Birth Order, Early Childhood Development and Adolescent Outcomes: Evidence from Administrative Data *

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Abstract

Previous research has exploited large administrative datasets to evaluate the effect of birth order on adolescent and adult outcomes. We leverage unique administrative data for the universe of students in England's public education sector, containing detailed teacher-assessed measures of age-five cognitive, socioemotional, and physical development skills, to provide new evidence on early childhood birth order effects. We first demonstrate that both cognitive and noncognitive age-five skills are strongly associated with subsequent high stakes exam performance as well as behavioral outcomes. For the majority white British population, firstborn siblings experience a modest advantage on age-five cognitive skills. There is no impact on socio-emotional skills; this null effect is precisely estimated. The firstborn advantage grows substantially through adolescence. For closely spaced white British siblings, on the other hand, firstborn children experience a *disadvantage* on age-five skills. Strikingly, this age-five penalty reverses by age-11, at which point firstborns outperform secondborn siblings. For minority students, firstborn children experience large penalties in age-five skills, which also reverse through adolescence. We provide suggestive evidence that for minority students language spillovers from the older sibling to the younger one can account for these results. Our novel set of findings establish birth order as an important determinant of early skill formation, with effects that vary by domain, family structure, and ethnicity, and that evolve non-monotonically over childhood and adolescence.

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1 Introduction

Families are a primary driver of children's early childhood and life cycle outcomes, influencing skills and wellbeing through the investment of time, money, and attention across childhood (Becker and Tomes, 1976; Cunha and Heckman, 2007). Large gradients in parental investments and the home environment are strongly associated with disparities in child development and adult outcomes (Almond and Currie, 2011; Björklund and Salvanes, 2011). Within the family, birth order (an individual's ordinal position among siblings within the family) has long been recognised as an important feature of family structure that can generate inequality between siblings (Galton, 1874; Adler, 1928; Behrman and Taubman, 1986; Sulloway, 1996). Recent empirical literature on birth order effects from developed countries has leveraged large administrative datasets, employing within-family fixed effects to isolate these impacts from the confounding influence of shared family background. These studies have documented systematic birth order gradients in outcomes, with firstborn and earlier-born siblings typically outperforming later-born ones on education attainment and labor market outcomes, as well as exhibiting improved behavioral outcomes, such as lower levels of adult crime (Black et al., 2005; Black et al., 2018; Breining et al., 2020).

Mechanisms put forward to account for these birth order effects include the resource dilution hypothesis which proposes that as family size grows, parental time and other inputs for each child may fall, generating systematic within-family differences by birth order (Blake, 1981; Black et al., 2005; Price, 2008). Alternative hypotheses include the dilution of the intellectual environment with the arrival of later-born siblings as well as the benefits for early-born siblings from teaching their younger siblings (Zajonc and Markus, 1975). Recent research by Daysal et al. (2025) provides novel evidence of disease spillovers from the firstborn to the secondborn sibling in early childhood, which accounts for some of the firstborn advantage in adult outcomes.

Notably, the absence of any firstborn advantage in neonatal health indicators suggests that the observed birth order effect is not a product of initial biological endowments, but rather 'nurture', i.e. the postnatal environment and parental investment, is the primary driver.[1] This leads to a critical empirical question: at what point in the early childhood

[1] Firstborn infants exhibit systematically lower birth weights and Apgar scores compared to their later-born siblings, and a higher probability of being born prematurely (Brenøe and Molitor, 2018; Pruckner et al., 2021).

developmental trajectory does the firstborn advantage in cognitive, noncognitive and behavioral skills begin to emerge?

Our understanding of the role that birth order plays in determining early childhood outcomes is hampered by the limited availability of large datasets which include early childhood measures. This study leverages administrative data which track the universe of students in the English public school system from school enrollment at age four and five in the 'Reception' grade through the end of secondary school. The data include unique early childhood measures on cognitive, noncognitive and physical development skills, collected by the Reception teacher, based on classroom observations. This allows for an analysis of whether birth order effects differ across cognitive skills, including language and numeracy skills, as well as socio-emotional skills and behavioral outcomes. The longitudinal nature of the data facilitates the estimation of dynamic birth order effects, revealing whether early childhood birth order effects are present, and whether they persist, attenuate, or widen as children progress through key developmental stages. Uncovering these effects is important because skill formation is inherently dynamic, with early capabilities potentially raising the productivity of later investments through self-productivity and dynamic complementarity, such that the same early gap between siblings can plausibly shrink or grow depending on subsequent inputs (Cunha and Heckman, 2007). Moreover, many early interventions exhibit fade-out along some dimensions, while some domains show delayed impacts (Duncan et al., 2023; Gray-Lobe et al., 2023; Heckman et al., 2013) which underscores the importance of tracing birth order trajectories across domains and over time.

The Reception grade is a unique phase of a child's formal schooling in England, marked by a particular emphasis on play-based learning. The Reception year in primary school is followed by Grade 1 (referred to as Year 1 in England), at which point students embark on a more traditional, academically focused curriculum. The theoretical basis for the Reception curriculum reflects a mix of developmental, social and educational theories (Evangelou et al., 2009). It emphasizes collaborative play, guided learning and 'scaffolding', highlighting a 'key person' approach, ensuring children have a primary carer (teacher) to build trust and emotional security.[2]

[2] Evangelou et al. (2009), and Siraj-Blatchford et al. (2002), provide references to the relevant developmental literature and its relation to the Foundation Stage, which incorporates the Reception grade. Siraj-Blatchford et

These administrative data also allow for rich demographic analysis given the diversity of the student population, including variation by ethnic background and immigration histories across different ethnic cohorts. Additionally, we exploit school-level information to examine novel mediating channels, including differences in school quality and peer composition.

We find that the mechanisms driving the early childhood results differ markedly between white British majority students and minority students, hence results are discussed separately for these two groups. The core age-five results for the white British population demonstrate that relative to their secondborn siblings, firstborn siblings experience an overall mean advantage of 0.05 standard deviation for language skills and a more modest advantage for numeracy skills. There is no evidence of any difference between firstborn and secondborn siblings on socioemotional skills. This latter result is surprising because the prior literature demonstrates that for adolescent and adult behavioral outcomes, firstborns enjoy substantial advantages (Breining et al., 2020; Black et al., 2018). We also demonstrate that age-five socioemotional skills strongly predict later education attainment as well as behavioral outcomes, so that measurement error in socioemotional skills alone cannot account for this null finding.

These overall effects for the white British population mask substantial heterogeneity by birth spacing, with the firstborn advantage in cognitive skills generally rising substantially as spacing between siblings increases. For example, for siblings who are three years apart, the firstborn advantage in language and numeracy skills is 0.1 and 0.05 standard deviation, respectively. For noncognitive skills, the effects are relatively small (0.01 and 0.03 standard deviation for socioemotional and creative development skills, respectively, for siblings with birth spacing of three years). On the other hand, for close spaced siblings –siblings born approximately one year apart, but not in the same grade at school – firstborn children experience a modest *disadvantage* on all age-five skill domains. [3]

In contrast to the headline results for the white British population, for minority children – who constitute over a fifth of the student population – there are very large *negative* effects for firstborn siblings across all five early childhood skill domains, ranging from -0.1

al. (2002) also highlight important lessons learnt from influential experiments such as the Perry Preschool program (Heckman et al., 2013).

[3] Note that because birth spacing is endogenous, such variation provides descriptive evidence of heterogeneity in birth order effects.

standard deviations to -0.2 standard deviations, relative to the secondborn sibling. This pattern holds consistently across diverse minority heritage groups, including students from South Asian, Afro-Caribbean, African, and Eastern European backgrounds, indicating that the underlying mechanism driving these birth order developmental gaps operates across cultural boundaries.[4] Further investigation supports the hypothesis that these effects are driven by positive English language spillover effects from the older sibling to the younger one.[5]

A key goal of our analysis is to characterize the dynamic evolution of birth order effects, specifically determining whether early developmental gaps persist, amplify, or fade as children transition into adolescence. In order to do so, we first corroborate findings from the prior literature demonstrating firstborn advantages on adolescent outcomes: firstborn siblings – from white British majority as well as minority families – have higher age-11 test scores, perform better on age-16 high stakes exams, and have lower school suspension rates. Overall, our results demonstrate that the birth order advantage for firstborn siblings increases between early childhood and adolescence.

Strikingly, we uncover two examples of a *reversal* in birth order effects between early childhood and adolescence. The first case is for relatively closely spaced white British siblings (siblings born approximately one year apart): the firstborn penalty on age-five skills for this group fully reverses by age 11, with first born siblings outperforming their younger siblings on education outcomes, which is sustained through to age-16. The second example of such a reversal is with respect to minority students: the large negative effects for age-five skills for firstborn sibling are not sustained, so that firstborn minority siblings perform better than their secondborn counterparts on high-stakes age-16 exams and are less likely to be suspended from school.

Our primary contribution is to the literature on the impact of birth order on individual outcomes (Black et al., 2005; Breining et al., 2020; Daysal et al., 2025; Lehmann et al., 2018; Mulimova et al., 2025; Pavan, 2016) as well as to the literature examining the determinants of early childhood development (Attanasio et al., 2022; Currie et al., 2018; Duncan et al., 2023; Heckman and Mosso, 2014). Estimating the reduced-form impact of birth order on early childhood outcomes is crucial for a better understanding of the early origins of skill gaps and

[4] On the interaction of birth order and cultural norms, see Jayachandran and Pande (2017).
[5] This contrasts with the negative diseases spillover effects for earlier-born siblings identified by Daysal et al. (2025).

the process of skill acquisition. For example, the prior evidence demonstrates that birth order affects adolescent and adult delinquency behavior and noncognitive abilities (Black et al., 2018; Breining et al., 2020), while a parallel literature points to early childhood noncognitive skills as potentially important mediators of later behavioral outcomes (Heckman et al., 2013). It is therefore important to determine whether the relationship between birth order and later behavioral outcomes could arise from the link between birth order and early noncognitive skills.[6]

This paper demonstrates that birth order is an important driver of early childhood cognitive skills; effects for noncognitive skills, on the other hand, are more muted. We find that the firstborn advantage grows between age five and adolescence. We also uncover striking heterogeneous effects where there is either no firstborn advantage or a firstborn deficit, but where a strong firstborn advantage subsequently appears during adolescence. This finding has parallels with 'sleeper' effects in the literature on early childhood investments, which has shown that the effect of interventions can fade in the short run, only to reappear in adolescence or adulthood (Chetty et al., 2011; Deming, 2009; Heckman et al., 2013; Bailey et al., 2020). We are not aware of any prior evidence of such a non-monotonic effect of birth order for early childhood cognitive or noncognitive skills in the prior literature.

In addition, our administrative data provide unusually rich measurements at age five, covering not only cognitive and socioemotional skills, but also creative and physical development. These unique aspects allow us to shed new light on important debates in the birth order and early childhood development literature. For example, with respect to age-five physical development, we demonstrate that firstborns *underperform* relative to their secondborn siblings, both for the white British as well as minority groups. This finding aligns with the established literature documenting inferior neonatal outcomes (such as birthweight) for firstborns (Brenøe and Molitor, 2018; Pruckner et al., 2021) which in turn suggests that the initial biological and physical disadvantage associated with being earlier-born may not be

[6] Prior studies investigating the links between birth order and early childhood development have lacked the statistical power to perform the detailed investigations needed to map developmental trajectories from early childhood to adolescence across skills and demographic groups. For example, both Lehmann et al. (2018) and Pavan (2016) use the Children of the National Longitudinal Survey of Youth 1979 to analyze birth order effects on early outcomes. Pavan focuses on cognitive skills and finds negative birth order effects for language skills, but no statistically significant effect for math skills. Lehmann et al. (2018) construct two broad index measures of cognitive and noncognitive skills. They find a negative birth order effect for the cognitive skill index at ages 0-3 and 4-6, but find no evidence of a birth order impact on noncognitive skills, though the estimates are imprecise and therefore cannot rule out economically meaningful effects.

fully attenuated in the early years, and persists at least through age five. In relation to age-five creative development, our results demonstrate that for white British children, firstborn siblings outperform secondborn siblings on this measure. This finding speaks to the debate concerning the role of birth order and creativity and individuals' openness to experience. Sulloway (1996) argues that firstborn siblings identify with parental authority and power, whilst later-born children are more open to new ideas, experience and creativity. Black et al. (2018) on the other hand, find no overall association between birth order and the likelihood of sorting into creative occupations. In contrast, our results point to a creativity advantage for firstborns in the early stages of childhood.

Finally, our study speaks to the literature on the education performance of first- and later-generation children from immigrant families (equivalent to minority students in our setting). The prior literature in this area has emphasized intergenerational education transmission (Borjas 1993; Card 2005; Casey and Dustmann, 2008) as well as critical periods for host-language acquisition (Bleakley and Chin, 2004, 2010). We demonstrate the role of birth order in determining education outcomes for this group of children. We document a reversal of the birth order effect between age five and adolescence, suggesting that language skills acquired at age five may be subject to dynamic substitutability for this group of students, as firstborn siblings catch up with, and subsequently overtake secondborn siblings on age-specific skills.

2 Theoretical Background and Prior Research

In this section we first provide a simple framework which helps motivate the empirical analysis which follows. Under the resource dilution hypothesis, the skill building framework (Cunha and Heckman) suggests that there are a number of channels through which birth order may influence children's outcomes. Given the data available in the current context, this may be illustrated with a simple three-period model; We further assume that there are two siblings in the family. Let $t = 0$ be the pre-school phase, $t = 1$ end of Reception grade (grade 'zero' in primary school for children age five) and $t = 2$ the adolescent phase, at age 11. At $t = 0$, pre-school cognitive and noncognitive outcomes, θ_0^C and θ_0^{NC}, respectively, are determined by parental investment, x_0, as follows: $\theta_0^C = f_0(x_0)$ and $\theta_0^{NC} = g_0(x_0)$. Later skills are determined by skills in the previous period and current school inputs, proxied by school quality:

$$\theta_t^C = f_t(\theta_{t-1}^C, \theta_{t-1}^{NC}, Q_t), \qquad \theta_t^{NC} = g_t(\theta_{t-1}^{NC}, \theta_{t-1}^C, Q_t),$$

where θ_t^C and θ_t^{NC} are the cognitive and noncognitive outcomes at time t, respectively, θ_{t-1}^C and θ_{t-1}^C are the previous period skills, Q_t is the quality of the child's school, and $t \in \{1,2\}$. We abstract from age-five and age-11 parental inputs by assuming that parental inputs are equal across school-age children.[7] Crucially, however, under the resource dilution hypothesis, pre-school parental inputs, x_0, favour the firstborn child, which are assumed to yield higher pre-school human capital, θ_0.

In light of this framework, a birth order effect emanating from higher initial investment, x_0, for the firstborn child, operates through multiple channels. The first channel is via self-productivity, which may may be expressed mathematically for age-five cognitive skills, for example, as follows: $\frac{\partial \theta_1^C}{\partial x_0} = \frac{\partial \theta_1^C}{\partial \theta_0^C}\frac{\partial \theta_0^C}{\partial x_0}$. Thus, initially higher investment (x_0) for a firstborn sibling, leads to higher pre-school human capital, which persists into later childhood via self-productivity, so that age-five outcomes for firstborn children are higher than for their secondborn counterparts.

A second channel is via dynamic complementarity (or substitutability), where higher levels of pre-school skills influence the productivity of school inputs, Q_1, as expressed by: $\frac{\partial^2 \theta_1^C}{\partial Q_1 \partial x_0} = \frac{\partial^2 \theta_1^C}{\partial Q_1 \partial \theta_0^C}\frac{\partial \theta_0^C}{\partial x_0}$.[8] Under dynamic complementarity (substitutability) returns from attending a higher quality school are larger (smaller) for the firstborn sibling thanks to higher pre-school human capital, θ_0.

Finally, there may be an impact from early parental investment, x_0, on later outcomes such as θ_t^C and θ_t^{NC}, which does not operate via θ_{t-1}^C and θ_{t-1}^{NC}. For example, very early investments (x_0) may boost human capital for firstborn children because this is a particularly sensitive phase of childhood development, but the firstborn impact may not be detected at age five, rather, emerging in adolescence. Such a mechanism may account for latent or 'sleeper' birth order effects.

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[7] We assume that the age gap between siblings is five years or less. Below we utilize survey panel data to shed light on the relationship between birth order and parental investment behavior.

[8] Similar expressions hold for noncognitive skills as well as for cross-productivities, for example, between early noncognitive and later cognitive skills.

3 Context and Data

Children in the English public (state) school system typically start formal schooling in the Reception grade at age four, during the academic year in which they turn five. The Reception grade follows a distinct pedagogical framework called the Early Years Foundation Stage, which differs significantly from the more formal, subject-based curriculum starting from Grade 1 ('Year 1'). The Reception curriculum is designed to support children's early development across learning, language, behavior, and social adjustment, while also easing their transition into more formal teaching in grade 1. The focus is on activities such as guided play, storytelling, songs and shared reading. As described in Evangelou et al. (2009) and Department for Education (2008-stat FW), the Reception curriculum is closely aligned with a developmental perspective which emphasizes that play and active engagement with the social environment are key to young children's socioemotional, cognitive and linguistic growth. By the end of the Reception year, teachers complete the Early Years Foundation Stage Profile for each child, a teacher-assessed summary of children's development. These are based on teachers' observations of children's day-to-day activities, gathered throughout the year from a wide range of learning and teaching contexts. The six areas for assessment are as follows: Personal, Social, and Emotional Development (including self-regulation, building relationships, and managing self-care); Creative Development (the cultivation of imagination and self-expression across artistic, musical and physical activities); Communication, Language and Literacy (spoken language, comprehension, reading, and writing); Problem Solving, Reasoning and Numeracy (counting, calculation and mathematical reasoning); Physical Development (movement, coordination, gross and fine motor skills); and Knowledge and Understanding of the World (early understanding of nature, objects, and everyday phenomena).

3.1 Data and Sample Construction

The key administrative data source for our analysis is England's National Pupil Database. These data include information on all four- and five-year old children in the public education system, enrolled in the Reception grade, as well as higher grades in the primary and secondary education system. Teacher assessments of all children's cognitive and non-cognitive skills in

the Reception grade Early Years Foundation Stage profile are available from 2007 (i.e. academic year 2006/2007) and were measured on a consistent basis through to 2012. The family identifier variable in the National Pupil Database is available for the years 2008, 2013 and 2016 only. This variable is constructed by the administrators by matching students with the same last name and the same full home address.

The starting point for constructing the estimation sample for the early childhood analysis is the set of students enrolled in the Reception grade in the years 2007 to 2012. Since the early childhood measures are available on a consistent basis in the period 2007 to 2012, children with an older sibling in the Reception grade in 2006 or earlier are excluded from the estimation sample. For example, consider students who enter Reception in 2007 and subsequently transition to grade 1 in 2008. The sample is restricted to those students in grade 1 in 2008 who do not have an older sibling in a higher grade (up to grade 11, the final year of compulsory formal academic study) and who *do* have at least one younger sibling enrolled in the Reception grade in years 2008 to 2012.[9] For this case, the cohort or grade spacing gap between siblings in the estimation sample ranges from one to five years.[10] Appendix A provides further details of the construction of the estimation sample.

The focus of this study is on siblings of birth order one and two, hence the estimation sample consists of sibling pairs (as in, for example, Breining et al., 2020). In the robustness analysis below, the sensitivity of the findings is assessed by exploiting information on higher birth orders. With regards to lack of information on maternal completed fertility, for the family fixed effect strategy this is not a concern because all time-invariant family characteristics are accounted for.

Outcomes for the 2007 – 2012 Reception grade cohorts are linked to their end-of-primary school (grade 6) test scores at age-11, measured in the years 2013 – 2018.[11] These age-11 standardized national tests, including in English reading and mathematics, occur in May of each academic year and are externally marked. For age-16 exam outcomes, the six

[9] For this 2007 Reception cohort of students, they will be incorrectly coded as the oldest sibling if the gap between the younger sibling and their next older sibling is more than ten years.

[10] Twins (siblings born in the same year and month) and siblings in the same grade are dropped from the sample. In the latter case, since school cohort sizes are relatively small in England (typically no larger than 60 or 90 students per cohort, i.e. two or three classrooms) there may be spillovers arising from teachers in their treatment of siblings of different ages in the same class.

[11] Note that 2019 is the last year that assessments and test score data are available before the COVID-19 pandemic disrupted the education system and formal testing arrangements. Students typically progress from one grade to the next each academic year in the English system and grade retention is extremely rare.

cohorts enrolled in grade 11 from 2014 to 2019 are used to construct the siblings sample. See Appendix A for further details.

Table 1 presents descriptive statistics for the cohorts of students enrolled in the Reception grade between 2007 and 2012, both for the full sample and the estimation sample. This shows that students in the estimation sample are somewhat less disadvantaged, as measured by the free lunch status. The estimation sample also contains a smaller share of minority students.

We classify the age-five skills into cognitive, noncognitive, and physical development domains. Noncognitive skills constitute socioemotional and creative development (Personal, Social, and Emotional Development; and Creative Development, respectively). Cognitive skills are language and mathematics development (Communication, Language and Literacy; and Problem Solving, Reasoning and Numeracy, respectively). In the robustness analysis below we also report on the final measure in the Reception teacher assessments, Knowledge and Understanding of the World.

Age-five scores are standardized within each national cohort to have mean zero and unit standard deviation. Table 1 shows that for cognitive and noncognitive skill measures at age five, students in the estimation sample score between 9% and 10% standard deviation higher than the full sample. The final two columns provide breakdowns of the estimation sample by white British or minority ethnic status.

The early childhood socioemotional skills measure is the aggregate of three sub-components (dispositions and attitudes, social development, and emotional development). The Cronbach's alpha coefficient for socioemotional skills is 0.90, suggesting that the three socioemotional scales are internally consistent. For early childhood language (four sub-scales) and numeracy skills (three sub-scales), Cronbach's alpha is 0.93 and 0.91, respectively. Each sub-scale is scored out of 9, and together with three further components (knowledge and understanding of the world, physical development, creative development), each scored out of 9, the maximum attainable score is 117. The total target score for all children is 78 points, with at least 6 points in each of the seven socioemotional and language scales. [online] Figure AXX plots the histograms for socioemotional, language, numeracy and aggregate scores. There is no evidence of score bunching at the threshold scores of 18 for socioemotional skills or 24 for language skills, nor at 78 for the overall EYFS total. There is modest evidence of

ceiling effects, indicated by heaping at the maximum on all three subscales and on the the aggregate score.

3.2 Relationship between early childhood skills and later outcome

This sub-section assesses how skills measured by teachers at age five, as well as test scores measured at age 11, are related to later outcomes.[12] This analysis helps anchor the results below which addresses how the impact of birth order evolves through different stages of a child's development. We focus on two outcomes: high stakes age-16 GCSE exams and school suspensions. School suspension and misbehavior partly reflect underlying noncognitive skills, including self-regulation, socioemotional adjustment and engagement, with consequences for later education and labor market outcomes (Bacher-Hicks et al., 2024; Jackson, 2018; Papageorge et al., 2022; Segal, 21012). If age-five skills forecast adolescent academic and behavioral outcomes then this indicates that these early childhood assessments capture meaningful underlying skills and behaviors and not simply transitory or noisy features of early development.

Table 2 presents evidence using the 2007 and 2008 Reception cohorts from the estimation sample. Outcomes for these two cohorts can be traced through to 2018 and 2019, when students are aged 16. Columns 1 to 3 present results for the nationally standardized GCSE age-16 exam outcome, and columns 4 to 7 focus on school suspensions. All regressions include indicators for free lunch status, female, month and year of birth, and ethnic group, as well as age-five school fixed effects.

Column 1 in Table 2 demonstrates that there is a strong positive association between age-five language and numeracy skills and age-16 exam outcomes, while the association between early socioemotional skills and age-16 exams is also positive and significant, but somewhat smaller. Conditional on these three age-five skills, creative and physical development at age five are negatively associated with age-16 exams. Column 2 assesses the association between age-11 test scores in reading and mathematics and age-16 exams, and

[12] For the age-11 (grade 6, 'Key Stage 2') assessments, we focus on reading and mathematics test scores, which are assessed on a consistent basis over the period of our analysis. The Key Stage 2 assessments comprise tests taken by all students at the end of primary school, which are externally marked.

this shows that the relative impact of the early cognitive skills in column 1 is comparable to that of age-11 test scores.

Columns 4 and 5 in Table XX indicate that age-five socioemotional skills are strongly negatively associated with the likelihood of a child ever being suspended in grades 1 to 6 (primary school) and grades 7 to 11 (secondary school). This strong negative relationship between school suspensions and socioemotional skills continues to hold even after the inclusion of age-11 test scores (column 7). Age-five creative and physical development, on the other hand, are positively associated with school suspensions.

As seen in column 3, when both age-five skills and age-11 test scores are included in the regression, the direct association between early skills and age-16 exam outcomes is markedly attenuated, consistent with early skills exerting much of their influence via age-11 skills (Heckman et al., 2006).

4 Empirical Strategy

The empirical approach adopted in this study leverages information on siblings to compare outcomes for the older versus the younger sibling. The core model exploits data for pairs of siblings, as described above. Results for three and more siblings are also produced in the robustness analysis. The family fixed effects model ensures that constant family-level characteristics common to siblings are differenced out (Black et al., 2005; Lehmann et al., 2018; Breining et al., 2019). The basic estimation model is as follows:

$$y_{if} = \beta_1 SecondChild_{if} + \gamma X_{if} + \mu_f + \epsilon_{if}, \qquad (1)$$

where y_{if} is the outcome for student i in family f (national standardized age-five cognitive or non-cognitive skills; standardized age-11 test scores, etc.). $SecondChild_{if}$ is switched on for the younger of the two children in the family. X_{if} contains a dummy indicating gender of student i, as well as month of birth dummies. μ_f are family fixed effects. Standard errors are clustered at the family level. The parameter of interest is β_1, the advantage or penalty for the second child compared to the first. In a set of sensitivity exercises, we probe the robustness of our baseline results by incorporating time-varying control variables in the regression

model, including free lunch status and the local poverty index, as well as using alternative transformations of the outcome variables.

In order to shed light on the role of birth spacing, models of the following form are also estimated:

$$y_{if} = \beta_1 SecondChild_{if} + \sum_{k=2}^{5} \beta_2^k SecondChild_{if} * BirthSpacing_f^k + \gamma X_{if} + \mu_f + \epsilon_{if} \quad (2)$$

where $BirthSpacing_f^k$ is a dummy variable indicating that the two siblings are k years apart from each other. As described in the previous section, in the estimation sample siblings are up to six years apart. The purpose of equation (2) is to unpack the impact of birth order, conditional on birth spacing, rather than an attempt to ascribe any causal relationship between spacing, birth order and the outcome of interest.

In all the analysis below, the left hand side variables are either nationally standardized test scores or, in the case of outcomes such as ~~special needs status or~~ school suspensions, are de-trended. [13]

5 The Impact of Birth Order on Age-Five Skills

This section presents results for children's age-five nationally standardized language, numeracy, socioemotional, creative, and physical development outcomes. Results are first reported for the full sample. However, given the large differences in birth order effects for the white British versus minority groups, all subsequent results are presented separately for these two groups.

[13] Note that although cohort effects can be identified in a family fixed effect model when there is variation in cohort spacing between siblings, in the current setting cohort effects are perfectly correlated with a spacing interaction term. To see this most clearly, consider the early childhood data in this study, 2007 – 2012 and *grade* spacing between siblings. (In the analysis below it is shown that birth spacing and grade spacing interactions produce very similar results.) In a model with cohort effects, CY_f^i where C is a cohort dummy for year Y for sibling i, $i \in \{1,2\}$, in family f, and an interaction term, $SecondChild_{if} * Spacing_f$, where $Spacing_f$ is the years or grades between the two siblings. In this case the following first differences equation holds: $C08_f^2 - C08_f^1 + 2\{C09_f^2 - C09_f^1\} + 3\{C10_f^2 - C10_f^1\} + 4\{C11_f^2 - C11_f^1\} + 5 * C12_f^2 = SecondChild_{if} * Spacing_f$. In cases where there is substantial difference in the impact of birth order effects by birth spacing, cohort dummies may capture these rather than true cohort effects.

Table 3 presents estimates using the family fixed effects model (equation (1) above) for each of the five outcomes. Simple OLS estimates are produced in Appendix Table 1. In most cases, the fixed effects estimates are qualitatively similar to their OLS counterparts. In the results reported below, the focus is on estimates from the preferred family fixed effects model.

Panel A of Table 3 reports results for the full sample. For the full sample, the estimates suggest that the secondborn child performs worse than the firstborn on language skills but enjoys an advantage on the four remaining skill measures. Separate results for the ethnic white British majority population and the minority population are presented in Panels B and C of Table 3, respectively.

Turning to the sample of white British students first, the estimates demonstrate that on average the secondborn child performs 0.05 standard deviation worse than the firstborn in language skills. The birth order effect for numeracy skills is substantially smaller, with the secondborn child performing just 0.01 standard deviation worse than the firstborn.[14] The impact on socioemotional skills is small and not statistically significant. This is a precisely estimated null effect, with an effect of more than 0.004 standard deviation (in absolute terms) ruled out at the 95% confidence interval level. There is, however, a small negative secondborn effect for creative development. Meanwhile, the secondborn effect for physical development is *positive*.

These overall effects mask substantial variation in birth order effects on age-five outcomes by birth spacing between siblings, as reported in Table 4. Estimates of the impact by birth spacing are undertaken using equation (2), which includes birth spacing interaction terms.[15] The results in Panel A, Table 4, for the white British population reveal very marked differences in the secondborn impact by birth spacing. Notably, at birth spacing one, the secondborn effect is positive across all five age-five outcomes. At birth spacing two, the secondborn effect is either positive or zero for four of the five outcomes, whilst there is a small negative effect for language skills. At birth spacing of three years and higher, on the other hand, there are large negative secondborn effects for cognitive skills (language and

[14] The larger impact for language skills relative to numeracy skills is consistent with the idea that older children may benefit from being exposed to a more sophisticated language environment than younger siblings (Zajonc and Sulloway, 2007).

[15] Appendix Table A4 report results for a *grade* spacing interaction term (instead of a spacing term measured in years between siblings' birth dates). These grade spacing results look very similar to those reported in Table 5.

numeracy). Effects for noncognitive skills (socioemotional and creative development), on the other hand, remain small. Two conclusions emerge from the analysis by birth spacing. First, relying solely on the basic model (equation 1) can give a misleading picture of the underlying birth order effects for early childhood outcomes, obscuring substantial heterogeneity and even masking effects of opposite sign. Second, relative to cognitive skills, the effects on noncognitive skills remain small. For example, while the secondborn effects for cognitive skills at higher birth spacings range between -0.05 and -0.16 standard deviation, the effects for socioemotional skills range between -0.01 and -0.03 standard deviation.[16]

For minority students, on the other hand, there is a large advantage enjoyed by secondborn children on all five skill measures. These are around 0.1 standard deviation for noncognitive skills and physical development and even larger for language and numeracy skills as reported in the baseline estimates in Panel C of Table 4. These effect remain positive at all birth spacings (Panel B, Table 5). Possible explanations for these positive effects for the minority population include cultural norms as well as differential sibling spillovers for minority families versus white British families. These are discussed in greater detail below.

5.1 Robustness Checks

The robustness of the baseline results for age-five outcomes are probed through a series of sensitivity analyses, including alternative transformations of the outcome variables. First, instead of standardizing scores, scores are expressed as percentile ranks within each cohort. The results are presented in Table 5, columns 1 to 5. All the results for the white British and minority populations are in line with the baseline results reported in Table 3, except for the white British socioemotional and physical development skills outcomes, for which there is now a small negative secondborn effect.

Second, the total age-five skills score is employed as the main outcome of interest. This is the sum of the scores for language, numeracy, socioemotional, creative development, physical development, as well as knowledge and understanding of the world. The results are reported in column 6 of Table 5. This shows that for the white British population, the

[16] Note that the purpose of the birth spacing analysis is to present heterogeneity in birth order effects for age-five skills. These estimates do not necessarily reveal the causal effects of the interaction between birth order and birth spacing. [birth spacing lit REFs]

secondborn effect is -0.02 standard deviation, whilst for the minority population the impact is 0.16 standard deviation

Third, two factor-indices are constructed to provide a parsimonious summary of each domain: a non-cognitive factor (the first factor from the socioemotional and creative development skill measures) and a cognitive factor (the first factor from language and mathematics skills as well as knowledge and understanding of the world). Each factor is then standardized to mean 0 and unit variance and used as the outcome variable. The results in columns 5 and 6 of Table 4 show that for the white British population the second-bord impact is -0.01 standard deviation and -0.05 standard deviation for the non-cognitive and cognitive factor, respectively; the results for the minority population are 0.12 standard deviation and 0.18 standard deviation, respectively.

In online Appendix Table A1, time-varying variables are included as controls in the main (family fixed effects) specification. Specifically, the free lunch status and the home location local poverty index are included, both measured at the time of Reception (age-five) enrollment. The results presented in Appendix Table A1 demonstrate that there is very little change in the estimates compared to the core results presented in Table 3.

Next, the model is re-estimated using a sample restricted to families with three siblings with early childhood outcomes in the 2007 – 2012 period. The main analysis focuses on first- and secondborn siblings, given the relatively narrow time span of availability of the early childhood outcomes on a consistent basis between 2007 and 2012. Given the limited window for the early childhood measures, restricting the sample to families with three siblings yields a smaller sample than in the main analysis. The estimates are reported in online Appendix Table A2. These show that the secondborn effects are broadly in line with the baseline results. Th only exceptions are numeracy and creative development skills for white British students, both of which yielded small negative effects in the baseline model, but are now statistically insignificant. Overall, these results suggest that the core results in Table 3 are robust to the inclusion of higher born siblings and are not driven by, for example, a 'last born' effect in, say, families of parity two. Finally it should be noted that, in general, there is a modest rise (in absolute terms) in impact for third-born children for both white British as well as minority families.

In another robustness exercise, normalization of skill measures is undertaken separately for the two main groups: scores are now standardized against that cohort's

national distribution, separately for white British and minority students. This accounts for, for example, the possibility that there is a secular improvement in skills for the minority group relative to the majority one. Results in Appendix Table A3, Panel A demonstrate that for the white British group there is very little change relative to the baseline results, whilst for the minority group the impact of being secondborn remains large and positive, although the estimates are around a third smaller relative to the earlier results.

5.2 Heterogeneous Effects

Table 6 reports results by free lunch status, a proxy for family background. For this analysis, both siblings are classified as belonging to a free lunch status family if the free lunch status variable is equal to one in any grade for either sibling. The results in Panel A of Table 6 suggest that for white British children differences in the birth order effect by free lunch status are not very large. For example, the impact on socioemotional skills remains insignificant for both groups. The largest differences are for language skills, where the impact is -0.06 standard deviation for non-free lunch families, whilst it is -0.02 standard deviation for free lunch families.

Results for minority students by free lunch status in Panel B of Table 6 shows that the positive impact for secondborn children is significantly larger for disadvantaged families. This pattern of results is discussed below in the context of the detailed minority-level analysis.

There may be important heterogeneity in the birth order effect by gender composition of the siblings. Online appendix Table Axx presents results separately for samples of boy-boy, girl-girl and mixed boy-girl pairs of siblings. For both the white British as well as the minority populations, there is no evidence of any strong variation in birth order impact on age-five skills by the gender composition of the sibling pairs, except for physical development. For the latter outcome, for the white British population the secondborn advantage is substantially larger for boy-boy pairs.

Detailed Minority Status Results

There are a number of plausible mechanisms for the opposite-signed birth order estimates observed among minority students, compared with the White British majority. One possible explanation hinges on different cultural norms between the white majority and the minority population. The administrative dataset allows for fine-grained analysis across multiple minority groups in order to explore this hypothesis. Table 7 presents results using detailed information on ethnicity. This shows estimates separately for children from the following major ethnicities or heritages reported in the administrative dataset: African, Afro-Caribbean, Bangladeshi, Indian, Pakistani and 'white other', which includes Eastern European heritage. These groups represent successive large waves of migration in the post-World War II era. For example, the Afro-Caribbean, Indian and Pakistani groups are among the earliest wave of migrants, whilst those from Eastern Europe are among the most recent. The results in Table 8 reveal that the large, positive advantage for secondborn siblings is present for *all* these minority groups. Given the diverse nature of these groups, simple explanations based on cultural norms originating the origin countries (for example, son preference as described in Jayachandran and Pande, 2017) would seem to be ruled out.

Another potential explanation for the large positive birth order effect for minority children is a spillover on English language skills from the older to the younger sibling in families which do not speak English at home. Table 8, Panel A reports results for minority students separately for those students who speak English versus those who speak another language at home. The results demonstrate that there are very large differences in birth order effects by home language status. For families where English is the language spoken at home, the benefit for secondborn children varies between 0.04 standard deviation and 0.08 standard deviation for the five age-five skill measures. For families where English is not the language spoken at home, the secondborn impact is between 0.14 standard deviation and 0.25 standard deviation. This large difference in impact by home language status for minority students points to a potentially important English language spillover effect from the older sibling to the younger one, which may drive the secondborn advantage among minority families.

6 Adolescent Education Outcomes and Behavior

This section assesses how the effect of birth order evolves over time. The first set of results below demonstrate how the impact of birth order on academic outcomes evolves from age 5 to age 11. This is followed by results for age-16 exam performance. Finally, results are reported for behavioral outcomes, namely school suspensions.

6.1 Age-11 Test Scores

Table 9 reports results for age-11 ("Key Stage 2") nationally standardized reading and mathematics test scores. The first two columns of Panel A show that for the white British population, the impact of being secondborn confers a substantial negative penalty, with estimates of -0.13 standard deviation and -0.06 standard deviation for reading and mathematics outcomes, respectively. Thus, compared to the impact at age five, there is a substantial increase in the penalty associated with being secondborn.

For minority students, the results in the third and fourth column show that the substantial positive benefit enjoyed by secondborn children in language skills at age five has disappeared by age-11 and in fact goes into reverse: the estimate for reading is now -0.03 standard deviation. For mathematics, although secondborn children in minority families continue to enjoy an advantage, this is substantially smaller than at age five (0.03 standard deviation). [17]

The secondborn impact on age-11 test scores for minority students by whether English is spoken at home are reported in Panel B of Table 8 (columns 1 to 4). These demonstrate that the very large skills advantages enjoyed by secondborn children at age five from families where English is not spoken at home – around 0.2 standard deviation – either shrink dramatically (0.05 standard deviation for mathematics) or become indistinguishable from zero (in the case of reading). For minority children where English is spoken at home, the small positive birth-order effects at age five turn negative by age 11.

[17] Estimating the model using age-11 test scores normalized with respect to each cohort's national distribution, separately for white British and minority students, yields very similar estimates to those reported in Table 10 (see online Appendix Table A6).

Results by detailed minority status, reported in online Appendix Table Axx, also demonstrates the stark changes in the impact of being second born between age five and age 11. For all minority groups, the benefits enjoyed by secondborn children are either reversed, becoming negative by age-11, or are substantially diminished.

Yet another striking case of a reversal of the birth order effect between age five and age 11 is revealed when examining the interaction between birth spacing and birth order. Columns 4 and 5 in Table 4 report estimates of equation (2), which includes birth spacing interaction terms, for age-11 standardized reading and mathematics scores, respectively. Recall that at birth spacing of one year, the secondborn effect for age-five skills for the white British population is positive. Columns 4 and 5 in Table 5, panel A reveal that by age 11 the birth order effect at birth spacing of one year is large and negative for reading (-0.1 standard deviation) and modestly negative for mathematics (-0.03 standard deviation). Similarly, at birth spacing of two years, age-five birth order effects on skills were either modestly negative or zero; in contrast, age-11 effects at birth spacing of two years are now large and negative.

Heterogeneous impact by free lunch status and by gender composition of the siblings are reported in online Table Axx and Table Axx. In both cases, there is little variation in the impact of birth order across the various sub-samples, either for the white British or the minority population.

6.2 Age-16 Exams

Turning to the high stakes age-16 exams ("GCSE's") outcome, results are reported in Panel B of Table 6. As explained above and in the data appendix, for these outcomes, students are enrolled in grade 11 in the six years 2014 to 2019. The results demonstrate that for the white British population, the impact of being secondborn leads to a large negative penalty of -0.15 standard deviation on the nationally standardized total GCSE exams score. For the minority population, the secondborn impact is now also negative, although somewhat smaller at -0.05 standard deviation. These results further reinforce the evidence that the advantage enjoyed by the firstborn siblings grows between the age of five and in subsequent years. [18]

[18] Once again, estimating the model using age-16 exam scores normalized with respect to each cohort's national distribution, separately for white British and minority students, yields very similar estimates to those reported in Table 6 (see online Appendix Table Axx).

Examining heterogenous effects by birth spacing, online Appendix Table Axx shows that the birth spacing interaction estimates for age-16 exam scores are consistent with the parallel results for age-11 test scores reported above. For the white British population, the birth order impact at birth spacing of one year and two years continues to be large and negative (in contrast to the age-five birth spacing results). For the minority population, the secondborn effect is negative at all birth spacings.

Results for minority students by English-is-spoken-at-home status are reported in Table 8, Panel B, columns 5 and 6. Once again, these results are consistent with the finding that there is a substantial reversal in the secondborn impact between age-five and adolescence. For age-16 exam scores the secondborn impact is consistently negative, both for those minority children who speak English at home, as well as those who do not.

Results by detailed minority status are reported in online Appendix Table Axx. These continue to demonstrates the dramatic change in the impact of being second born between age five and subsequent ages. By age-16, for all minority groups, the impact of being secondborn is now in all cases either negative or statistically insignificant. [19]

6.3 School Suspensions

Table XX reports the impact of being secondborn on ever having been suspended in Reception through grade 6 (i.e. during the primary schooling phase); and grade 7 to grade 11 (i.e. during the secondary phase). In the primary phase, being suspended is relatively rare and hence an extreme outcome; the mean suspension rate in the primary phase is 1.6%. In the secondary phase, on the other hand, 10% of students experience at least one school suspension. Rates for boys are higher than for girls and results by gender composition of the siblings are also reported below.

Results for the white British population are shown in Panel A of Table 10. These show that at the secondary school phase (grades 7 through 11) the impact is 1.1 percentage points, representing an 11% increase relative to the mean. For minority students, the impact in the

[19] Online Table Axx and Table Axx report heterogeneous impact by free lunch status and by gender composition of the siblings, respectively. Once again results are very similar across the different sub-groups.

secondary phase is also 1.1 percentage points, which represents a 13% effect for this population.

Overall, the results in Table 10 demonstrate that both for the white British as well as the minority populations, the secondborn child is more likely to be suspended from school. For the white British population this effect emerges in primary school. For the minority population there is no discernible impact until the secondary schooling phase.

Online Appendix Table X shows the impact by birth spacing. This demonstrates that the impact of being secondborn at lower birth spacing is always positive, both in the primary as well as secondary schooling phases, for white British as well as minority students. At higher birth spacing the impact appears to be negative.

Online appendix table Y reports results by the gender composition of the siblings. This shows that the impact is somewhat larger for boys than for girls, although relative to the mean suspension rate by gender, it is broadly similar across the different samples. For example, white British secondborn boys are 1.4 percentage points more likely to be suspended in the boy-boy sample, whilst the impact is 0.8 percentage points for girls in the girl-girl sample; the overall mean suspension rates for these two samples are 14% and 6.4%, respectively. Similar findings hold for the minority population.

7 Conclusion

The prior literature has established the importance of birth order effects for adolescent and adult outcomes using large administrative datasets (Black et al., 2005; Breining et al., 2020). This study exploits unique administrative data with unusually rich measures of child development at age five to address whether birth order gradients are present in early childhood. We arrive at the surprising conclusion that among white British students, although firstborns exhibit advantages in early cognitive development, there is no impact on age-five socioemotional skills. In particular, for closely spaced siblings, firstborns experience a *disadvantage* on age-five outcomes relative to their secondborn siblings. Significantly, this penalty is reversed by middle childhood. For white British siblings overall, the firstborn advantage grows through adolescence, and is large and positive for age-11 test scores, high stakes exams at age-16, and adolescent behavioral outcomes.

The growth, as well as the non-monotonic feature, of the birth order effects that we identify are striking. One way to interpret these findings is through the lens of the dynamic human capital model, a natural approach if the resource dilution hypothesis is taken seriously (Pavan, 2016; Price. 2008). This interpretation would suggest that in the case of age-five noncognitive skills for the overall white British population, as well as both cognitive and noncognitive skills for closely-spaced white British siblings, there is a 'sleeper' effect, mirroring a pattern documented in the early childhood interventions literature: even if gains from relatively higher parental investment in their first years of life for firstborns do not appear at age five, they subsequently emerge in adolescent behavioral outcomes as well high stakes exams.[20] This pattern of results is unlikely to be explained by simple measurement error or test score scaling in the different stages of schooling. One reason is that the early childhood skill measures we use strongly predict outcomes through adolescence. Another is that the impact of being firstborn not only grows over time, but also flips sign in some cases. We can speculate why positive firstborn effects are absent at age five, only to emerge later in adolescence. One set of explanations may hinge on returns to noncognitive skills at different stages of schooling. For example, in a structured teacher-led environment at age five, gaps in children's socioemotional skills may be masked, whilst they may re-emerge as children progress through the education system when, under weaker adult supervision, children are faced with increasing demands on such skills (McClelland and Cameron, 2011, discuss this in the context of kindergarten and school transitions). Another set of explanations may relate to spillovers between siblings, including role model effects, information transmission and resource reallocation (Altmed et al., 2021; Black et al., 2020; Dahl et al., 2014). A limitation of our study is that for the white British population, we have no clear evidence on such mechanisms.

For the population of minority students, we find that firstborns experience large penalties on all age-five skills compared to secondborn siblings. These age-five birth order results run counter to the consensus finding in developed country settings for adolescent and adult outcomes. Our findings are consistent with the hypothesis that for minority students

[20] Studies documenting fade-out followed by longer-term impacts include Chetty et al. (2011), Deming (2009) and Heckman et al. (2013). Recent examples of early childhood intervention studies which find evidence of impact on early childhood cognitive skills but more muted effects on socioemotional skills include Carneiro et al. (2025), and Doyle (2020).

there are positive language spillovers from the older sibling to the younger one. This firstborn penalty is reversed in adolescence, with firstborns overtaking their secondborn siblings on test scores and high stakes exams, suggesting that any early language advantage between siblings from a minority background fades over time.

A key lesson from our analysis of birth order effects in the early years is the value of large administrative datasets for uncovering patterns that would otherwise remain hidden. The population-level scale of the data make it possible to detect heterogeneous effects across groups, tracing how birth order gradients evolve from early childhood to the adolescent years. Even without unpacking the precise mechanisms driving birth order effects, our results demonstrate that identifying these effects is crucial for a better understanding of the dynamics of early childhood development. For example, from a policy perspective, if birth order systematically shifts the initial stock of cognitive skills, it fundamentally alters the gains from all subsequent investments under the assumption of dynamic complementarity. Similarly, birth order may interact with policy interventions targeting early childhood development, suggesting that birth order should be taken into account when devising interventions.

Table 1 Descriptive Statistics: Full Sample and Estimation Samples

	Full		Estimation sample		White British sample		Minorities sample	
	mean	sd	mean	sd	mean	sd	mean	sd
Female	0.487	0.500	0.487	0.500	0.486	0.500	0.490	0.500
Free lunch	0.319	0.466	0.293	0.455	0.262	0.440	0.390	0.488
White British	0.733	0.443	0.783	0.412				
Age-five skills								
Socioemotional	0.00541	0.987	0.0864	0.961	0.137	0.932	-0.0922	1.030
Language	0.00931	0.985	0.101	0.962	0.157	0.930	-0.0954	1.038
Numeracy	0.00840	0.984	0.0944	0.953	0.159	0.908	-0.130	1.059
Age-11 test scores								
Reading	0.0196	0.987	0.0946	0.982	0.111	0.985	0.0445	0.965
Mathematics	0.00777	0.995	0.0980	0.974	0.0811	0.973	0.163	0.970
N		3,402,000	925,234		693,930		192,182	
Sibling pairs			462,617		346,965		96,091	

Notes : The full sample consist of students in the Reception (age four or five) grade in the years 2007 to 2012. The estimation sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. See text for full details.

Table 2 Relationship Between Age-5, Age-11 and Later Outcomes

	Age-16 exam performance			Ever suspended, Grades 1 - 6	Ever suspended, Grades 7 - 11		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age-5 skills:							
Language	0.363***		0.0933***	0.00128*	-0.0154***		0.00327*
	(0.00451)		(0.00369)	(0.000673)	(0.00178)		(0.00183)
Numeracy	0.162***		-0.0284***	0.00241***	-0.0114***		0.00160
	(0.00421)		(0.00338)	(0.000692)	(0.00174)		(0.00176)
Socioemotional	0.0742***		0.0606***	-0.0166***	-0.0427***		-0.0418***
	(0.00349)		(0.00280)	(0.000688)	(0.00145)		(0.00144)
Creative dvpt.	-0.0384***		-0.00837***	0.00230***	0.0105***		0.00846***
	(0.00333)		(0.00264)	(0.000509)	(0.00128)		(0.00128)
Physical dvpt.	-0.0534***		-0.0370***	0.00158***	0.0180***		0.0168***
	(0.00301)		(0.00241)	(0.000524)	(0.00127)		(0.00126)
Age-11 test scores:							
Reading		0.314***	0.294***			-0.0239***	-0.0212***
		(0.00203)	(0.00208)			(0.00102)	(0.00106)
Mathematics		0.382***	0.360***			-0.0262***	-0.0236***
		(0.00209)	(0.00220)			(0.00106)	(0.00112)
Observations	250,168	250,180	250,168	250,168	250,168	250,180	250,168
R-squared	0.266	0.489	0.494	0.021	0.063	0.067	0.072
Sibling pairs	15,786	15,786	15,786	15,786	15,786	15,786	15,786

Notes: This table relates nationally standardized age-16 exam performance ('GCSE' exams) and school suspension to age-5 and age-11 test scores. 'Evere suspended' is a binary dummy variable indicating whether the student was ever suspended in the respective grades. Estimates are from OLS regressions, which include indicators for free lunch status, female, month and year of birth, and ethnic group, as well as age-five school fixed effects. Age-five skills are teacher assessment scores for: Communication, Language and Literacy ('Language'); Problem Solving, Reasoning and Numeracy ('Numeracy'); Personal, Social, and Emotional Development ('Socioemotional'); Creative Development; and Physical Development. Age-11 reading and mathematics test scores comprise the grade 6, 'Key Stage 2,' assessments at the end of primary school. Scores are standardized within each national cohort to have mean zero and unit standard deviation.

Table 3 Impact of Birth Order on Age-Five Outcomes

	Language (1)	Numeracy (2)	Socioemotional (3)	Creative dvpt. (4)	Physical dvpt. (5)
All					
Second child	-0.00424***	0.0305***	0.0274***	0.0110***	0.0485***
	(0.00146)	(0.00151)	(0.00159)	(0.00164)	(0.00168)
Girl	0.305***	0.104***	0.311***	0.443***	0.261***
	(0.00206)	(0.00213)	(0.00224)	(0.00231)	(0.00236)
Observations	925,234	925,234	925,234	925,156	925,203
R-squared	0.144	0.090	0.090	0.106	0.069
Sibling pairs	462,617	462,617	462,617	462,617	462,617
White British					
Second child	-0.0517***	-0.0135***	0.000290	-0.0128***	0.0312***
	(0.00163)	(0.00167)	(0.00178)	(0.00185)	(0.00190)
Girl	0.302***	0.0910***	0.304***	0.444***	0.264***
	(0.00228)	(0.00234)	(0.00250)	(0.00259)	(0.00266)
Observations	693,930	693,930	693,930	693,882	693,906
R-squared	0.153	0.093	0.092	0.111	0.072
Sibling pairs	346,965	346,965	346,965	346,965	346,965
Minorities					
Second child	0.161***	0.183***	0.125***	0.0963***	0.111***
	(0.00352)	(0.00372)	(0.00382)	(0.00389)	(0.00391)
Girl	0.313***	0.152***	0.337***	0.441***	0.247***
	(0.00504)	(0.00533)	(0.00547)	(0.00558)	(0.00560)
Observations	192,182	192,182	192,182	192,154	192,176
R-squared	0.143	0.105	0.093	0.096	0.063
Sibling pairs	96,091	96,091	96,091	96,091	96,091

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. The outcomes are teacher assessment scores for: Communication, Language and Literacy ('Language'); Problem Solving, Reasoning and Numeracy ('Numeracy'); Personal, Social, and Emotional Development ('Socioemotional'); Creative Development; and Physical Development. Scores are standardized within each national cohort to have mean zero and unit standard deviation.

Table 4 Sibling Spacing Interaction

	Age-Five					Age-11	
	Language	Numeracy	Socioemotional	Creative dvpt.	Physical dvpt.	Reading	Maths
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
White British							
second_born	0.0365***	0.0531***	0.0151***	0.0210***	0.0471***	-0.0990***	-0.0285***
	(0.00423)	(0.00435)	(0.00465)	(0.00482)	(0.00494)	(0.00483)	(0.00478)
second_born_YrsSpace2	-0.0606***	-0.0411***	-0.00616	-0.0188***	-0.00469	-0.0271***	-0.0202***
	(0.00489)	(0.00503)	(0.00537)	(0.00557)	(0.00571)	(0.00556)	(0.00550)
second_born_YrsSpace3	-0.131***	-0.101***	-0.0243***	-0.0558***	-0.0243***	-0.0397***	-0.0433***
	(0.00520)	(0.00535)	(0.00572)	(0.00593)	(0.00608)	(0.00590)	(0.00583)
second_born_YrsSpace4	-0.176***	-0.143***	-0.0363***	-0.0703***	-0.0491***	-0.0233***	-0.0503***
	(0.00645)	(0.00664)	(0.00710)	(0.00735)	(0.00754)	(0.00730)	(0.00721)
second_born_YrsSpace5	-0.192***	-0.157***	-0.0461***	-0.0745***	-0.0567***	-0.0419***	-0.0813***
	(0.00996)	(0.0102)	(0.0109)	(0.0113)	(0.0116)	(0.0112)	(0.0111)
second_born_YrsSpace6	-0.169***	-0.110***	0.0128	-0.0780**	-0.0354	0.00272	-0.0437
	(0.0299)	(0.0308)	(0.0329)	(0.0341)	(0.0350)	(0.0339)	(0.0335)
female_dum	0.302***	0.0906***	0.304***	0.444***	0.264***	0.166***	-0.106***
	(0.00227)	(0.00234)	(0.00250)	(0.00259)	(0.00266)	(0.00256)	(0.00253)
Observations	693,930	693,930	693,930	693,882	693,906	639,022	639,022
R-squared	0.156	0.095	0.092	0.112	0.072	0.051	0.026
Sibling pairs	346,965	346,965	346,965	346,965	346,965	319,511	319,511
Minorities							
second_born	0.219***	0.232***	0.133***	0.117***	0.127***	-0.0133*	0.0328***
	(0.00757)	(0.00801)	(0.00822)	(0.00839)	(0.00842)	(0.00740)	(0.00719)
second_born_YrsSpace2	-0.0372***	-0.0325***	-0.00236	-0.00753	-0.00458	-0.0157*	-0.0108
	(0.00931)	(0.00986)	(0.0101)	(0.0103)	(0.0104)	(0.00910)	(0.00884)
second_born_YrsSpace3	-0.101***	-0.0801***	-0.0215*	-0.0446***	-0.0296**	-0.0261**	0.0158
	(0.0104)	(0.0111)	(0.0114)	(0.0116)	(0.0116)	(0.0102)	(0.00989)
second_born_YrsSpace4	-0.144***	-0.125***	-0.0271*	-0.0504***	-0.0594***	-0.0236*	-0.00996
	(0.0132)	(0.0140)	(0.0143)	(0.0146)	(0.0147)	(0.0129)	(0.0125)
second_born_YrsSpace5	-0.116***	-0.109***	0.0107	-0.0377*	-0.0305	0.0121	0.0342*
	(0.0199)	(0.0211)	(0.0216)	(0.0221)	(0.0221)	(0.0194)	(0.0188)
second_born_YrsSpace6	-0.0807	-0.0890	0.00112	-0.0750	0.00116	0.0303	-0.0203
	(0.0576)	(0.0609)	(0.0626)	(0.0639)	(0.0641)	(0.0559)	(0.0543)
female_dum	0.313***	0.152***	0.337***	0.441***	0.247***	0.159***	-0.0895***
	(0.00504)	(0.00533)	(0.00547)	(0.00558)	(0.00560)	(0.00492)	(0.00478)
Observations	192,182	192,182	192,182	192,154	192,176	175,062	175,062
R-squared	0.145	0.106	0.093	0.097	0.063	0.030	0.020
Sibling pairs	96,091	96,091	96,091	96,091	96,091	87,531	87,531

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. The outcomes are teacher assessment scores for: Communication, Language and Literacy ('Language'); Problem Solving, Reasoning and Numeracy ('Numeracy'); Personal, Social, and Emotional Development ('Socioemotional'); Creative Development; and Physical Development. Age-11 reading and mathematics test scores comprise the grade 6, 'Key Stage 2,' assessments at the end of primary school. Scores are standardized within each national cohort to have mean zero and unit standard deviation.

Table 5 Alternative Measures for Age-Five Outcomes

	Percentile ranks					Total age-5 score	Cognitive skills factor	Non-cognitive skills factor
	Numeracy	Language	Socio-emotional	Creative dvpt.	Physical dvpt.			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: White Brit								
Second child	-0.0205***	-0.00714***	-0.00419***	-0.0149***	-0.00145***	-0.0227***	-0.0324***	-0.00708***
	(0.000480)	(0.000502)	(0.000518)	(0.000527)	(0.000489)	(0.00162)	(0.00169)	(0.00182)
Girl	0.0916***	0.0196***	0.0893***	0.132***	0.0624***	0.263***	0.182***	0.420***
	(0.000672)	(0.000703)	(0.000725)	(0.000737)	(0.000685)	(0.00227)	(0.00236)	(0.00255)
Observations	693,930	693,930	693,930	693,882	693,906	693,930	693,906	693,882
Number of groupid	0.172	0.110	0.102	0.122	0.075	0.133	0.122	0.122
	346,965	346,965	346,965	346,965	346,965	346,965	346,965	346,965
Panel B: Minorities								
Second child	0.0385***	0.0425***	0.0287***	0.00912***	0.0161***	0.164***	0.186***	0.124***
	(0.000949)	(0.000979)	(0.00102)	(0.000992)	(0.000910)	(0.00358)	(0.00377)	(0.00392)
Girl	0.0849***	0.0296***	0.0888***	0.115***	0.0491***	0.293***	0.225***	0.437***
	(0.00136)	(0.00140)	(0.00146)	(0.00142)	(0.00131)	(0.00514)	(0.00540)	(0.00562)
Observations	192,182	192,182	192,182	192,154	192,176	192,182	192,167	192,154
Number of groupid	0.157	0.115	0.099	0.099	0.061	0.130	0.126	0.112
	96,091	96,091	96,091	96,091	96,091	96,091	96,091	96,091

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. For columns 1 to 5, age-five assessment scores are expressed as percentile ranks within each cohort. For column 6, the total age-five skills score is the sum of the scores for language, numeracy, socioemotional, creative development, physical development, and knowledge and understanding of the world. For columns 7 and 8, two factor-indices are constructed: a non-cognitive factor (the first factor from the socioemotional and creative development skill measures) and a cognitive factor (the first factor from language and mathematics skills as well as knowledge and understanding of the world), respectively. Each factor is standardized to mean 0 and unit variance.

Table 6 Birth Order and Early Years: Free Lunch Status

	Language		Numeracy		Socioemotional		Creative dvpt.		Physical dvpt.	
	FL = 0	FL = 1	FL = 0	FL = 1	FL = 0	FL = 1	FL = 0	FL = 1	FL = 0	FL = 1
White British										
Second child	-0.0632***	-0.0219***	-0.0223***	0.00853**	0.00176	-0.00383	-0.0180***	0.000320	0.0335***	0.0245***
	(0.00181)	(0.00350)	(0.00181)	(0.00374)	(0.00200)	(0.00377)	(0.00208)	(0.00389)	(0.00209)	(0.00413)
Girl	0.285***	0.348***	0.0733***	0.138***	0.289***	0.345***	0.437***	0.461***	0.251***	0.298***
	(0.00252)	(0.00493)	(0.00253)	(0.00527)	(0.00280)	(0.00532)	(0.00290)	(0.00549)	(0.00293)	(0.00581)
Observations	503,178	190,752	503,178	190,752	503,178	190,752	503,158	190,724	503,166	190,740
R-squared	0.162	0.141	0.097	0.089	0.095	0.087	0.116	0.101	0.074	0.069
Number of groupid_sgas	251,589	95,376	251,589	95,376	251,589	95,376	251,589	95,376	251,589	95,376
Minorities										
Second child	0.130***	0.205***	0.151***	0.226***	0.110***	0.145***	0.0771***	0.123***	0.102***	0.122***
	(0.00442)	(0.00574)	(0.00460)	(0.00618)	(0.00482)	(0.00620)	(0.00493)	(0.00631)	(0.00488)	(0.00643)
Girl	0.297***	0.337***	0.128***	0.187***	0.323***	0.356***	0.439***	0.444***	0.235***	0.264***
	(0.00629)	(0.00829)	(0.00655)	(0.00893)	(0.00686)	(0.00897)	(0.00702)	(0.00912)	(0.00695)	(0.00930)
Observations	112,250	79,932	112,250	79,932	112,250	79,932	112,237	79,917	112,248	79,928
R-squared	0.141	0.148	0.101	0.112	0.093	0.093	0.100	0.093	0.064	0.063
Number of groupid_sgas	56,125	39,966	56,125	39,966	56,125	39,966	56,125	39,966	56,125	39,966

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. This table reports results separately for students eligible for Free Lunch (FL = 1) versus those not eligible for Free Lunch (FL = 0).

Table 7 Birth order and Early Years: Detailed Minority Status

	Heritage						
	White British	African	Afro-Caribbean	Bangladeshi	Indian	Pakistani	White other
Language							
Second child	-0.0528***	0.278***	0.0945***	0.232***	0.136***	0.155***	0.212***
	(0.00179)	(0.0121)	(0.0229)	(0.0194)	(0.0113)	(0.0101)	(0.0122)
Girl	0.301***	0.339***	0.346***	0.366***	0.289***	0.303***	0.304***
	(0.00251)	(0.0170)	(0.0318)	(0.0316)	(0.0161)	(0.0149)	(0.0169)
Observations	628,093	23,827	6,361	9,400	19,879	30,259	29,572
R-squared	0.154	0.164	0.147	0.166	0.144	0.135	0.164
Number of groupid_sgas	346,965	14,602	4,236	5,824	11,611	17,838	22,193
Numeracy							
Second child	-0.0142***	0.278***	0.115***	0.256***	0.154***	0.185***	0.220***
	(0.00184)	(0.0128)	(0.0236)	(0.0211)	(0.0115)	(0.0109)	(0.0129)
Girl	0.0890***	0.210***	0.126***	0.202***	0.130***	0.177***	0.111***
	(0.00257)	(0.0179)	(0.0327)	(0.0345)	(0.0165)	(0.0160)	(0.0180)
Observations	628,093	23,827	6,361	9,400	19,879	30,259	29,572
R-squared	0.094	0.124	0.103	0.131	0.106	0.104	0.122
	346,965	14,602	4,236	5,824	11,611	17,838	22,193
Socioemotional							
Second child	0.000503	0.207***	0.117***	0.169***	0.124***	0.0927***	0.168***
	(0.00197)	(0.0133)	(0.0254)	(0.0212)	(0.0123)	(0.0108)	(0.0131)
Girl	0.305***	0.414***	0.373***	0.355***	0.278***	0.300***	0.334***
	(0.00275)	(0.0186)	(0.0353)	(0.0347)	(0.0175)	(0.0158)	(0.0183)
Observations	628,093	23,827	6,361	9,400	19,879	30,259	29,572
R-squared	0.093	0.114	0.101	0.099	0.090	0.081	0.109
	346,965	14,602	4,236	5,824	11,611	17,838	22,193
Creative dvpt.							
Second child	-0.0130***	0.146***	0.0828***	0.147***	0.0938***	0.0830***	0.142***
	(0.00204)	(0.0131)	(0.0250)	(0.0214)	(0.0126)	(0.0112)	(0.0136)
Girl	0.443***	0.469***	0.430***	0.475***	0.414***	0.389***	0.453***
	(0.00286)	(0.0184)	(0.0347)	(0.0349)	(0.0180)	(0.0164)	(0.0190)
Observations	628,048	23,822	6,361	9,395	19,876	30,258	29,570
R-squared	0.112	0.106	0.106	0.100	0.095	0.077	0.118
	346,958	14,601	4,236	5,824	11,611	17,838	22,192
Physical dvpt.							
Second child	0.0318***	0.153***	0.0676**	0.160***	0.101***	0.0967***	0.143***
	(0.00209)	(0.0137)	(0.0263)	(0.0212)	(0.0123)	(0.0117)	(0.0131)
Girl	0.264***	0.314***	0.236***	0.215***	0.195***	0.221***	0.247***
	(0.00292)	(0.0191)	(0.0365)	(0.0347)	(0.0175)	(0.0172)	(0.0183)
Observations	628,071	23,825	6,361	9,399	19,878	30,259	29,571
R-squared	0.073	0.077	0.059	0.064	0.061	0.050	0.075
	346,965	14,602	4,236	5,824	11,611	17,838	22,193

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. This table reports results separately for students from different minority ethnic hertiage groups.

Table 8 Impact for Minority Students: English Spoken at Home Status

	Language		Numeracy		Socioemotional		Creative dvpt.		Physical dvpt.	
	English = 1	English = 0	English = 1	English = 0	English = 1	English = 0	English = 1	English = 0	English = 1	English = 0
Panel A: Age 5										
Second child	0.0436***	0.238***	0.0762***	0.254***	0.0536***	0.176***	0.0306***	0.139***	0.0686***	0.140***
	(0.00579)	(0.00551)	(0.00604)	(0.00588)	(0.00640)	(0.00595)	(0.00649)	(0.00610)	(0.00654)	(0.00609)
Girl	0.333***	0.308***	0.140***	0.163***	0.353***	0.326***	0.462***	0.434***	0.272***	0.235***
	(0.00820)	(0.00794)	(0.00855)	(0.00847)	(0.00906)	(0.00858)	(0.00919)	(0.00879)	(0.00925)	(0.00878)
Observations	85,148	105,332	85,148	105,332	85,148	105,332	85,136	105,316	85,146	105,328
R-squared	0.140	0.156	0.086	0.123	0.089	0.099	0.104	0.096	0.066	0.063
Number of groupid_sga	53,901	64,022	53,901	64,022	53,901	64,022	53,894	64,018	53,900	64,021

Pabel B: Age 11 and 16	KS2				KS4	
	Reading		Mathematics		Point Score	Point Score
	English = 1	English = 0	English = 1	English = 0	English = 1	English = 0
Second child	-0.0673***	-0.00757	-0.0169***	0.0563***	-0.0712***	-0.0310***
	(0.00605)	(0.00522)	(0.00600)	(0.00499)	(0.00629)	(0.00441)
Girl	0.198***	0.137***	-0.0649***	-0.105***	0.282***	0.248***
	(0.00858)	(0.00753)	(0.00851)	(0.00720)	(0.00885)	(0.00649)
Observations	77,136	96,374	77,136	96,374	56,961	102,277
R-squared	0.040	0.028	0.018	0.024	0.051	0.037
Number of groupid_sga	48,913	58,557	48,913	58,557	33,089	55,900

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Sample consists of sibling pairs with age-five outcomes from one of the years 2007 to 2012. This table reports results for students from the minority ethnic group, separately for those famnilies where Eglish is spoke at home (English = 1) versus those where Englsh is not spken at home (English = 0).

Table 9 Impact of Birth Order on Adolescent Academic Outcomes

	White British		Minorities	
	Reading	Mathematics	Reading	Mathematics
Age-11 test score				
Second child	-0.126***	-0.0576***	-0.0278***	0.0321***
	(0.00183)	(0.00181)	(0.00343)	(0.00333)
Girl	0.166***	-0.106***	0.159***	-0.0896***
	(0.00256)	(0.00253)	(0.00492)	(0.00478)
Observations	639,022	639,022	175,066	175,066
R-squared	0.050	0.026	0.030	0.019
Number of groupid_sgas	319,511	319,511	87,533	87,533

	White British	Minorities
Age-16 total points score	Total points score	Total points score
Second child	-0.148***	-0.0461***
	(0.00158)	(0.00340)
Girl	0.252***	0.261***
	(0.00222)	(0.00493)
Observations	676,470	160,266
R-squared	0.068	0.041
Number of groupid_sgas	338,235	80,133

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Table shows the impact of birth order on age-11 and age-16 academic performance. Age-11 reading and mathematics test scores comprise the grade 6, 'Key Stage 2,' assessments at the end of primary school. Age-16 exam points score is the total points score on all GCSE exams. Age-11 and age-16 scores are standardized within each national cohort to have mean zero and unit standard deviation.

Table 10 Impact of Birth Order on School Suspension

	Ever suspended, Grades Reception - 6	Ever suspended, Grades 7 - 11
White British		
Second child	0.00141***	0.0107***
	(0.000320)	(0.000675)
Girl	-0.0302***	-0.0767***
	(0.000448)	(0.000946)
Observations	693,930	676,470
R-squared	0.013	0.020
Sibling pairs	346,965	338,235
Minorities		
Second child	-0.000451	0.0107***
	(0.000586)	(0.00152)
Girl	-0.0272***	-0.108***
	(0.000840)	(0.00220)
Observations	192,182	160,266
R-squared	0.011	0.030
Sibling pairs	96,091	80,133

Notes : Standard errors are clustered at the family level, shown in parentheses. *, **, *** denote significance at the 10%, 5% and 1% level, respectively. All regressions control for family fixed effects and include dummy variables for month of birth. Table shows the impact of birth order on school suspensions. 'Ever suspended' is a binary dummy variable indicating whether the student was ever suspended in the respective grades.