo r-squared		0.2274	0.1472	0.1365	0.1079

Source: MCS2-MCS5. Sample weights, clustering and stratification accounted for.
***p<0.001, **p<0.01, *p<0.05

Income and other SES characteristics. Differences in the probability of scoring in the bottom decile of the measured cognitive ability distribution by household income quintile are largest at age 3 holding all other factors constant. The probability of scoring in the bottom decile of cognitive ability is 7 points, 5 points, 4 points and 2 points lower for children in the top, fourth, third and second quintiles, respectively, than for their peers in the bottom income quintile. Income differences get smaller at ages 5 and 7, but widen again by age 11, reaching levels comparable to those at age 3.[13] Conversely, differences by parental social class are largest at age 7, when income explains less of the variation, and narrower at age 11 when income differences are relatively more important. Overall, social class differences are somewhat more persistent than income differences as children get older, perhaps reflecting the more permanent nature of social class. Similarly, differences by parental education are large and persistent, especially between the lowest and highest NVQ levels. Everything else being equal, differences by parental work status are of a similar size at ages 3, 5 and 7, but they are no longer statistically significant at age 11.

Parental involvement. Children whose parents had read to them more often and who had a regular bedtime at age 3 are significantly less likely to score in the bottom decile of the cognitive ability distribution at ages 3, 5, 7 and 11. A one point higher frequency of reading on the 6-point scale is associated with a 2-point lower probability of scoring in the bottom group at age 3 and a one-point lower probability at ages 5 to 11. Thus, the predicted difference in the probability of being in the bottom of the distribution between children whose parents had read to them every day at age 3 and those whose parents had never read to them at that age amounts to 10 points at age 3 and 5 points at older ages. These are substantively large effects. Meanwhile, even after controlling for parental education and social class, the effects of watching TV are non-linear: children who had watched TV for under 1 hour a day at age 3 are more likely to score in the bottom decile of the cognitive ability distribution at age 3 than those who watched TV more often. At age 5, those who had not watched any TV at age 3 are the most likely to score in the bottom decile. This finding is consistent with the positive association between TV viewing and children's cognitive ability found in Sullivan et al (2013), suggesting that the content of TV/video (e.g. educational programmes) may be more important than the frequency of watching. However, there is no information on the TV content in the survey. There are no more significant differences resulting from early TV watching at ages 7 and 11.

Conditions around the time of birth. Children of older mothers are significantly less likely to score in the bottom decile of the cognitive ability distribution at ages 5 and 7. Low birthweight has a large negative effect on cognitive outcomes at younger ages, but it dissipates by age 11. Conversely, having been breastfed for at least 6 months (not necessarily exclusively) has a significant independent effect on cognitive ability at ages 7 and 11 only, suggesting that other factors controlled for in the model were more important at earlier ages. Lasting positive benefits of breastfeeding on cognitive development outcomes have been documented at age 5 (Quigley et al. 2012) and up to age 7 (Fitzsimons and Vera-Hernandez 2013), but the causal mechanism is unclear. The unique composition of breastmilk could have lasting beneficial effects

[13] If income poverty status is used instead of income quintiles, children from poor households are 2 points more likely to score in the bottom decile at ages 3 and 5, but the differences are no longer statistically significant at ages 7 and 11 (estimates available from the authors on request).

on brain development, but extended breastfeeding (if physiologically feasible) could also be a proxy for the mother's awareness of good nutritional and other health practices, which in turn can promote children's cognitive development.

First born children are significantly less likely to score in the bottom of the distribution at age 11, with no significant differences at earlier ages. Number of siblings in the household has no significant independent effects at any age.

Child's sex, ethnicity and language. Confirming the descriptive results in Table 1, gender differences (in girls' favour) are no longer statistically significant at age 11. Differences by ethnic background narrow substantially over time, after controlling for SES and other covariates. At age 3, Pakistani and Bangladeshi children had a 20-point higher probability of scoring in the bottom decile of observed ability than their white counterparts. However, at age 7 all children are similarly likely to score in the bottom decile, except children from 'other' ethnic backgrounds who are significantly less likely to do so than any other ethnic group (a 5 point difference). The findings are similar at age 11 except it is Indian children who are now less likely than their peers to obtain low test scores. Differences by language spoken at home follow the same pattern: children from homes where English is the only or main language are less likely to score in the bottom decile at ages 3 and 5, but the effects are no longer statistically significant at ages 7 or 11.

4.2 Mobility across the cognitive ability distribution between ages 3, 5, 7 and 11

Figure 1 – ***Distribution of cognitive ability at the next MCS sweep for children who scored in the bottom decile in the previous sweep, by contemporary income poverty status (between ages 3, 5, 7 and 11), per cent.***

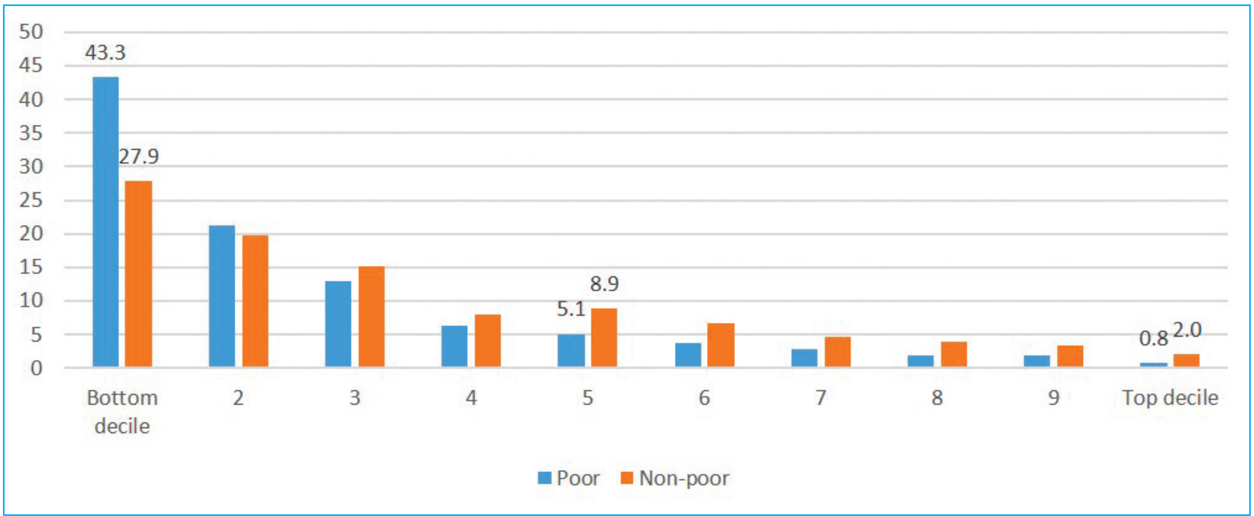

Figure 1 shows the shares of MCS children who scored in the bottom decile of the cognitive ability distribution in a given year (i.e. at ages 3, 5 or 7) and who remained in the bottom decile or moved up the distribution the next time they were tested. While 37 per cent of children who scored in the bottom decile in one year remained in the bottom decile in the following period, on average, children from income-poor households (43 per cent) are substantially more likely to get trapped in the bottom of the distribution than are their counterparts from non-poor households (28 per cent).[14] Most of both poor and non-poor children who exit the bottom decile move up only a few deciles, but non-poor children progress a little farther along the distribution. Three in five (60 per cent) children from poor households who exit the bottom decile end up in the second or third decile, while the same proportion (59 per cent) of non-poor children move up to the second, third or fourth deciles. Thus, there is a 'sticky floor' for all children with low cognitive scores; but it is far stickier for those from income-poor families.[15]

Table 4 (page 23) shows the results of discrete-time event history analysis models for conditional probabilities of exit from the bottom decile and entry into the bottom decile, controlling for a host of child- and household-level characteristics. Unlike in the descriptive analysis above, which only used valid cases from any two consecutive sweeps, we now use data from the next available sweep if information on cognitive ability is missing in the one in between. This has the advantage of drawing on as much information as possible, but it results in increasing the number of cases that did not make a transition in or out of the lowest decile of the cognitive ability distribution and, therefore, decreases the proportion of exits and entries.[16] It should be noted that transitions in and out of the bottom decile are not driven by small movements around the decile border (i.e. between the 9th or 10th and the 11th and 12th centiles). Excluding such small movements from the definition of transitions reduces the average exit rate by 1 percentage point and does not affect the entry rate. Given the unequal relative sizes of the 'origin' and 'destination' samples, exiting the bottom of the cognitive distribution is of course a much more frequent event than entering it. However, the socio-economic and demographic characteristics studied here explain similar amounts of variation in both models.

Household income predicts entry into the bottom decile of cognitive development, but not exit from it. Conditional on scoring in a higher decile in one year, the predicted probability of moving into the bottom decile is 3 points higher for children in the 20 per cent poorest households than for their counterparts in the richest 20 per cent of households. Since the probability of moving into the bottom decile from higher up in the ability distribution is so low to start with (i.e. 5 per cent on average), the effects of income are substantively very large. It is remarkable that there are no significant differences by income in the chances of exiting from the bottom ability decile, everything else being equal, but children from lower income families are significantly and substantially more

[14] The results are similar if children aged 3 are excluded, but the proportion of children remaining in the bottom decile in two successive sweeps is somewhat larger: 47 per cent for poor and 30 per cent for non-poor children.

[15] This is especially so for children with SEN (evaluated at age 7) from income-poor families: 63 per cent remain in the bottom decile between any two waves, compared with 43 per cent of non-poor SEN children, 39 per cent of income-poor non-SEN children and 23 per cent of non-poor non-SEN children.

[16] While in the 'balanced panel' analysis (see Figure 1) we observe 63 per cent of children who were in the bottom decile of the cognitive ability distribution in one wave exiting it by the next wave, only 42 per cent of these children make a transition if information from the next available wave is used for those who have a missing value between the two waves. The corresponding entry rate, for those who started out in a higher decile, decreases from 6 per cent to 4 per cent. Alternative estimates of the models in Table 3 using data from consecutive waves only yield qualitatively similar findings, but some of the coefficients are more precisely estimated (available on request from the authors). The results reported in Table 3 are, therefore, more conservative.

likely to score in the bottom decile in the first place (see Table 2). If household income is entered in the 'exit' model without any covariates other than the sweep/period number, children from the top income quintile are 13 points more likely to exit from the bottom ability decile than their peers in the bottom income quintile. This indicates that the observed effects of income (see Figure 1) on the probability of exit are all explained away by other SES characteristics and controls. However, the SES indicators studied here (i.e. income, parental occupation and education) may affect children's cognitive mobility at different rates, with income effects likely to be the most transitory.

However, the effects of parental occupational class on the probability of exit are not statistically significant either, while there are significant differences in the probability of entering the bottom decile. Parental current work status has no significant effects on either exit or entry, but children whose parents have never worked (and, thus, provide no occupational class information), are 16 points less likely to exit from the bottom decile than children in managerial or professional households. Meanwhile, parental education has large effects on the probability of exit and smaller but still substantially large and significant effects on the probability of entry. Children with the highest educated parents are 14 points more likely to exit from the bottom decile and 3 points less likely to enter the bottom decile from higher up in the ability distribution. These results indicate that of all SES-related predictors, parental education is the most influential in predicting transitions in and out of the bottom of the cognitive ability distribution. However, the effect of parental education may be biased upwards if it captures unobserved inherited cognitive ability or unmeasured positive parental practices.

The three SES predictors also vary in the degree of mobility between waves. This is a valid reason for entering them in the model separately, rather than combining them into one index. Parental education is the most stable variable, with the shares of children in the same category between any two waves (from MCS2 to MCS5) ranging from the low of 82 per cent (NVQ1) to the high of 97 per cent (NVQ5). There are slightly more movements across categories of parental occupational status: the share of children with parents in the same occupational category between any two waves ranges from the low of 61 per cent for low supervisory and technical occupations to the high of 89 per cent for managers and professionals. The degree of mobility is highest for household income, with the share of children in the same quintile in both waves ranging from 39 per cent in the third quintile to 63 per cent in the top quintile. While 65 per cent of children who are income poor in one wave remain poor in the next one, only 9 per cent of those who are not poor fall into poverty by the next interview. If we were to control for transitions in and out of poverty, rather than the income quintile in a given wave, there would still be no significant effects on the probability of exiting the lowest cognitive decile, but there would be significant differences in the probability of entry into the bottom decile (estimates available on request). Compared to children who were out of poverty in both waves, everything else being equal, those who enter poverty between the two waves are 2 percentage points more likely to enter the bottom decile of the cognitive ability distribution at the same time. Those who are poor in both waves would also be 2 points more likely to move into the bottom decile. However, given the length of time between any two waves of the survey, we do not know the exact timing of poverty transitions.

Table 4 – ***Exit and entry into the bottom decile between two periods (average marginal effects)***

		Exit from the bottom decile	Entry into the bottom decile
Age 5 (ref: Age 3)		-0.12***	-0.004
Age 7		-0.09***	0.004
Girl (ref: boy)		0.04	-0.01*
Child's ethnicity (ref: white)	Mixed	-0.04	-0.01
	Indian	0.09	-0.004
	Pakistani and Bangladeshi	0.01	0.03**
	Black	0.07	0.02*
	Other	0.09	0.01
Number of siblings in the household (ref: none)	One	0.03	-0.01*
	Two	-0.01	-0.01
	Three or more	-0.02	0.04
Income quintile (ref: bottom)	Second	-0.01	-0.01*
	Third	0.05	-0.01*
	Fourth	0.05	-0.02**
	Top	-0.03	-0.03***
Parental occupational class (ref: managerial and professional)	Intermediate	0.03	0.01*
	Small employers and self employed	-0.06	0.01*
	Lower supervisory and technical	-0.06	0.01
	Semi-routine and routine	-0.04	0.02***
	Never been in work	-0.16**	0.02
Parental qualification (ref: none)	NVQ1	0.05	0.01
	NVQ2	0.11***	-0.003
	NVQ3	0.10**	-0.02*
	NVQ4	0.12**	-0.02**
	NVQ5	0.14*	-0.03***
Parental work status (ref: both in work)	One working	-0.03	0.002
	None working	-0.04	0.01
Lone parent (ref: married or cohabiting)		0.02	-0.01*
	English is the only/main language spoken at home	-0.08*	0.01*
	Mother's age at birth of child	0.003	-0.00**
	Low birthweight child	-0.03	0.01**
	Child breastfed for at least 6 months	0.06*	-0.01*
	First born child	-0.03	-0.01*
	Fine motor function delay at MCS1	0.06	0.01
	Gross motor function delay at MCS1	-0.08*	0.01*
	Communication gestures delay at MCS1	-0.003	0.01
TV watching at age 3 (ref: 3 or more hours a day)	1-3 hours a day	0.01	0.003
	Under 1 hour a day	-0.01	0.01
	None at all	-0.16*	0.02
Regular bedtime at age 3	Sometimes	0.05	-0.01
	Usually	0.10**	-0.02**
	Always	0.10**	-0.03***
	Frequency of reading to the child at age 3	-0.01	-0.01***
Country (ref: England)	Wales	0.08**	0.003
	Scotland	-0.12***	0.01
	Northern Ireland	0.06*	-0.01
Observations (person-periods)		3,776	33,259
Observations (persons)		2,829	13,738
Pseudo r-squared		0.06	0.07

Source: MCS2-MCS5. Sampling weights used. *** p<0.001, ** p<0.01, * p<0.05.

Children aged 3 are significantly more likely to exit the bottom decile by the next sweep of the survey than children aged 5 or 7, but there are no differences by age in the risks of entering the bottom decile. This indicates that there is more mobility across the ability distribution in the early years, and children who score in the bottom decile after entering primary school are more likely to remain there. Girls and boys are just as likely to leave the bottom decile, but boys are more likely to enter it. Similarly, there are no differences by ethnic group in the probability of exiting the bottom decile, but Pakistani and Bangladeshi as well as black children are significantly more likely than their peers from other ethnic groups to move into the bottom of the distribution from a higher ability decile between any two successive sweeps of the MCS. Everything else being equal, children whose only or main language spoken at home is English are less likely to exit the bottom decile and more likely to enter the bottom decile, but this is probably because they are less likely to score in the bottom decile in the first place (see Table 2). Those who do, are more likely to get 'trapped' in the bottom of the distribution.

Children of younger mothers, low birthweight children and those who are not first born are more likely to move into the bottom decile from higher up the ability distribution. Children who had been breastfed for at least 6 months are both more likely to move out of the bottom decile and less likely to fall into it. Children who have had a delay in gross motor function development are less likely to exit from and more likely to enter the bottom decile as they grow older.

Consistently with the cross-sectional results in Table 2, children who had not been allowed to watch any TV/video at age 3 are substantially less likely to exit the bottom decile, but there are no differences in the risks of entering it. Meanwhile, regular bedtime at age 3 is both a protective factor against slipping into the bottom of the cognitive ability distribution and a helping factor for exiting the bottom decile. More frequent reading to the child at age 3 protects from falling into the bottom decile but has no effect on exiting from it.

5. DISCUSSION AND CONCLUSION

A large body of research investigates differences in children's average cognitive scores by socio-economic characteristics of their families and parental inputs, both at a point in time and over the life course. Using longitudinal data from the UK MCS, the present study contributes to this literature by focusing on movements into and out of the very bottom of the cognitive ability distribution in order to identify child and household-related factors that help boost poor cognitive test performance and those that perpetuate the risk of low achievement.

Our findings are generally in line with the mainstream literature. Although special education needs (proxied by gross motor delay at the age of 9 months in our models) increase the likelihood of scoring in the bottom decile of the cognitive ability distribution, household income and other SES characteristics all have substantial independent effects. Distinguishing income poverty from parental occupational status and education shows the life-course variation in the relative importance of cash liquidity vs. more stable human capital and social status. Everything else being equal, differences in the probability of being in the bottom decile of cognitive ability by household income are larger at ages 3 and 11 than at 5 and 7. This suggests that monetary investments are most important in the pre-school period, when low income families could struggle to fund full time pre-school education and care above the limited hours of subsidised provision. The second period coincides with the transition from primary to secondary education, when extra household resources can pay for out-of-class tuition and extracurricular activities, leaving lower income households at a disadvantage. In contrast, the influence of parental occupational status and education is relatively stable over different stages of development, but the net effect of parental education is larger. Although we do not account for school-level characteristics explicitly, lower SES families are also more likely to live in economically deprived areas, where schools might not have sufficient resources to support the needs of low achieving children.

Overall, we find relatively high mobility into and out of the bottom of the cognitive ability distribution from the age of 3 onwards, with over half of the children, on average, exiting the bottom decile and moving up the ability distribution by the next sweep of the survey. Yet, a substantial 37 per cent of children remained in the bottom decile in two successive periods, rising to 43 per cent among children from income-poor households. They are almost twice as likely to remain in the group of low achievers for two successive periods than their peers from non-income-poor households (28 per cent). Thus there is a 'sticky floor' of low cognitive performance for all children, but more so for those from poor households.

However, once other key child and household characteristics are controlled for, income is no longer significantly associated with the probability of exiting from the bottom decile of the cognitive ability distribution by the time of the next MCS sweep (for children who had scored in the bottom decile in a given wave). Parental education is an SES characteristic with the greatest net influence on the probability of exiting the bottom decile, followed by parental lifetime work status (i.e. whether at least one parent had ever worked or not). Occupational status, similarly to income, has no independent association with the likelihood of moving up from the bottom of the cognitive ability distribution. However, all SES predictors have strong independent associations with the risks of falling into the bottom decile for children who have scored in any higher decile in a given wave.

These results suggest that higher income and social class play a protective role in shielding higher scoring children from slipping into the bottom of observed test performance, but they do not necessarily help children move out of the bottom decile. In other words, money and social status do not guarantee cognitive transitions from the bottom to higher deciles, but their lack puts even higher performing children at risk of falling behind. In contrast, parental education both protects children from entering the bottom decile and helps them move up if they stumble into it. Although we control for a range of parental behaviours when children were 3 years old, parental education is probably picking up other (unobserved) parental strategies, beliefs and aspirations conducive to children's greater relative cognitive development.

Regular bedtime at age 3 is the most influential of the parental behaviour variables controlled for. Children whose bedtime at age 3 was 'usually' or 'always' enforced are both more likely to exit from the bottom decile by the next wave if they score in the bottom in any given year and, vice versa, less likely to fall into the bottom decile if they score higher up the distribution. This finding of the importance of regular bedtime at an early age could have practical implications for parenting support programmes and general policy guidelines. Frequency of reading to children at age 3 is a significant protecting factor against moving into the bottom of the distribution, but it has no independent effect on the probability of moving out of the bottom group.

The role of higher income, parental education and social class in shielding children from entering the bottom of the cognitive ability distribution may have long-lasting implications for society in the UK. Intergenerational mobility is lower in the UK than in most other rich countries that collect comparable data, as parental income is a very strong predictor of children's adult earnings (Blanden et al. 2004). The SES gaps in children's school readiness at age 4 or 5 are wider in the UK and the US than in Australia and Canada (Bradbury et al. 2011). Consistent with the literature on the importance of the earliest years, we find that the chances of moving up the cognitive ability distribution from the bottom decile are highest in the pre-school period (between ages 3 and 5), and became progressively smaller over time as children progress through primary school. This is a window of opportunity for children who are falling behind: by the time they start primary schooling, their place in the age-specific cognitive ability distribution is more or less fixed and the chances of making substantial progress are limited.

Although we have focussed on cognitive ability, the MCS also measures the development of non-cognitive skills over time. Non-cognitive skills have been shown to be important in both US data (e.g. Cunha et al. 2010) and UK data (Blanden and Machin 2010; Ermisch 2008; Flouri et al. 2012, 2014). Future research on socio-economic status, parental inputs and children's outcomes needs to take account of the mutually reinforcing nature of cognitive and non-cognitive skills.

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ANNEX

Table A1 – *Factor loadings for cognitive ability at ages 3, 5 and 7*

Assessment	MCS2	MCS3	MCS4
BAS Naming Vocabulary	0.89	0.74	
Bracken School Readiness	0.89		
BAS Picture Similarity		0.74	
BAS Pattern Construction		0.76	0.75
BAS Word Reading			0.77
BAS Verbal Similarities			0.85
NFER Number Skills	79.3	56.1	62.5
% of variance explained	79.3	56.1	62.5
Unweighted observations	13,557	14,863	13,103

Figure A1 – *Transitions along the cognitive ability distribution (between ages 3, 5, 7 and 11), per cent*

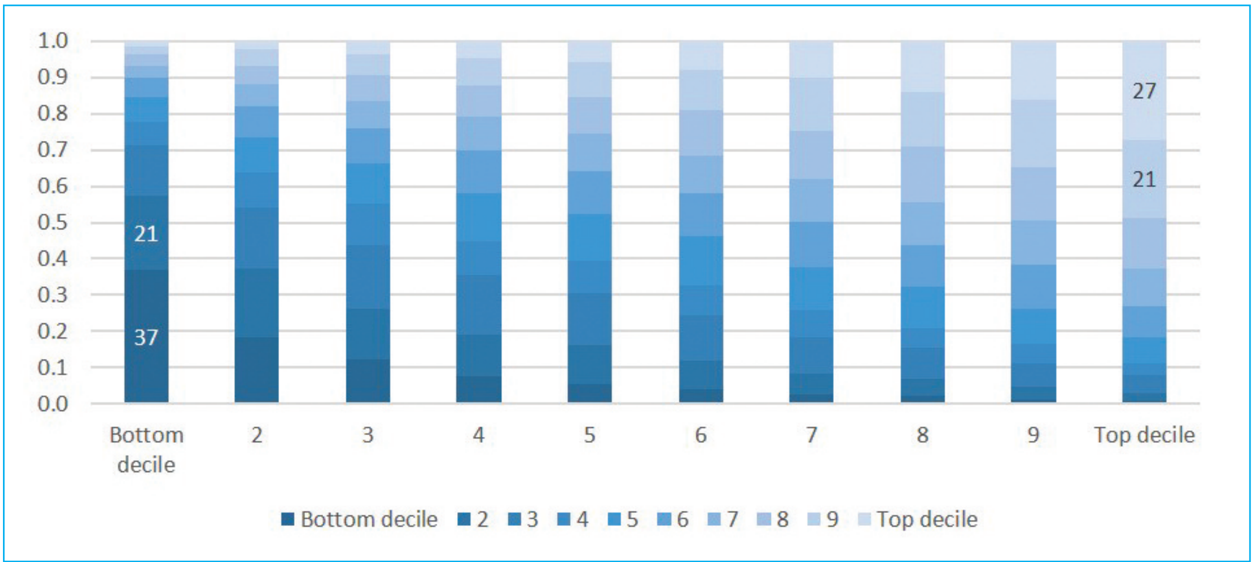

Table A2 – *Means of key predictors*

		MCS2 Age 3	MCS3 Age 5	MCS4 Age 7	MCS5 Age 11
Girl (ref: boy)		0.50	0.50	0.50	0.50
Child's ethnicity (ref: white)	Mixed	0.03	0.03	0.03	0.03
	Indian	0.02	0.02	0.02	0.02
	Pakistani and Bangladeshi	0.03	0.03	0.04	0.04
	Black	0.02	0.02	0.02	0.03
	Other	0.01	0.01	0.01	0.01
Number of siblings in the household (ref: none)	One	0.47	0.49	0.47	0.44
	Two	0.18	0.23	0.27	0.27
	Three or more	0.09	0.11	0.14	0.16
Current income poverty (ref: non-poor)	Income poor	0.29	0.28	0.26	0.19
Parental occupational class (ref: managerial and professional)	Intermediate	0.14	0.13	0.13	0.14
	Small employers and self employed	0.08	0.09	0.10	0.11
	Lower supervisory and technical	0.08	0.07	0.07	0.06
	Semi-routine and routine	0.20	0.19	0.20	0.22
	Never been in work	0.04	0.03	0.03	0.02
Parental qualification (ref: none)	NVQ1	0.06	0.05	0.05	0.05
	NVQ2	0.25	0.23	0.23	0.22
	NVQ3	0.16	0.16	0.16	0.15
	NVQ4	0.37	0.38	0.36	0.35
	NVQ5	0.08	0.10	0.12	0.14
Parental work status (ref: both in work)	One working	0.32	0.27	0.24	0.20
	None working	0.16	0.15	0.15	0.16
	Lone parent (ref: married or cohabiting)	0.17	0.18	0.25	0.25
	English is the only/main language spoken at home	0.99	0.96	0.96	0.96
	Mother's age at birth of child	28.85	29.02	28.72	28.43
	Low birthweight child	0.06	0.06	0.06	0.06
	Child breastfed for at least 6 months	0.23	0.23	0.22	0.22
	First born child	0.42	0.42	0.42	0.42
	Fine motor function delay at MCS1	0.06	0.06	0.06	0.06
	Gross motor function delay at MCS1	0.04	0.04	0.04	0.04
	Communication gestures delay at MCS1	0.01	0.00	0.01	0.01
TV watching at age 3 (ref: 3 or more hours a day)	1-3 hours a day	0.59	0.60	0.59	0.59
	Under 1 hour a day	0.22	0.22	0.22	0.22
	None at all	0.01	0.01	0.01	0.01
Regular bedtime at MCS2 (ref: never)	Sometimes	0.13	0.13	0.13	0.14
	Usually	0.38	0.38	0.37	0.37
	Always	0.42	0.42	0.42	0.42
Frequency of reading to the child at MCS2 (0 "never" – 5 "every day")		4.27	4.29	4.27	4.22
Country (ref: England)	Wales	0.05	0.05	0.05	0.05
	Scotland	0.09	0.09	0.09	0.08
	Northern Ireland	0.04	0.04	0.04	0.04
Special education needs at MCS 4		0.08	0.08	0.08	0.08
Observations		13,557	12,109	11,132	10,615

Source: MCS2-MCS5. Sampling weights used. Base: children with valid cognitive ability scores.