FAMILY COMPOSITION

AND CHILDREN'S

EDUCATIONAL OUTCOMES

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Abstract:

This paper explores the relationship between sibship structure and educational outcomes, in the context of theories of dilution of parental time. Special efforts are made to disentangle the effects of family size and birth order, since these effects have often been confounded in the past. Children from larger families are found to do worse than children from smaller families, and children lower down the birth order do worse than those higher up the birth order. These findings are consistent with theoretical predictions, but the finding that only children perform worse than those from two-child families, even controlling for a whole range of parental and school characteristics, is not. This paper suggests that as well as inputs from parents, interactions with other children may be important in children's educational development: this idea is supported by the finding that mixing with other children outside school reduces the disadvantage otherwise associated with being an only child. Additionally, the important finding emerges that only children are at much more of a disadvantage on mathematically-based measures of performance than on language-based measures, suggesting that these skills may be acquired via different processes.

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Non-technical summary

This paper explores the relationship between sibship structure (the number of siblings one has, and where one is in the birth order) and educational outcomes. This is done in the context of theories of dilution of parental time, which suggest that children in smaller families should do better than those in larger families.

Special efforts are made to disentangle the effects of family size and birth order, since these effects have often been confounded in the past. For example, some studies have included birth order as a variable taking the value 1 for a first-born, 2 for a second-born, and so on – but this way, the effect of being low down the birth order (for example, an eighth-born child) is hopelessly entangled with the effect of growing up in a large family. Data from the National Child Development Study are used, and a range of educational outcomes, from tests at age seven through to educational attainment at age 23, are examined.

In general, from sibships of two and larger, children from larger families are found to do worse than children from smaller families, and children lower down the birth order do worse than those higher up the birth order. For sibship sizes between 2 and 8, each additional sibling is associated with a reduction in test or examination performance of between 11 and 17 per cent of a standard deviation, (depending on the outcome measure used) falling to between 3 and 13 per cent of a standard deviation when controls for parental and school characteristics are added. Being an eldest child is associated with an increase in test or examination performance of around 10 per cent of a standard deviation.

These findings are consistent with theoretical predictions, but the finding that only children perform worse than those from two-child families, even controlling for a whole range of parental and school characteristics, is not. This paper suggests that as well as inputs from parents, interactions with other children may be important in children's educational development: this idea is supported by the finding that mixing with other children outside school reduces the disadvantage otherwise associated with being an only child. Additionally, the important finding emerges that only children are at much more of a disadvantage on mathematically-based measures of performance than on language-based measures, suggesting that these skills may be acquired via different processes.

1 INTRODUCTION

This study focuses on the relationship between the structure of the family within which a child grows up, and later educational outcomes, using the National Child Development Study, a sample of young British people born in March 1958. In the US, this subject has been studied in some detail: Hanushek (1992), Kuo and Hauser (1997) Kessler (1991) and Behrman and Taubman (1986) study the effects of family size and birth order; Powell and Steelman (1990 and 1993) examine the effects of sibling spacing; and Butcher and Case (1994), Kaestner (1996), Hauser and Kuo (1998) and Powell and Steelman (1989) investigate the effect of the sex composition of siblings. In Britain, certain areas have been extensively researched: it is clear from numerous studies[1] that children from larger families do worse in terms of educational outcomes than children from smaller families; however, the relationship between birth order and educational outcomes is less clear; and no study to date in the UK has attempted a comprehensive analysis of the effects of family structure which properly separates out the effects of sibship size and birth order.

There are good reasons why this issue should be studied using British data, rather than assuming that findings from other countries will apply in the UK. The effects of sibship structure may vary a great deal between countries: for example, higher education has been accessible in Britain at much lower cost to the family than in the US; thus, theory would predict that in terms of access to university education, children from large families would be at less of a disadvantage in Britain than in the US.

1 See, for example, Ermisch and Francesconi (2000); Dearden (1998); Robertson and Symons (1996), Prosser, (1977).

Of course, there are fundamental difficulties in attempting to estimate the effects of many aspects of sibship structure on children's outcomes. Family size is linked so strongly with socio-economic background that it is difficult if not impossible to completely disentangle the effects of family size from other variables. However, this does not mean that research in this area is not important or potentially fruitful. As Blake (1981) argues, most of the factors which influence children's success (parents' social class, parents' education and so on) are in large part fixed once parents have started their families; completed family size, on the other hand, is a variable which (in theory at least) may have a large effect on children's attainment, and which may still be influenced by social policy at a relatively late stage in parents' lives. Therefore, although our best estimates of the effects of family size on children's attainment may not be perfectly 'clean', they are nevertheless interesting from the perspective of social policy.

In the attempt to obtain estimates of the effect of family size uncontaminated by the effects of parental characteristics, one approach is to use exogenous fertility events such as the birth of twins, unplanned pregnancy, or secondary infertility. The NCDS data does not permit this approach, since it contains no suitable identifying information; however, the data set is ideally suited to an alternative approach, similar to the 'matching' approach described by Blundell et al (1997), where the effects of parental background may be to a certain extent 'washed out' by controlling for as wide as possible a range of background characteristics.

This paper also investigates the relationship between birth order and children's outcomes separately from the effect of family size; and examines whether these effects vary over a child's educational career, as has been suggested by Zajonc et al. (1979). This is possible thanks to the longitudinal nature of the NCDS, which provides details of children's test scores in mathematics and reading at ages 7, 11 and 16, as well as summative measures of educational attainment at ages 16 and 23.

Research on the effect of sibship size and position has been based on a theory of the allocation of parental resources, as presented in Becker (1981), Becker and Tomes (1976), Becker and Lewis (1973) and Leibowitz (1974). Under this model, parents' decisions about the level of resources they allocate to their children arise from the maximization of a household utility function, in which parents care about the future incomes (or utility) of their offspring; inherent in these models is a trade-off between the number of children and the average 'quality' of children in a family. This paper follows Hanushek (1992) in embedding this model within a more general model of educational attainment. Hanushek specifies an educational production function where children's attainments depend on inputs from parents, the school and other exogenous factors; this paper extends this by allowing inputs from *other* children to enter the educational production function. Several researchers in the field of psychology and child development (Blake 1981; Claudy et al. 1979; Falbo 1977 and 1978; Zajonc et al. 1979) have argued that inputs from siblings play an important part in children's cognitive development, but this idea has not so far been incorporated into education production functions in the economics literature. In this paper, the hypothesis that inputs from siblings affect children's development is supported by the finding that 'only' children who have regular contact with children outside their families are at less of a disadvantage educationally than 'only' children who do not.

Throughout the paper, the terms 'family size' 'sibship' and 'sibship size' are used more or less interchangeably, and refer to the total number of children in the study child's family, including the study child herself. The terms 'sibship structure' and 'family structure' refer to the combination of sibship size and the child's position in the birth order.

2 CONCEPTUALISING THE EFFECTS OF SIBLINGS

The relationship between sibship structure and educational attainment has been differently modelled in different areas of the social science literature. All models are able to explain the stylized facts that children's attainment declines as the number of siblings increases, and the (not undisputed) fact that later-born children perform less well than their earlier-born siblings.

The 'confluence' model, developed in the psychological literature by Zajonc and Markus (1975), Zajonc, Markus and Markus (1979) and Zajonc and Mulally (1997), conceptualizes the family's 'intellectual environment' as a weighted average of the mental ages of all members of the family. Thus, the model predicts that the larger the number of children, the lower the average mental age of the family, and the poorer the intellectual development of the children. The model also predicts that closely-spaced children suffer relative to more widely-spaced children; additionally, Zajonc et al (1979) hypothesize that children benefit from having a younger sibling to teach, so youngest and 'only' children are disadvantaged by having no younger sibling.

The 'resource dilution' model used in the sociological literature (van Ejick and de Graaf 1995; Powell and Steelman 1990) argues that children's attainments depend on inputs of time and money from their parents: the more children there are in the family, the less of both inputs there are for each child, and children's development suffers accordingly. As well as predicting that children from large families will do worse than those from smaller families, it also predicts that closely-spaced children will do worse than more widely-spaced children; and that younger children (who have never had their parents to themselves) will do less well than their older siblings (who have had their parents to themselves for at least some of their lives). However, the youngest siblings in large families (who have their parents to themselves again in their teenage years after older siblings have left home; and who may benefit from the improved financial position of the family in the presence of resource constraints) may do better than middle siblings, and possibly even better than first-born siblings, in large families.

The models of the parental allocation of time used by economists (Becker 1981; Behrman, Pollak and Taubman 1982; Becker and Tomes 1986) are based on the same idea as the 'resource dilution' model – that there is less to 'go round' in a large family - but they are embedded within a more formal framework, in which parents care about the number and 'quality' (measured as future income, utility or educational attainment) of their children, and make decisions about their investments into their children via a process of utility maximization within the family. Inherent in these models is a trade-off between the quantity and 'quality' of children: the more children parents have, the lower their average 'quality' will be.

The 'quantity/quality' relationship will be mediated by the way in which child quality enters into the parental utility function. Becker and Tomes (1976) and Behrman, Pollak and Taubman (1982) refer to three possible maximization strategies. Under *nondiscriminatory* time allocation, parents allocate the same amount of time to each child regardless of that child's productivity. As the number of children increases, the amount of resources parents expend on each child will fall – and this amount will not depend on the characteristics of the child or its siblings. If (as Becker and Tomes conclude is most likely) parents pursue an *achievement maximization* strategy, they will concentrate their resources on the most productive child. Under this strategy, an additional child in the family will mean all children will receive less resources, but the addition of a more able sibling will have more deleterious effects. Finally, parents may prefer their offspring to have equal outcomes, in which case they will pursue *compensatory resource allocation*. In this case, more resources go to those children whose productivity is lowest – again, the addition of any sibling will reduce inputs, but this time the addition of a less able sibling will have more deleterious effects.

These different strategies have implications for the allocation of resources between more and less able siblings, but also for the allocation of resources between male and female children in the family, since male children may be thought of as more ‘productive’ in terms of the wages they will later command.

The effects of these resource allocation strategies also depend on how far the family’s liquidity is constrained. In the absence of borrowing constraints, parents will invest in children until the rate of return to their investment is equal to the rate of interest. Where there are borrowing constraints, even if parents prefer to equalize outcomes between their children, they will invest more in their more able children. Additionally, in the presence of borrowing constraints, youngest children in a family may benefit, since their parents may be better-off during the time when they are in need of financial resources (Kessler, 1991, Oppenheimer 1974). Parents’ capacity to borrow may also affect the amount of time their children are given: parents have only a limited amount of time to give their children, but they may buy inputs of time from other adults. In the absence of borrowing constraints, they will be able to buy most time when it is needed most – when the largest number of children are competing for resources. Thus, birth order effects may be less obvious in families with fewer borrowing constraints.

Finally, the *way* in which parents give time to their children matters. Hill and Stafford (1974) refer to the concept of ‘public’ and ‘private’ time. Some parent-child interactions, such as helping with homework, may be considered as ‘private’ time in that they benefit one child and have no spill-over effect to other siblings. Other interactions (such as activities *en famille*, or the transmission of ethics and values) may be considered as ‘public’ time, in that they benefit all siblings equally and the addition of another child does not decrease the benefits accruing to each child. As additional siblings are born, parents may choose to substitute public time for private time, which may mitigate the loss of parental inputs felt by children as new siblings are added to the family.

3 EMPIRICAL FRAMEWORK FOR ESTIMATION

Along the lines proposed by Hanushek (1992) an education production function is estimated of the form

$$\boldsymbol{A}_{it} = \Phi(\boldsymbol{F}_{it}, \boldsymbol{S}_{it}, \boldsymbol{X}_{it})$$

where $\boldsymbol{A}$ denotes the attainment of student i at time t; $\boldsymbol{F}$ is a vector of inputs from the family; $\boldsymbol{S}$ denotes inputs from schools; and $\boldsymbol{X}$ denotes other exogenous inputs. In Hanushek (1992) and in the first part of this paper, the inputs in $\boldsymbol{F}$ come from the child's parents rather than his or her siblings, but in Section 5.3 $\boldsymbol{F}$ is re-defined to include inputs from other children.

In the model above, $\boldsymbol{F}$, $\boldsymbol{S}$ and $\boldsymbol{X}$ refer to cumulative inputs over the life of the child. Hanushek mainly uses a value-added specification, of the form

$$\boldsymbol{A}_{it} = \boldsymbol{\varphi}(\boldsymbol{F}_{i(t-t^*)}, \boldsymbol{S}_{i(t-t^*)}, \boldsymbol{X}_{i(t-t^*)}, \boldsymbol{A}_{it^*})$$

on the grounds that in this specification, it is only necessary to include inputs in the time between t^* and t on the right hand side of the equation, rather than the entire past history of inputs. However, in this paper the first specification is used, since a large amount of data over the life of the child is available; and since the points of observation are such that many children do not experience any change in their number of siblings between t^* and t.

How should family composition enter the function? Many studies have used specifications which (a) restrict the effects of family size and birth order to be linear;

and (b) which confound the effects of family size and birth order. Both of these are potentially serious deficiencies.

Economic theory predicts that the effect of family size is likely to be non-linear, since with the birth of a new sibling, a child who already has several siblings will lose less in the way of inputs than a child with fewer siblings to start with. How this impacts on attainment will depend on the shape of the education production function; but there is no reason to suspect *a priori* that the relationship between family size and attainment will be linear. Additionally, according to the arguments put forward by Zajonc (1979) and others, a non-linearity may be expected between family sizes of one and two. As discussed in Section 2, theory also predicts that the relationship between birth order and outcomes may be non-linear. Therefore, it is crucial that any specification should allow for non-linear effects of family size and birth order.

The problem of confounding birth order and family size is discussed by Kessler (1991), who criticizes the use of specifications which do not allow these two effects to be separately estimated. For example, if birth order is specified using a variable taking the value 1 for a first-born, 2 for a second-born and so on, then a birth order of (say) five can only occur in a family of five or more; the effects of family size and birth order are clearly conflated and impossible to separate, even if family size is separately controlled for. This is also the case where researchers have attempted to control for birth order by including variables for the number of older siblings and the number of younger siblings.

The following strategy is therefore adopted. Children living in families with nine or more children (around 1% of the sample) are excluded from the analysis. Dummy variables (n=2, n=3, etc) are included to pick up the effects of living in a family of two to eight children, with the only child as the omitted reference category.

The measure of sibship size used is the number of siblings present when the study child was aged seven. Siblings born after this age are entered into regressions separately, since being further from the study child in age, they may have a different effect on his or her performance than siblings who were in the household (and competing for resources) when he or she was younger. For outcome measures at age 16 or over, new siblings born when the child was aged between 7 and 11, and those born between ages 11 and 16, were entered separately: however, the two variables yielded virtually identical coefficients, so they were replaced by a single variable indicating the number of new siblings born between age 7 and 16.

To pick up the effects of birth order, the following set of dummy variables is used:

- Younger of 2 children
- Middle of 3 children
- Youngest of 3 children
- Middle of 4 children
- Youngest of 4 children
- Middle of 5 children
- Youngest of 5 children
- Middle of 6 or more children
- Youngest of 6 or more children

These variables pick up the effect of being a middle or youngest child in a family of a given size, relative to being the eldest child in the same size family. A more parsimonious specification is not possible without confounding the effects of family size and birth order. Even the not particularly parsimonious specification used here confounds family size and birth order for sibships of six and over, since families of eight children have proportionately more middle children and fewer youngest children, than families of six children. Therefore, the estimated effect of being a middle child in a family of six or more children will be biased downwards, and the effect of being a youngest child will be biased upwards. For smaller families, however, the effects of family size and birth order are properly separated.

In terms of outcome measures, this paper takes advantage of the fact that data on NCDS children was collected at several points in their lives. In all, ten measures of educational outcomes are used: test scores in reading and mathematics at ages 7, 11 and 16; measures of the child's highest attainment level in public examinations ('O' levels) in English and Mathematics at age 16; the total number of 'O' levels passed at age 16; and a measure of the highest qualification achieved by age 23.

Using several different measures of outcome, it is possible (a) to assess whether one's findings are reasonably consistent and robust, (b) to investigate whether the effects of family size vary over the child's life, and (c) to investigate whether sibship structure has different effects on different aspects of a child's development.

All outcome measures have been standardised to have a mean of zero and a standard deviation of one, so that the coefficients in OLS regressions all have the same interpretation (namely, the change in outcome associated with a one-unit change in the input concerned, measured in units of one standard deviation). For some outcome measures, an alternative to OLS is preferable (for example, the high proportion of students with no 'O' level passes means that Tobit is preferable to OLS when estimating the determinants of success in these exams; an ordered probit or logit would be preferable when estimating the determinants of the highest qualification at age 23, since this is an ordinal measure ranging from 1 (no qualifications) to 7 (degree-level qualifications). Tobit estimates may easily be compared with OLS estimates; however, this is not the case with estimates from an ordered logit or probit regression, and therefore OLS has been used on a normalized 'highest qualification' variable, with some sacrifice of econometric purity. Summary statistics for all the outcome measures, plus graphs of their distributions, are given in the Appendix. Additionally, the Appendix gives estimates of the effects of family size and birth order on the probability of children gaining ‘O’ level passes in English and Mathematics, and gaining a degree, i.e. of regressions on a non-standardised dependent variable.

Three specifications are estimated. In the first specification, only sibship variables and gender are included: this specification gives reduced form estimates of the relationship between family structure and outcomes. The second specification includes a set of ‘standard’ controls commonly considered to be the most important features of family background: parents’ age, education and social class at the child’s birth. A series of variables is also included indicating whether the child was born into a non-intact family, or whether the family split up between birth and 7, 7 and 11, or 11 and 16. The third specification includes controls for a wide range of background characteristics, including measures of parents’ human capital, financial resources, and inputs given to the child from parents and school. This specification attempts to come as close as possible to estimating the effect of family size net of the effects of family background. Descriptions of the variables included in this specification are given in the Appendix.

4 DATA: THE NCDS.

This paper uses data from the National Child Development Study (NCDS). This is a longitudinal study which takes as its subjects all children born in the week of 3rd - 9th March 1958. It was originally conceived as a one-off perinatal mortality study, and the first wave of data, collected shortly after the subjects' birth, contains detailed medical and socioeconomic histories of their families.

TABLE 1:
INFORMATION AND SAMPLE SIZES FOR WAVES 0-3 OF NCDS

	Age	Number of Observations	Areas covered
Perinatal Mortality Survey	Birth	18553	Maternal health, parental characteristics, perinatal medical details
1st Follow-up (wave 1)	7	14395	Parental characteristics School characteristics Medical examination Test scores
2nd follow-up (wave 2)	11	13654	Parental characteristics School characteristics Medical examination Test scores
3rd follow-up (wave 3)	16	11502	Parental characteristics School characteristics Medical examination Test scores Individual interview
4th follow-up (wave 4)	23	12230	Employment history Fertility history Educational attainment Housing and health
5th follow-up (wave 5)	33	9512	Employment history Fertility history Educational attainment Housing and health

Note: Sample sizes given refer to the number of individuals with non-missing data on number of siblings and at least one non-missing outcome variable for that wave.

Five follow-up studies were carried out when the cohort was aged 7, 11, 16, 23 and 33. The studies at ages 7, 11 and 16 contain information on educational attainment, schooling, health, and family circumstances. Those at ages 23 and 33 give a detailed account of the subjects' health, labour market behaviour and family situation since age 16.

The NCDS is ideal for investigating the relationship between family structure and educational outcomes. Firstly, the data set is relatively large; secondly, because it is a longitudinal study, one is able to observe the effect of family structure at several different points in time; thirdly, the data set is unusually rich in both family background variables and measures of children's attainment. Finally, the children in the NCDS are all the same age, to within a week of each other. This eliminates the possibility of estimates being contaminated by cohort effects[2].

A word is in order here about the definition of sibship variables in the NCDS. Waves 1 and 2 (collected when the study children were aged 7 and 11) asked for data on the number of children under age 21 living in the household, rather than data on the study child's actual number of siblings. By contrast, Wave 3 (collected at age 16) asked about the numbers of older and younger brothers and sisters born to the same mother as the study child, not necessarily still living in the same house. This means that older sibs who have left home are not counted at Waves 1 and 2, but are counted at Wave 3. In the data used for analysis, older siblings reported at Wave 3 but not at Waves 1 or 2 were 'added back' into the measure of sibship, therefore constructing a variable indicating the study child's total number of siblings rather than just those living at home. The data was additionally manipulated to impute family composition variables where data was

[2] For example, if family size has been falling and educational standards have been rising over time, using a sample where individuals are of different ages could exaggerate the estimated relationship between small families and higher attainment. Estimates of the effect of birth order are also subject to contamination by cohort effects if the sample consists of full or partial sibships, since older siblings will come disproportionately from older cohorts, and younger siblings from younger cohorts.

missing in one wave but available in others[3]. Where data has been imputed or adjusted, checks have been made to ensure that this has not altered the results reported. Table 2 and Table 3 give some background information on the sibship structures of the NCDS study children.

Table 2 shows that at Wave 1, 9% were only children, 35% were in families with two children, 26% were in families with three children, and the rest were in larger families. Between Waves 1 and Waves 3, the proportion of only children fell slightly, and the proportion of children in sibships of four or more rose slightly, reflecting the continuing birth of younger siblings.

TABLE 2: NUMBER OF SIBLINGS

No. of children in family (including study child)	Wave 1 (age 7)		Wave 2 (age 11)		Wave 3 (age 16)	
1	1291	(8.88)	1049	(7.62)	750	(6.54)
2	5019	(34.54)	4162	(30.23)	3283	(28.64)
3	3770	(25.94)	3464	(25.16)	2873	(25.06)
4	2184	(15.03)	2299	(16.70)	1994	(17.40)
5	1023	(7.04)	1235	(8.97)	1132	(9.88)
6	567	(3.90)	700	(5.08)	636	(5.55)
7	306	(2.11)	379	(2.75)	350	(3.05)
8	168	(1.16)	226	(1.64)	200	(1.74)
9	105	(0.72)	161	(1.17)	119	(1.04)
10 or more	100	(0.69%)	94	(0.68%)	126	(1.10%)
Total	14533		13769		11463	

Table 3 shows that at Wave 1, 38% of children were eldest or only children, while 31% were 'middle' children and 31% were the youngest in their family. Again, these

3 These imputations are not quite precise. For example, if Wave 2 data are used to fill in missing data at Wave 1, the child will be coded as having more siblings than he or she really had at Wave 1 if one of them is more than seven years younger than the study child. However, in 70% of cases where data is available for all waves, the number of reported siblings does not change between waves in 70% of cases; therefore, the imputation procedure is likely to be reasonably reliable.

proportions change slightly in later waves, reflecting the birth of younger siblings, with the proportion of only and eldest children remaining unchanged, the proportion of middle children rising slightly, and the proportion of youngest children falling slightly.

TABLE 3: POSITION IN THE FAMILY

Study child's position in family	Wave 1 (age 7)		Wave 2 (age 11)		Wave 3 (age 16)	
Eldest (or only)	5520	(38.0%)	5200	(37.8%)	4454	(38.9%)
Middle	4430	(30.5%)	4759	(34.6%)	3925	(34.2%)
Youngest	4583	(31.4%)	3810	(27.7%)	3084	(26.9%)
Total	14533		13769		11463	

5 RESULTS

5.1 Sibship size

The relationship between sibship structure and educational outcomes is dominated by family size. Full estimates of the relationship between family size and outcomes are shown in the Appendix; in this section, the results are shown graphically in Figures 1 and 2 and in processed and abbreviated form in Table 4. At this stage, the estimates have been obtained using only sibship size variables (rather than sibship size plus birth order variables) on the right hand side of the equation. This enables an understanding of the relationship between sibship size and outcomes uncomplicated by the effects of birth order, which will be examined in the following Section.

Figure 1 shows the relationship between sibship size and test scores at 7, 11 and 16, while Figure 2 shows the relationship between sibship size and 'real' educational outcomes: grades in Mathematics and English attained at 'O' level or equivalent; the number of 'O' levels or equivalent passed; and educational attainment at age 23. In each Figure, the left-hand panel shows the 'raw' relationship between family size and outcomes; the middle panel shows how outcomes vary with family size after the addition of 'standard' controls; and the right-hand panel shows how outcomes vary with family size after the much larger set of controls has been added. In each case, the dependent variable has been normalized, so the units of measurement on the vertical axis are standard deviations of the outcome measure in question.

FIGURE 1: THE RELATIONSHIP BETWEEN SIBSHIP SIZE AND TEST SCORES

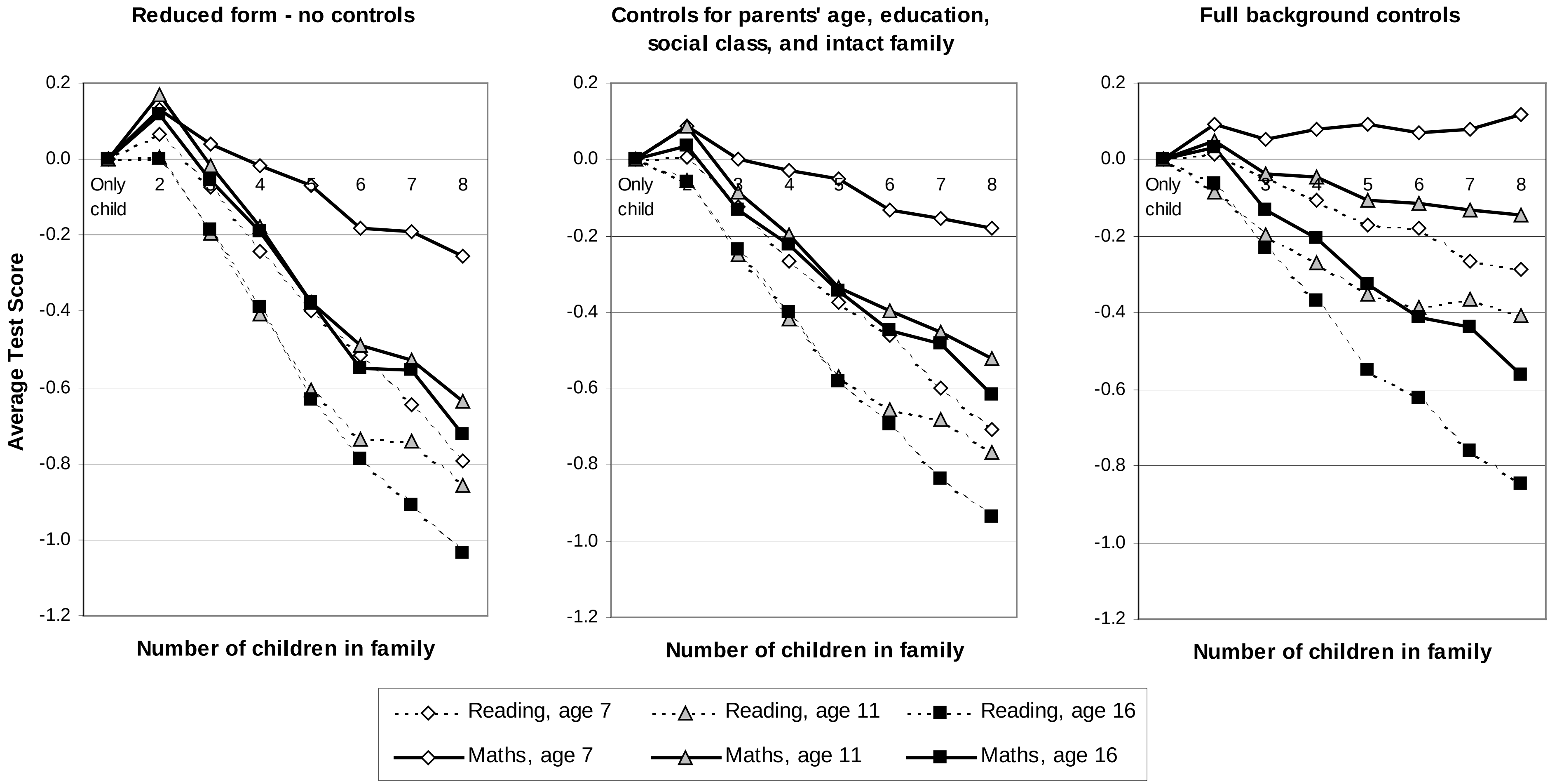

FIGURE 2: THE RELATIONSHIP BETWEEN SIBSHIP SIZE AND EDUCATIONAL ATTAINMENT

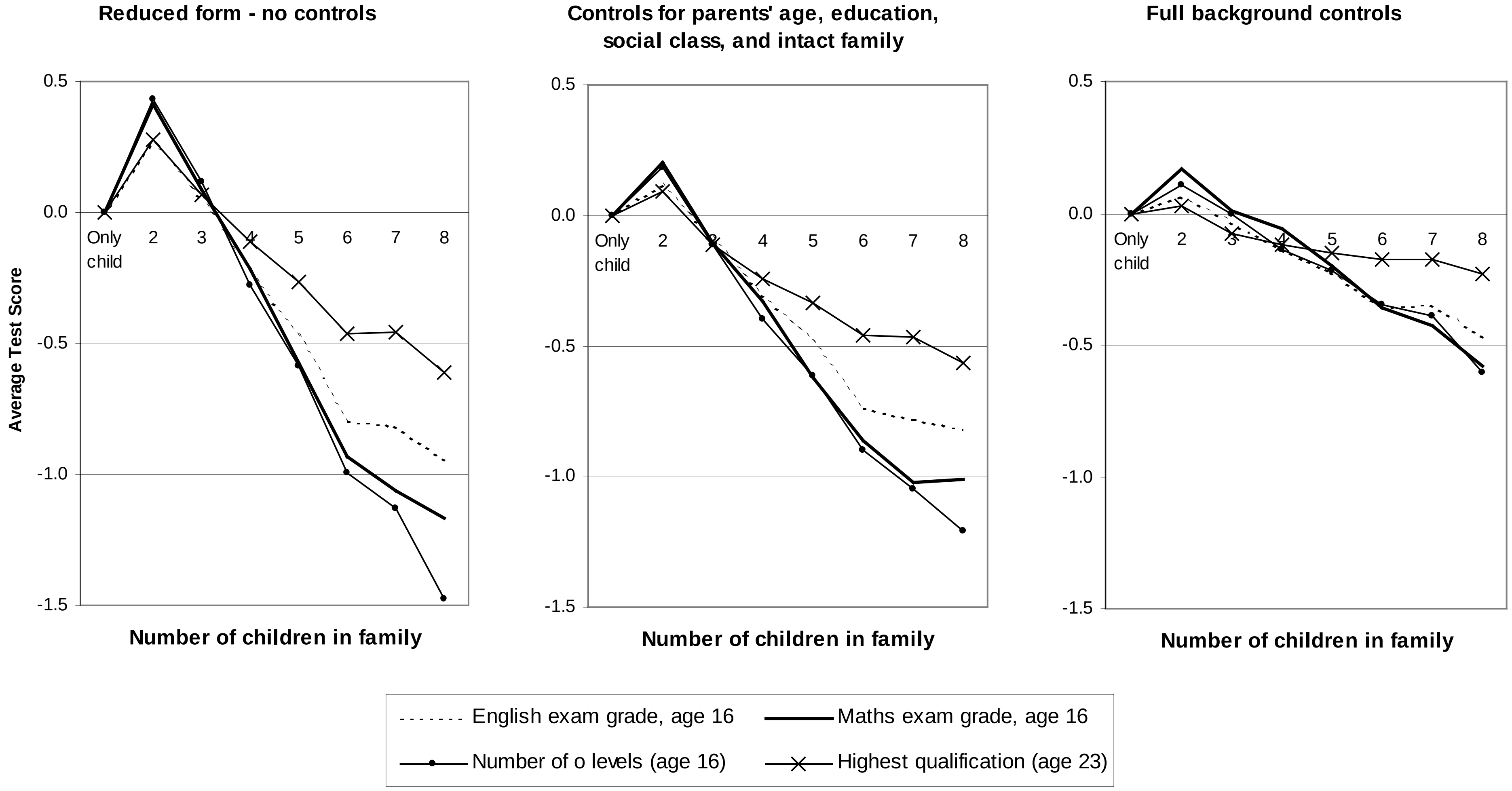

Table 4: Sibship Size and Outcomes

		Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English 'O' level result	Maths 'O' level result	Number of 'O' levels	Highest qualifica -tion (23)
(A)	Sibship 2 does better than only child	**6.7**	**13.3**	0.5	**16.8**	0.3	**12.0**	*7.1*	**22.3**	**17.0**	**7.8**
No additional controls	Ave. reduction with each extra sib (2-8)	14.3	6.4	14.4	13.3	17.2	14.0	19.0	26.0	31.1	14.6
	Reduction with each sib born after age 7	-	-	**13.7**	**10.6**	**12.3**	**8.9**	**15.5**	**18.1**	**24.1**	**11.7**
	Convex function?					×		×	×	×	
(B)	Sibship 2 does better than only child	0.6	**8.6**	*-5.5*	**9.0**	*-5.6*	3.7	-2.5	*9.1*	2.1	-0.7
Standard controls	Ave. reduction with each extra sib (2-8)	11.8	4.4	11.8	10.2	14.6	10.8	14.8	20.2	23.2	10.8
	Reduction with each sib born after age 7	-	-	**8.4**	**6.0**	**8.7**	**4.4**	**9.6**	**10.1**	**14.3**	**6.9**
	Convex function?	×	×			×			×	×	
(C)	Sibship 2 does better than only child	1.4	**9.1**	**-8.4**	**5.1**	**-7.3**	1.6	-2.5	*7.6*	3.0	0.4
Extended controls	Ave. reduction with each extra sib (2-8)	5.0	-0.4	5.3	3.2	8.7	5.4	7.3	10.7	10.6	3.9
	Reduction with each sib born after age 7	-	-	**4.1**	1.2	**4.9**	-0.5	2.5	0.4	1.0	1.8
	Convex function?	×	×			×	×	×	×	×	×

Notes:

Figures in this table are derived from the estimates in Table A2 in the Appendix.

Figures are based on coefficients from OLS regressions except in the case of 'O' level results, where they are based on Tobit regressions.

Figures are in percentages of one standard deviation (eg, in reading scores at age 7, a child in a sibship of 2 does better than an only child by 6.7 per cent of a standard deviation).

In the first 4 rows in each section, figures in bold type indicate differences significant at the 5% level or better; figures in italics indicate differences significant at the 10% level but not the 5% level.

Looking first at the ‘raw’ relationships, the results are quite consistent, and highlight three general features of the relationship between sibship size and outcomes. Firstly, on each measure of outcomes, only children do worse than those with one sibling (though the difference is not significant in every case). Table 4 shows that the penalty associated with being an only child rather than one of two, ranges from less than 1% of a standard deviation (reading scores at 11 and 16) to 22% of a standard deviation (mathematics ‘O’ level results). Second, in sibships of two and above, outcomes decline steadily with family size. Table 4 shows that for sibships between two and eight, the average reduction in outcomes associated with each additional sibling is between 13% of a standard deviation (maths at age 11) and 31% of a standard deviation (number of ‘O’ levels), except for the mathematics test administered at age 7, where results are much less closely linked to family size, and where the average reduction in outcome with each extra sibling is only 6% of a standard deviation. Third, the decrease in outcomes between sibships of 2 and 6 appears to be more or less linear – it appears that some of the curves flatten off after sibships of six, but this certainly does not apply in all cases.

When standard controls for parents’ age, education, social class and intact family are added, the relationships between sibship size and outcomes remain qualitatively similar, with two major differences. Firstly, the penalty associated with being an only child is smaller. Secondly, the decline in outcomes with family size becomes slightly shallower: controlling for basic family characteristics, each additional sibling is associated with an average reduction in scores of between 10% and 23% of a standard deviation, except for mathematics test at age 7, when it is again associated with a smaller reduction of only 4% of a standard deviation.

As expected, when a comprehensive set of controls for the family’s circumstances and inputs to the child are included, the relationship between family size and outcomes becomes still less pronounced; however, it does not disappear completely by any means. Adding this set of controls appears to completely eliminate the relationship between family size and test scores in mathematics at age seven; however, all other test scores, as well as the ‘real’ outcome measures, retain their association with family size, with an average penalty associated with each additional sibling (in sibships of 2-8) of between 3% and 11% of a standard deviation. Even with this large set of background controls, a significant penalty associated with being an only child remains for some measures of mathematical attainment. This feature of the performance of only children is discussed in more detail in Section 5.3.

Table 4 also shows how outcomes vary with the number of siblings born after the study child was aged seven. In all cases, the reduction in attainment associated with each such sibling is smaller than the average reduction associated with earlier-born siblings. While not constituting a full investigation into the effects of sibship density, this finding confirms the findings of Powell and Steelman (1990 and 1993), that closely-spaced siblings are associated with more negative effects than widely-spaced sibs.

The final row in each section of Table 4 tests whether the slight convexity which is discernible in some of the graphs is statistically significant – in other words, whether the reduction in outcomes associated with an extra sibling is lower for larger families. The test used is an F-test of whether *any* segment in the graph has, at the 5% level or better, a significantly flatter slope than *any* of the segments to its left. Even on this extremely undemanding test, there is no significant convexity in more than half the graphs, indicating that the reduction in outcomes associated with an extra sibling does not vary with family size. This finding is not due to a lack of adequate controls in regressions, since there is least evidence of convexity when the largest set of controls has been used. Although theory does not predict unequivocally that an extra child would reduce performance less in an already-large family (since the effect would depend on the shape of the education production function), it would seem intuitively that this would be the case, since in an already-large family, fewer inputs have to be taken away from each existing child to be given to the newcomer. Additionally, other researchers have found convex rather than uniform effects: Hanushek (1992) finds that the effects of an extra sibling decline with family size, while Van Eijck and de Graaf (1995) find virtually no relationship between sibship size and outcomes in sibships of five and above.

5.2 Birth order

As before, regressions are estimated for 10 outcome variables: not only is this useful for validation purposes, but it also provides a means of following the effect of birth order over childhood and early adulthood. Zajonc et al. (1979) claim that the effects of birth order do vary with age: when children are young, later-born children out-perform earlier-born children, but this is reversed in the early teens, when earlier-born children begin to perform better than their younger siblings; this difference then persists until adulthood. In all regressions, position in the family is measured at the same time the outcome measure is obtained, except for highest qualification at age 23, in which case the respondent's position in the family at age 16 is used.

Results are shown numerically in Table 5 and graphically in Figure 3. The coefficients refer to the difference in performance of middle and youngest children relative to eldest children in a family of the same size; effects are measured in units of a standard error.

Before discussing the results in detail, it is worth pointing out that among the outcome measures there is a very noticeable outlier: middle and youngest children do worse than firstborns on nearly all measures, but they do better on the mathematics test administered at age 7. To an extent this is consistent with the findings of Zajonc et al (1979), who find that when performance is measured at a young age (such as 7), later-born siblings perform better than earlier-born siblings, but that earlier-born children begin to pull ahead after the early teens. However, the fact that later-born siblings do *not* do better in *reading* scores at age 7 means that some other explanation should be sought. One explanation (as the author has pointed out elsewhere) is that there may be problems with the mathematics test itself – the fact that the mathematics score at age 7 does not predict later mathematical attainment particularly well means that it may not be a particularly good measure of mathematical ability. Another explanation is that literacy and numeracy skills are acquired in different ways, and that family structure impacts differently on progress in the two areas. This idea will be revisited towards the end of the paper; the discussion which follows focuses on the other outcome measures.

From Table 5 and Figure 3, it is clear that apart from the one exception just discussed, middle and youngest children tend to perform consistently less well than eldest children. Younger children in sibships of two perform less well than elder children by between 1 per cent and 10 per cent of a standard deviation, with this difference significant at the 5% level in 6 of the 10 measures. The addition of controls for parents' age, education, social class and presence of a father yields larger and more significant coefficients, since certain parental characteristics which are linked with positive outcomes are also linked with being lower down the birth order. Parents are on average older at the birth of their younger children, and the (job-defined) social class of the father may be higher at the time of birth of a younger child than at the time of birth of an eldest child. With the addition of these controls, the younger sibling performs less well by between 4 per cent and 16 per cent of a standard deviation, significant at the 5% level on 8 out of 10 measures of attainment.

TABLE 5(A)
BIRTH ORDER EFFECTS (NO ADDITIONAL CONTROLS IN REGRESSIONS)

	Younger of two	Middle of three	Youngest of three	Middle of four	Youngest of four	Middle of five	Youngest of five	Middle of six or more	Youngest of six or more
Reading (7)	-0.0642	-0.0464	-0.0951	-0.0472	-0.0846	0.1999	0.1696	-0.0138	-0.0490
	(-2.34)	(-1.20)	(-2.40)	(-0.87)	(-1.32)	(2.02)	(1.45)	(-0.08)	(-0.27)
Maths (7)	0.0352	0.0821	0.0446	0.0841	0.07901	0.0954	0.1266	0.3569	0.3687
	(1.24)	(2.06)	(1.09)	(1.50)	(1.20)	(0.93)	(1.05)	(2.04)	(1.97)
Reading (11)	-0.0195	-0.1154	-0.0018	-0.0726	-0.1043	-0.0728	0.0170	0.0613	0.1338
	(-0.67)	(-3.32)	(-0.05)	(-1.86)	(-1.78)	(-1.39)	(0.18)	(0.87)	(1.23)
Maths (11)	-0.0120	-0.0549	-0.0455	-0.0619	-0.1536	-0.0808	-0.0844	0.0618	0.0684
	(-0.41)	(-1.56)	(-1.14)	(-1.57)	(-2.59)	(-1.52)	(-0.90)	(0.87)	(0.62)
Reading (16)	-0.0749	-0.1347	-0.0387	-0.0541	-0.0474	-0.0342	0.1197	-0.0250	0.1434
	(-2.50)	(-3.78)	(-0.98)	(-1.39)	(-0.83)	(-0.67)	(1.40)	(-0.39)	(1.44)
Maths (16)	-0.0622	-0.0575	-0.0385	-0.0677	-0.1759	-0.1050	-0.0622	-0.0100	0.0342
	(-2.00)	(-1.55)	(-0.94)	(-1.68)	(-2.96)	(-1.98)	(-0.70)	(-0.15)	(0.33)
English Exam (16)	-0.0799	-0.0374	-0.1092	-0.1140	-0.2261	-0.1693	-0.2853	-0.0796	-0.1029
	(-2.05)	(-0.79)	(-2.08)	(-2.15)	(-2.96)	(-2.45)	(-2.39)	(-0.89)	(-0.71)
Maths Exam (16)	-0.0595	-0.0245	-0.1027	-0.0738	-0.3257	-0.1925	-0.4052	0.0223	0.0150
	(-1.10)	(-0.37)	(-1.39)	(-0.98)	(-2.97)	(-1.94)	(-2.32)	(0.17)	(0.07)
Number of O levels (16+)	-0.0969	-0.1341	-0.1709	-0.0496	-0.2564	-0.1624	-0.1308	-0.0193	0.1051
	(-1.95)	(-2.19)	(-2.54)	(-0.72)	(-2.56)	(-1.76)	(-0.83)	(-0.16)	(0.55)
Highest Qualification (23)	-0.0992	-0.1056	-0.1265	-0.0844	-0.2272	-0.1332	-0.0465	-0.0389	-0.0437
	(-3.31)	(-2.90)	(-3.17)	(-2.12)	(-4.04)	(-2.60)	(-0.54)	(-0.60)	(-0.43)

Notes:

Figures are based on coefficients from OLS regressions except in the case of 'O' level results, where they are based on Tobit regressions.

T-statistics are given in parentheses

Figures are in percentages of one standard deviation and refer to the performance of a youngest or middle child relative to an eldest child in the same-sized sibship. For example, in reading at age 7, the younger child in a sibship of 2 does worse than the elder of 2 children by 6.42% of a standard deviation.

TABLE 5(B)
BIRTH ORDER EFFECTS (REGRESSIONS WITH STANDARD FAMILY BACKGROUND CONTROLS)

	Younger of two	Middle of three	Youngest of three	Middle of four	Youngest of four	Middle of five	Youngest of five	Middle of six or more	Youngest of six or more
Reading (7)	-0.0771	-0.0574	-0.1167	-0.0458	-0.0969	0.1646	0.0782	-0.0973	-0.1823
	(-2.81)	(-1.52)	(-2.89)	(-0.86)	(-1.52)	(1.71)	(0.68)	(-0.59)	(-1.03)
Maths (7)	0.0336	0.0820	0.0456	0.0975	0.0954	0.0874	0.0897	0.3198	0.3049
	(1.17)	(2.08)	(1.08)	(1.76)	(1.44)	(0.87)	(0.75)	(1.86)	(1.65)
Reading (11)	-0.0751	-0.1666	-0.0904	-0.1127	-0.1848	-0.1252	-0.1536	-0.0116	-0.0310
	(-2.70)	(-5.08)	(-2.36)	(-3.05)	(-3.27)	(-2.53)	(-1.74)	(-0.17)	(-0.30)
Maths (11)	-0.0366	-0.0905	-0.0893	-0.0802	-0.1727	-0.1062	-0.1900	0.0211	-0.0214
	(-1.30)	(-2.72)	(-2.29)	(-2.14)	(-3.02)	(-2.12)	(-2.13)	(0.31)	(-0.20)
Reading (16)	-0.1250	-0.1743	-0.1301	-0.0820	-0.1401	-0.0471	0.0177	-0.0335	0.0052
	(-4.30)	(-5.18)	(-3.33)	(-2.22)	(-2.51)	(-0.97)	(0.22)	(-0.56)	(0.05)
Maths (16)	-0.0978	-0.0911	-0.1120	-0.0775	-0.2164	-0.0933	-0.1139	0.0082	-0.0577
	(-3.31)	(-2.66)	(-2.82)	(-2.07)	(-3.81)	(-1.89)	(-1.36)	(0.13)	(-0.60)
English Exam (16)	-0.1137	-0.0769	-0.1786	-0.1459	-0.2642	-0.1571	-0.3133	-0.0764	-0.2259
	(-3.05)	(-1.73)	(-3.47)	(-2.92)	(-3.58)	(-2.41)	(-2.77)	(-0.91)	(-1.65)
Maths Exam (16)	-0.1093	-0.0880	-0.2153	-0.1222	-0.3900	-0.1666	-0.4337	0.0520	-0.1444
	(-2.10)	(-1.41)	(-2.97)	(-1.72)	(-3.68)	(-1.77)	(-2.62)	(0.43)	(-0.73)
Number of O levels (16+)	-0.1616	-0.2136	-0.3039	-0.1204	-0.3365	-0.1368	-0.1989	0.0097	-0.1016
	(-3.58)	(-3.91)	(-4.83)	(-1.93)	(-3.65)	(-1.64)	(-1.40)	(0.09)	(-0.59)
Highest Qualification	-0.1254	-0.1353	-0.2026	-0.0897	-0.2578	-0.1151	-0.1119	-0.0185	-0.1460
(23)	(-4.51)	(-4.11)	(-5.35)	(-2.48)	(-4.88)	(-2.48)	(-1.42)	(-0.31)	(-1.59)

Notes:

Figures are based on coefficients from OLS regressions except in the case of ‘O’ level results, where they are based on Tobit regressions.

T-statistics are given in parentheses

Figures are in percentages of one standard deviation and refer to the performance of a youngest or middle child relative to an eldest child in the same-sized sibship. For example, in reading at age 7, the younger child in a sibship of 2 does worse than the elder of 2 children by 6.42% of a standard deviation.

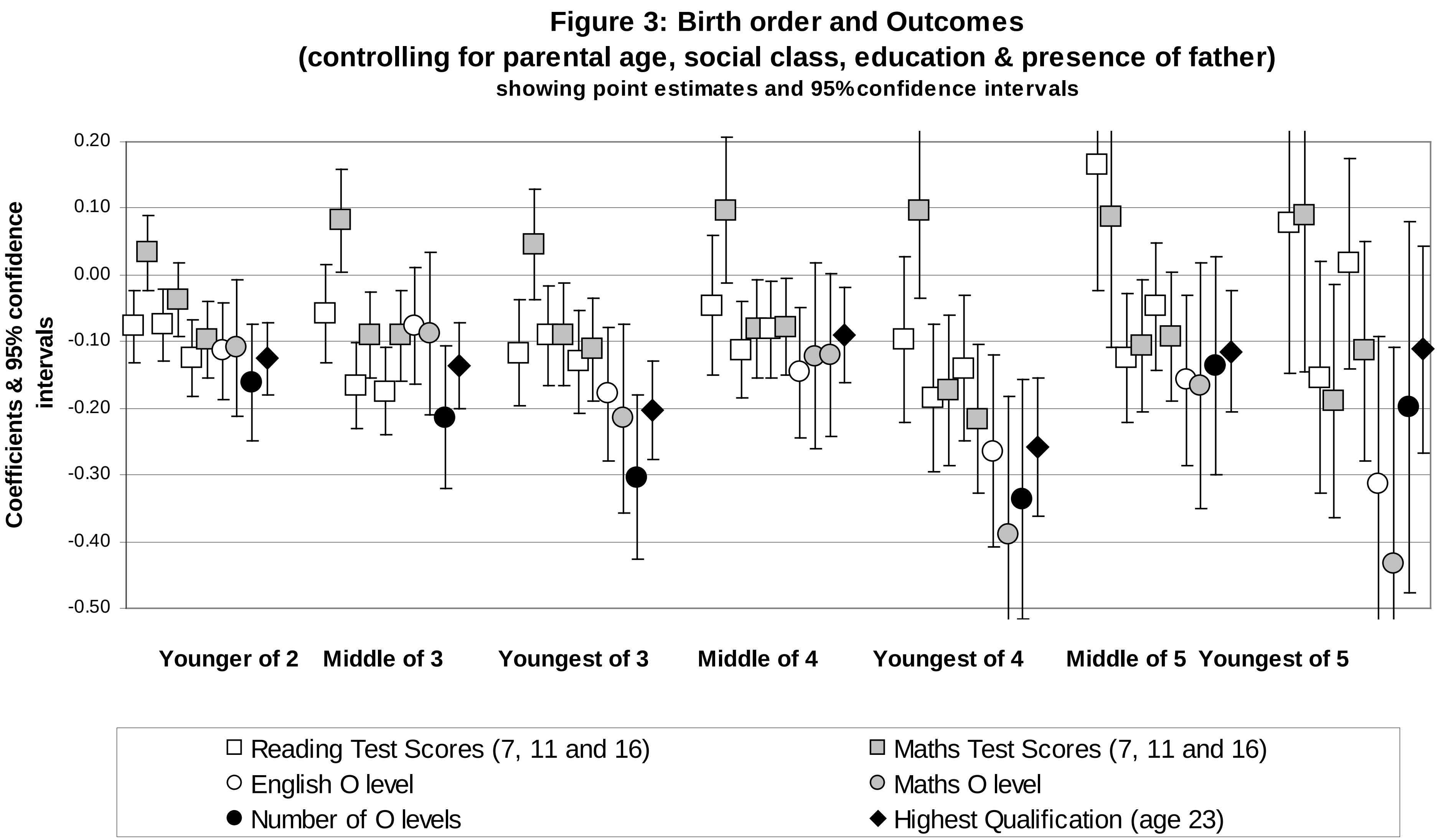
Figure 3: Birth order and Outcomes
(controlling for parental age, social class, education & presence of father)
showing point estimates and 95%confidence intervals
Coefficients & 95% confidence intervals
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Younger of 2
Middle of 3
Youngest of 3
Middle of 4
Youngest of 4
Middle of 5
Youngest of 5
Reading Test Scores (7, 11 and 16)
Maths Test Scores (7, 11 and 16)
English O level
Maths O level
Number of O levels
Highest Qualification (age 23)

In sibships of three, the middle child does worse than the eldest child by between 2 per cent and 13 per cent of a standard deviation, though without controls the effect is significant in only 4 out of 10 regressions; where controls for parental characteristics are added, the effect is significant in 6 out of 10 regressions. The youngest child in a family of three also does worse than the eldest child, by 0.01 to 0.17 standard deviations without controls, and by between 0.09 and 0.30 standard deviations with controls: the coefficients are significant at the 5% level on 4 out of 10 outcome measures without controls, and on 9 out of 10 measures when controls are included.

In sibships of four, middle children do significantly worse than eldest children on 6 out of 10 measures, and worse at the 10% level on another 2 measures; with controls, the youngest of 4 does significantly worse than the eldest in 8 out of 10 measures.

In larger sibships, it is more difficult to see a consistent pattern (although in sibships of five the middle child certainly appears to do less well than the eldest child). Firstly, sample sizes are small, with a corresponding loss in precision of these estimates. Second, as mentioned before, estimates are biased downwards for the middle child and upwards for the youngest child in families of six or more. Thirdly, in large sibships, it is difficult to interpret the meaning of estimated effects at age 7. The effects of being a middle- or youngest-born child are measured relative to being the eldest in the same size family, but any child reported as being the eldest child in a very large sibship at age 7 is also in a very densely spaced sibship – something which may not be the case for a middle- or last-born child in the same sized sibship at age 7. Therefore, it is important not to read too much into the fact that in large sibships, firstborns perform badly compared to later-born children at age 7.

Taken as a whole, these findings suggest that middle and youngest children do worse than older children in all sibships up to five. Significant effects are not found for every single sibship on every single outcome measure, but the fact that in coefficients for middle- and last-born children are nearly always negative, and that they are significant in a clear majority of cases, means that on the balance of evidence, one may conclude that first-born children are at an advantage, performing around 0.1 standard deviations better than their later-born counterparts. There is no evidence at all that that last-born children do better than middle-born children as the theory predicts they might: however, effects have only been estimated fully for sibships up to five, so it is quite possible that this effect may be apparent in larger sibships. If anything, inspection of Figure 3 suggests that last-born children do somewhat *worse* than middle-born children in the same size family, especially at later ages. In sibships of three, last-born children do worse than middle-born children on measures of highest qualification at age 23, and attainment at English and Mathematics O level, though the difference is significant only at the 10% level. In sibships of four, last-born children do worse than middle-born children on measures of qualifications at age 23, the total number of O levels, and performance in Mathematics O level: these differences are all significant at the 5% level or better. Another way of looking at this is that the negative effect of being a middle child is more or less constant throughout the age range, whereas the negative effect of being a youngest child shows an increase between ages 7 an 23.

These findings are not consistent with the findings of other researchers – although it is important to remember that many of these have not controlled for birth order and family size separately. Hanushek (1992) finds that birth order has very little effect in smaller families (up to four children) but a U-shaped effect thereafter: in families of five or more children it is better to be lastborn than firstborn, and worst of all to be in the middle. Van Eijck and de Graaf (1995) find a similar shape for their data for Hungary: attainment falls with birth order in smaller families, but increases after the fourth child for larger families. Kessler (1991) and Hauser and Sewell (1985) find that birth order has very little effect at all.

5.3 Only children

This section returns to a discussion of only children. Section 5.1 generated the unambiguous finding that only children do worse than children in sibships of two, even though theory predicts that they should do better. Although some of the relatively poor performance of only children may be explained by parental characteristics (notably, the absence from the household of the child's biological father), the differences persist even when a wide range of parental and school characteristics are controlled for.

Behrman and Taubman (1986) suggest that the poor performance of only children may arise because parents use the information they gain after the birth of their first child to decide whether or not to have subsequent children. Those who get a 'bad draw' with their first child may decide not to have future children, whereas those who get a 'good' draw would continue to have more children. Hence, only children would tend to have 'worse' characteristics than children in larger families. However, there are two reasons why this may not be a good explanation. Firstly, many parents have their second child before the ability of their first child has become fully apparent. Certainly, some problems linked with extremely low attainment may be apparent before a child's second or third birthday, but there is absolutely no evidence in this sample that the poor performance of only children is linked with a clustering of very low test scores among children with no siblings. Secondly, one would need to explain why this 'learning' process does not happen for larger sibships – if parents learn from a draw of one, why would they not continue to learn from a draw of two, proceeding to have more children if their first two draws were 'good', and stopping if they had two 'bad' draws?

Zajonc et al (1979) tabulate the results of six large studies of IQ, all in different countries, noting that in each study there is an inverse relationship between IQ and family size, but that in all studies there is a marked discontinuity at one child, with only children performing worse than those in two-child families in five of the six studies. They offer a different explanation for the poor performance of only children, namely that they are disadvantaged because they have no younger siblings to teach, a disadvantage that also applies to the youngest child in a family.

In many empirical studies of the effects of family size and birth order, only children have been omitted from the analysis or discussion. Many authors (Murnane et al. 1981; Wolfe 1982; Behrman and Taubman 1986; Stafford 1987; Hanushek 1992) include continuous terms in family size, without allowing for a discontinuity between one- and two-child families. Others (Lindert 1977; Olneck and Bills 1979; Hauser and Sewell 1986; Kuo and Hauser 1997) use pairs of siblings in order to be able to control for children’s family background, which means that only children are eliminated from their analysis altogether.

Among the much smaller number of studies which *do* allow for non-linearities in family size effects, by no means all find that only children are at a disadvantage. Kessler (1991) finds no evidence that being an only child affects either wage levels or wage growth. Kuh and Wadsworth (1991), in one of the few studies in this area to use British data, also examine adult earnings, and report that only children are *more* likely than those from two- or more- child families to be in the top third of the earnings distribution.

A number of authors examining academic attainment (Hauser and Sewell 1985, Blake 1981, Van Eijck and de Graaf 1995) find that only children are at no advantage or disadvantage compared to those in sibships of two. Blake (1981) asserts that the disadvantage apparently suffered by only children relative to those in two-child families may be entirely explained by the fact that they come from less advantaged backgrounds;

Van Eijck and de Graaf (1995) find that once only children's increased likelihood of living in a non-intact family is taken into account, only children do no worse than those in two-child families.

The fact that in these studies only children are found to do 'no worse' than those in sibships of two is worthy of comment in itself. All variants of resource dilution theory predict that since only children are without any competition at all for parental resources, they should do *better* than those in sibships of two, not 'as well as'. And of course, in the NCDS sample used here, only children do significantly worse than those in two-child families on many measures of performance.

Table 6 shows how only children differ in performance from first-borns in families of two, three and four children on the same measures of attainment used in previous sections[4].

The most striking finding from Table 6 is that *on indicators of mathematical ability and attainment, only children do consistently worse than those in two-child families, whereas on indicators of reading or linguistic ability and attainment, there is very little, if any, significant difference between only children and those from two-child families*. In other words, it seems quite clear that being an only child matters much more in some areas of cognitive development than it matters in others. This difference between language- and mathematically-based indicators is unambiguous, and robust to the addition of background controls. For example, the elder sibling in a two-child family does better than an only child by 10% of a standard deviation on the measure of

[4] Since first-born children do rather better than later-born children, only children appear to do worse relative to other first-borns than they do relative to all children in larger families. However, the comparison with other first-borns is the more interesting one to make, since only children would be first-borns in larger families if their parents had gone on to have more children. Comparisons between only children and all children in larger families are available in Table A3 in the Appendix, which gives results from regressions where birth order variables have not been included. They are qualitatively very similar to the results shown here.

attainment in English ‘O’ level, but does 25% of a standard deviation better in Mathematics ‘O’ level. These differences are reduced by the addition of controls, and the difference between only children and the elder of two siblings is rendered insignificant for attainment in English ‘O’ level. However, in Mathematics ‘O’ level, the difference between only children and the elder of two children survives the addition of controls. Even with a large and comprehensive set of controls, only children do worse than children with one younger sibling by 12% of a standard deviation. Although the results are not quite so stark in every case, this effect is mirrored throughout Table 6, and confirm that only children are far more disadvantaged in terms of mathematical skills and attainment than they are in terms of language-based indicators.

Clearly, research on other samples is needed before this finding should be firmly accepted, but it may be of absolutely critical importance in any area where researchers use test scores as measures of cognitive development or educational achievement. In particular, it may provide the key towards reconciling some of the contradictory findings in this area of research: it is possible that these contradictions have arisen in part because some investigators have used language-based outcome measures, whereas others have used mathematically-based measures.

TABLE 6: THE PERFORMANCE OF ELDEST CHILDREN IN FAMILIES OF 2, 3 AND 4 CHILDREN RELATIVE TO THE PERFORMANCE OF ONLY CHILDREN

		Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English O level result	Maths O level result	Number of O levels	Highest qualifica-tion (23)
(A)	Eldest of 2	0.0988	0.1151	0.0187	0.1754	0.0352	0.1441	0.1027	0.2457	0.2110	0.1186
No additional controls		(3.01)	(3.40)	(0.55)	(5.14)	(1.01)	(3.97)	(2.26)	(3.84)	(3.63)	(3.43)
	Eldest of 3	-0.0241	-0.0031	-0.1507	0.0191	-0.1362	-0.0264	-0.0857	-0.0434	-0.0427	-0.0465
		(-0.62)	(-0.08)	(-4.02)	(0.50)	(-3.59)	(-0.67)	(-1.71)	(-0.62)	(-0.67)	(-1.23)
	Eldest of 4	-0.1962	-0.0822	-0.3457	-0.1093	-0.3548	-0.1230	-0.3153	-0.2976	-0.4423	-0.2053
		(-3.63)	(-1.47)	(-7.77)	(-2.43)	(-8.02)	(-2.68)	(-5.37)	(-3.57)	(-5.78)	(-4.62)
(B)	Eldest of 2	0.0477	0.0681	-0.0124	0.1130	-0.0023	0.0797	0.0277	0.1442	0.0995	0.0505
Standard controls		(1.47)	(2.01)	(-0.39)	(3.48)	(-0.07)	(-0.0738)	(0.65)	(2.39)	(1.91)	(1.61)
For family background	Eldest of 3	-0.0615	-0.0452	-0.1579	-0.0207	-0.1508	-0.0738	-0.1429	-0.1121	-0.1118	-0.0984
		(-1.60)	(-1.13)	(-4.41)	(-0.57)	(-4.16)	(-2.00)	(-3.01)	(-1.67)	(-1.93)	(-2.84)
	Eldest of 4	-0.2143	-0.1090	-0.3151	-0.1133	-0.3396	-0.1468	-0.3194	-0.3027	-0.4226	-0.2252
		(-4.03)	(-1.96)	(-7.45)	(-2.64)	(-8.07)	(-3.43)	(-5.76)	(-3.84)	(-6.14)	(-5.56)
(C)	Eldest of 2	0.0605	0.0778	-0.0518	0.0674	-0.0322	0.0450	0.0169	0.1216	0.0888	0.0411
With extended controls		(1.97)	(2.37)	(-1.78)	(2.37)	(-1.07)	(1.54)	(0.40)	(2.03)	(1.87)	(1.35)
	Eldest of 3	0.0379	0.0338	-0.1253	0.0136	-0.1062	-0.0337	-0.0681	-0.0252	0.0085	-0.0258
		(1.03)	(0.86)	(-3.85)	(0.43)	(-3.22)	(-1.05)	(-1.46)	(-0.38)	(0.16)	(-0.78)
	Eldest of 4	-0.0422	0.0183	-0.1960	0.0080	-0.2267	-0.0517	-0.1719	-0.0693	-0.1683	-0.0856
		(-0.83)	(0.34)	(-5.06)	(0.21)	(-5.90)	(-1.38)	(-3.14)	(-0.89)	(-2.68)	(-2.20)

Notes:

Figures are coefficients from OLS regressions except in the case of 'O' level results, where they are based on Tobit regressions.
T-statistics are given in parentheses
Coefficients are in units of one standard error of the outcome measure.

5.3.1 Inputs from other children

The NCDS data do not permit the researcher to test all possible explanations for why only children perform relatively poorly. For example, the 'learning' explanation proposed by Behrman and Taubman (1986) cannot easily be tested using NCDS data. However, the idea that only children's poor performance is due to the lack of inputs from other siblings may be tested. If lack of inputs from siblings is indeed a factor, this may be partially offset by inputs from children outside the family. In the interviews conducted when the child is aged 7, parents are asked "Does the child meet other children outside the household? (Exclude going to and from, and in school)". A dummy variable taking the value 1 if the child meets other children most days or every day, is inserted into the same regressions used in Section 5.2, and interacted with 'only child' status. Results are shown in Table 7.

When additional controls are not used, the interaction term is significant in mathematics scores at 11 and 16, and in all post-16 measures of 'real' attainment (though only at the 10% level in Mathematics 'O' level). This is robust to the addition of 'standard' controls in two of the post-16 outcome measures, and marginally so in another two cases, providing a certain amount of evidence to support the hypothesis that only children's poor performance may in part be because they miss out on a certain type of interaction with other children; and that this disadvantage can be partially offset by mixing regularly with other children outside the family.

TABLE 7: CONTACT WITH OTHER CHILDREN

		(A) Coefficient on 'daily contact with other children'		(B) Interaction coefficient on 'daily contact' x 'only child' (no extra controls)		(C) Interaction coefficient (with standard controls)	
Age 7:	Reading	-0.0403	(-1.91)	0.0088	(0.13)	-0.0394	(-0.58)
	Maths	-0.0137	(-0.62)	0.0813	(1.12)	0.0375	(0.53)
Age 11:	Reading	-0.1693	(-7.62)	0.0938	(1.24)	0.0182	(0.26)
	Maths	-0.1253	(-5.55)	**0.1596**	**(2.08)**	0.0799	(1.11)
Age 16:	Reading	-0.1387	(-5.85)	0.0463	(0.57)	0.0075	(0.10)
	Maths	-0.1758	(-7.05)	**0.1823**	**(2.12)**	0.1245	(1.58)
Post-16:	Highest grade (English)	-0.2183	(-6.98)	**0.2696**	**(2.61)**	**0.1963**	**(2.05)**
	Highest grade (maths)	-0.3249	(-7.47)	*0.2544*	*(1.77)*	0.1456	(1.09)
	Number of 'O' levels	-0.2667	(-6.66)	**0.3572**	**(2.71)**	*0.2220*	*(1.91)*
Age 23:	highest qualification	-0.2016	(-8.42)	**0.2648**	**(3.36)**	**0.1400**	**(1.98)**
	(ordered probit)	-0.2264	(-8.46)	**0.2837**	**(3.25)**	**0.1723**	**(1.96)**

Notes:

Coefficients are from regressions as estimated in Section 5.2, with the addition of 'daily contact with other children' plus an interaction term with 'only child'. Columns (B) and (C) give the interaction coefficients.
T-statistics are given in parentheses.
Bold type denotes significant coefficients at the 5% level; italics denote significant coefficients at the 10% level.
Coefficients are in units of one standard error of the outcome measure.

5.4 Interaction effects

Until now, this paper has concentrated on the average effects of family size and birth order among children. However, it is important to know whether these effects are common to all groups of children, or whether they vary between groups: for example, between girls and boys (as suggested by Jordan et al 1982), or between children from different social backgrounds.

A full examination of how sibship structure interacts with other variables is beyond the scope of this paper, since there are many different ways in which the effects may vary between groups. Rather than attempting a full investigation, therefore, this section attempts to indicate the areas where interaction effects may be expected, and performs some preliminary investigations. Rather than using the full set of sibship structure variables to create a set of interaction terms, an abbreviated specification is used, with sibship size denoted by two variables: 'number of siblings' and 'only child'; and birth order denoted by two additional variables: 'middle child' and 'youngest child'. Although this specification is subject to the criticisms highlighted earlier in the paper, it will give an idea of whether or not the population is homogeneous with regard to sibship effects, and point to where future research might be most fruitfully carried out.

One reason why interaction effects may be expected, is that credit constraints are experienced by some groups of parents much more than by others. Those parents who are less credit-constrained are able to borrow money in order to make inputs to their children at the time when they are required, while those who are more credit-constrained are not able to smooth the family's consumption in this way. Hence, the effects of having many siblings, or several siblings close in age, may be less for families who are less subject to credit constraints. This prediction may be tested by interacting sibship structure variables with social class or income variables.

The effects of family size and birth order may also vary between groups as a result of the optimization strategies pursued by parents, as discussed in Section 2. If parents pursue an achievement maximization strategy, they will put more resources into those of their children for whom the return to their inputs is highest: their more able children, or possibly (given that men's wages are higher and men spend longer in the labour market than women) their sons. If this is the case, then on average the presence of a more able sibling (or possibly, a brother) will have more deleterious effects on existing siblings than the presence of a less able sibling (or possibly, a sister). Given that the NCDS has no data on siblings' characteristics, it may be more useful to look at this another way: on average, more able children (and possibly, boys) should experience less of a deleterious effect by the presence of an extra sibling than less able children (and possibly, girls).

However, if parents are pursuing a compensatory strategy, the opposite would be true: more able children on average would suffer more by the presence of an extra sibling than less able children.

These predictions may be investigated by interacting sibship structure with sex and (in the absence of a measure of ability separate from academic attainment) with previous academic attainment. However, in the absence of information about parents' preferences (for example, it is not at all clear that parents measure the returns to their inputs into children by children's academic attainment or labour market outcomes), it will not be easy to interpret any interaction effects unequivocally.

TABLE 8: INTERACTION EFFECTS (REGRESSIONS WITHOUT ADDITIONAL CONTROLS)

(A)	(B)	Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English 'O' level result	Maths 'O' level result	Number of 'O' levels	Highest qualifica -tion (23)
Female Child x	Total no. of siblings	0.004	-0.011	-0.011	-0.005	-0.004	0.007	-0.057	-0.020	-0.019	0.001
(49% of sample)	Only Child	0.069	0.056	0.043	**0.157**	0.005	0.100	-0.050	0.117	0.073	0.032
	Middle Child	0.045	-0.003	**0.089**	*0.075*	0.001	0.061	0.080	**0.230**	0.076	0.015
	Youngest Child	**0.106**	0.013	**0.126**	**0.127**	0.004	0.059	-0.009	**0.154**	**0.142**	0.016
	Sibs born after age 7	-	-	-0.010	-0.001	-0.007	-0.010	-0.002	0.054	0.012	0.009
Class I, II, III(n) x	Total no. of siblings	0.020	-0.004	0.024	0.018	0.035	-0.013	**0.067**	**0.091**	**0.069**	-0.004
(29% of sample)	Only Child	-0.034	-0.053	-0.007	-0.121	0.005	-0.103	0.018	-0.031	-0.039	-0.046
	Middle Child	0.042	0.036	-0.029	-0.048	0.012	-0.020	0.063	-0.020	0.009	0.024
	Youngest Child	0.016	-0.036	0.014	-0.048	0.011	-0.019	0.077	0.019	0.011	0.020
	Sibs born after age 7	-	-	0.063	*0.079*	**0.124**	**0.097**	**0.114**	**0.197**	**0.254**	**0.081**
	Sibs born after age 7 - coefficient	-	-	**(-0.112)**	**(-0.091)**	**(-0.127)**	**(-0.067)**	**(-0.118)**	**(-0.144)**	**(-0.202)**	**(-0.077)**
Financial Problems x	Total no. of siblings	-0.030	0.015	**-0.024**	**-0.038**	**-0.056**	**-0.028**	**-0.085**	**-0.104**	**-0.112**	**-0.030**
(7% of sample)	Only Child	0.111	0.117	-0.015	0.085	0.016	*0.282*	-0.081	0.023	0.119	-0.133
	Middle Child	0.149	-0.066	0.095	*0.105*	0.009	*0.118*	0.027	0.055	-0.036	0.089
	Youngest Child	0.149	-0.021	0.106	*0.141*	0.024	0.018	-0.035	-0.186	0.080	-0.089
	Sibs born after age 7	-	-	0.030	0.007	*0.068*	0.059	0.064	**0.168**	**0.142**	0.048
	Sibs born after age 7	-	-								

Notes:

Coefficients reported are interaction effects between the variable in column (A) and the variable in column (B)
As before, coefficients are from OLS regressions except in the case of 'O' level results, where they are from Tobit regressions.
Bold type denotes significant coefficients at the 5% level; italics denote significant coefficients at the 10% level.
Coefficients are in units of one standard error of the outcome measure.

Table 8 shows the results of interacting sibship variables with gender; with an indicator of social class; and with an indicator of financial hardship. The first panel of Table 8 shows the coefficients on the interaction terms between sibship structure and gender, and makes rather puzzling reading. There are no significant interaction effects between gender and the number of children in the family, or the number of siblings born after age 7. However, half the regressions do yield a large and significant positive coefficient on the interaction term between ‘female’ and ‘youngest child’, indicating the girls may be to an extent protected from the disadvantage of being the youngest child in the family. In these cases, the coefficient on the interaction terms is almost as large as the coefficient on the ‘youngest child’ variable, and of opposite sign, indicating that in these cases girls who are the youngest in their families do as well as eldest children. There is no particular pattern to which outcome measures yield this result, and this is clearly an interesting direction for future research.

The two middle panels of Table 8, showing interactions of sibling structure with the family’s socio-economic class and whether the family reports financial problems, are designed to test the prediction that family size and birth order effects are more pronounced in those families which are subject to borrowing constraints. Separating the sample by social class, into manual and non-manual workers, shows no difference in the effects of birth order. There is some evidence that being in a large family has less of a deleterious effect for children in non-manual families than for children in manual families (for all measures of attainment at ‘O’ level). Additionally, there is clear evidence that siblings born after the study child is aged seven have a different impact on children from different social classes. The coefficient on the un-interacted ‘sibs born after age 7’ variable has been included in parentheses under the interaction coefficient, so it is easy to see that in nearly every case the two coefficients are approximately equal and opposite. In other words, later arrivals have no effect on the performance of existing children in non-manual families, but a strong impact in manual families.

When sibship variables are interacted with a variable indicating whether the family is experiencing financial hardship, the interaction term between financial hardship and family size is significant in all outcome measures except those at age 7, showing that children in families with financial problems are affected significantly more by being in a large family than children in families without such problems. This follows theoretical predictions; interestingly, however, no interaction effect from birth order is apparent.

There is scope for investigating many more interaction effects than these: two important examples are the interactions between sibship structure and a child's ability, the sex of his or her siblings, or the presence in the household of the child's natural father. These and other effects are beyond the scope of this paper, but form an interesting research agenda for the future.

6 CONCLUSIONS

In this paper, the relationships between the number of siblings, position in the birth order and educational outcomes have been investigated in a thorough and systematic way; this is the first time which this has been done using data from the UK. The following conclusions have been reached. Firstly, children in larger families perform worse than children with fewer siblings, even when a whole raft of parental and school characteristics is controlled for. For sibship sizes between 2 and 8, each additional sibling is associated with a reduction in test or examination performance of between 11 and 17 per cent of a standard deviation[5], (depending on the outcome measure used) falling to between 3 and 13 per cent of a standard deviation when controls for parental and school characteristics are added.

Birth order effects were also found, with middle- and youngest-born children doing significantly worse than first-born children. The magnitude of these effects varies according to sibship size and the measure of attainment under consideration; but on average, there is a penalty of around 10 per cent of a standard deviation associated with being a middle or youngest child.

Only children perform significantly worse than theory would predict, performing over 10 per cent of a standard deviation worse than the elder of two children on all measures of mathematical performance, and on two summative measures of educational attainment (the number of 'O' levels passed and the highest qualification at age 23). Although controlling for background factors does account for a certain proportion of this disadvantage, a significant disadvantage associated with being an only child does remain. One of the most interesting and potentially important findings

[5] As discussed in Section 5.1, this excludes mathematics scores at age 7.

of this paper is that only children are at far more of a disadvantage on mathematically-based measures of attainment than on language-based measures. This suggests that it is important for researchers to specify in detail the type of outcome measures used in research; additionally, it suggests that some of the conflicting findings about outcomes for only children may arise because different measures were used.

Finally, a certain amount of support for the hypothesis that only children perform badly because of a lack of inputs from other children was found. Only children who had contact with other children outside of school when they were aged seven did better on many measures of attainment later in life than only children who did not have contact with other children. This effect is robust to the inclusion of standard family background controls, but disappears when a very large set of controls is used.

The paper finishes by noting the importance of ascertaining whether sibship effects affect all groups of children equally, or whether they affect some groups of children more than others. Although there is not space here to permit a full investigation of interaction effects, evidence that they exist and are potentially important was presented. In particular, there is evidence that sibship size is a far more important determinant of attainment for children whose families are in financial difficulties than for other groups of children.

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8 APPENDIX

FIGURE A1: DISTRIBUTION OF OUTCOME MEASURES IN THE NCDS.

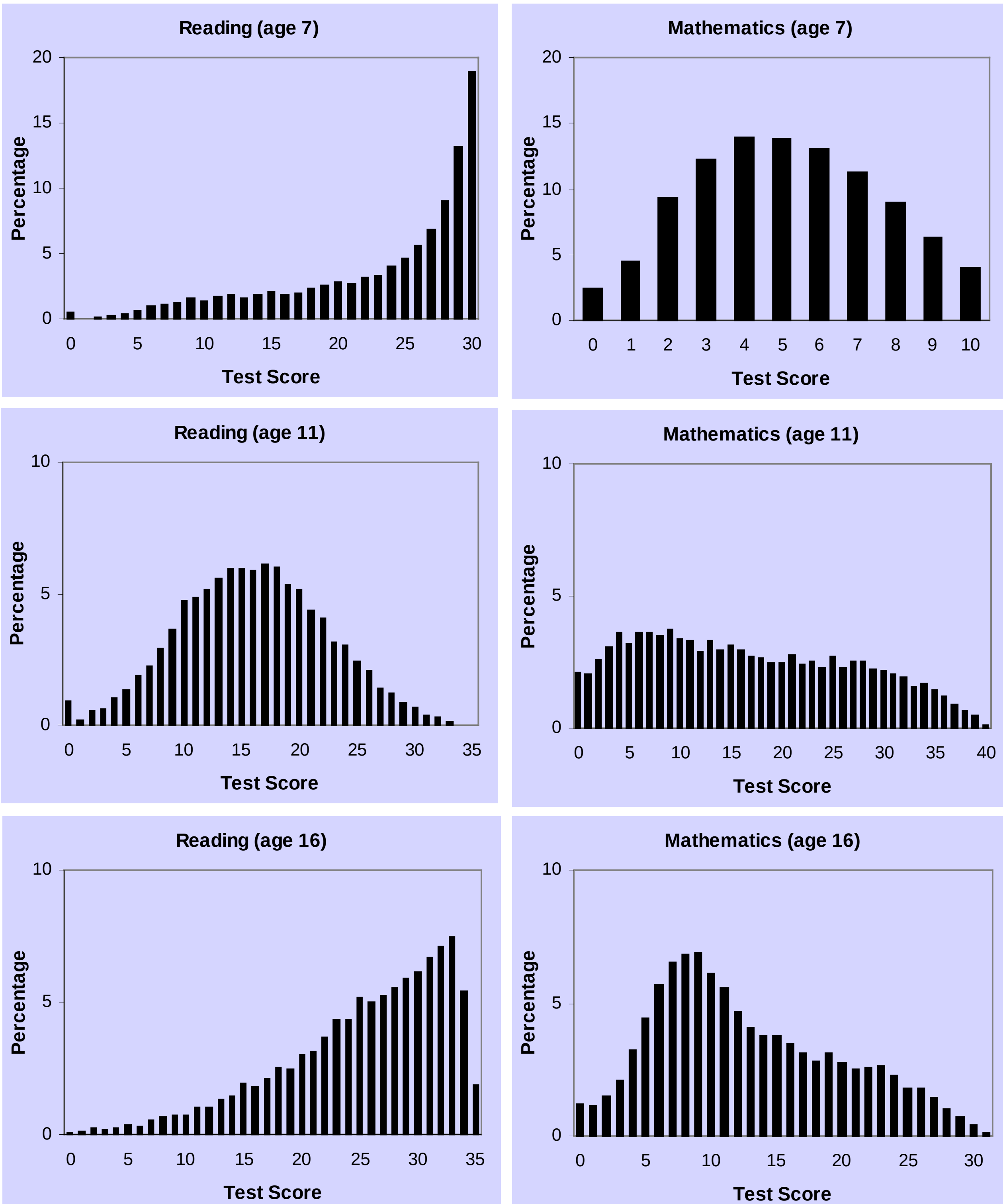

Figure A1 (continued): Distribution of outcome measures in the NCDS

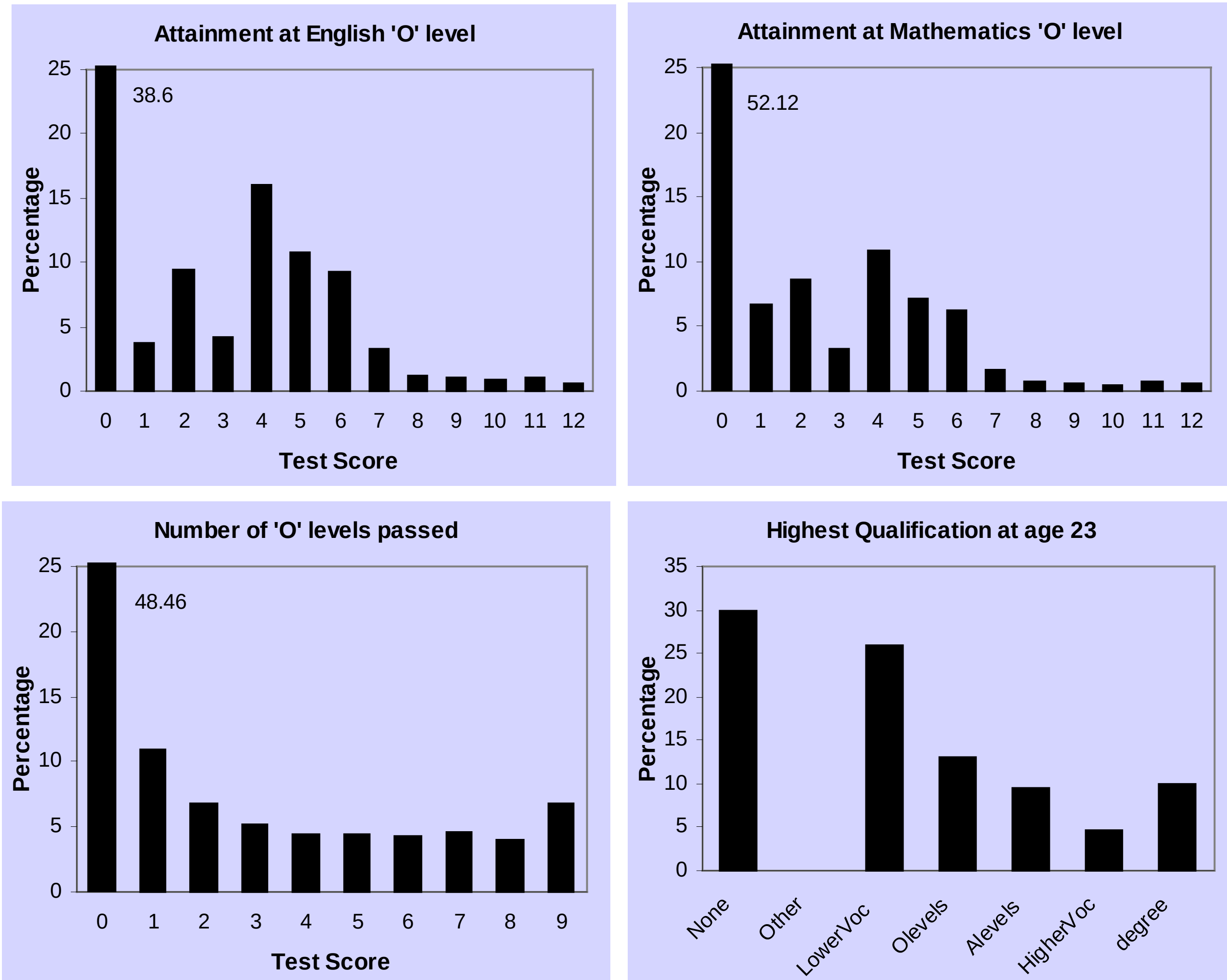

Table A9: Outcome Measures

Outcome measure	Range	Mean	Median	Inter-quartile range	S.D.
Reading Test Score (age 7)	0-30	23.3	26	19-29	7.1
Maths Test Score (age 7)	0-10	5.1	5	3-7	2.5
Reading Test Score (age 11)	0-35	16.0	16	12-20	6.3
Maths Test Score (age 11)	0-40	16.6	15	8-25	10.4
Reading Test Score (age 16)	0-35	25.3	27	21-31	7.1
Maths Test Score (age 16)	0-31	12.8	11	7-18	7.0
English ‘O’ level result (age 16+)	0-12	2.7	2	0-5	2.8
Maths ‘O’ level result (age 16+)	0-12	1.9	0	0-4	2.6
Number of ‘O’ levels passed (age 16+)	0-9	2.3	1	0-4	3.0
Highest qualification attained (age 23)	1-7	3.1	3	1-4	2.0

TABLE A10: SUMMARY STATISTICS

	Variable	Range	Mean	S.D.
Sibship Size Variables at age 7	Only child (omitted category)	0-1	0.09	0.28
	2 children	0-1	0.33	0.47
	3 children	0-1	0.25	0.44
	4 children	0-1	0.16	0.36
	5 children	0-1	0.08	0.27
	6 children	0-1	0.04	0.21
	7 children	0-1	0.02	0.15
	8 children	0-1	0.01	0.11
	Number of sibs born ages 7-11	0-7	0.18	0.48
	Number of sibs born ages 7-16	0-7	0.29	0.64
Birth order variables (age 7)	Younger of 2	0-1	0.17	0.37
	Middle of 3	0-1	0.10	0.29
	Younger of 3	0-1	0.08	0.27
	Middle of 4	0-1	0.09	0.28
	Younger of 4	0-1	0.04	0.18
	Middle of 5	0-1	0.05	0.23
	Youngest of 5	0-1	0.01	0.11
	Middle of 6+	0-1	0.07	0.24
	Youngest of 6+	0-1	0.01	0.11
Standard controls	Female	0-1	0.49	0.50
	Father's age at child's birth	16-78	30.49	6.39
	Age mother left education	12-23	14.95	1.48
	Age father left education	12-23	15.26	2.09
	Father: social class I	0-1	0.04	0.20
	Father: social class II	0-1	0.13	0.33
	Father: social class III non-manual	0-1	0.10	0.30
	Father: social class III manual	0-1	0.49	0.50
	Father: social class IV	0-1	0.19	0.32
	Father: social class V (omitted)	0-1	0.12	0.32
	Father unemployed	0-1	0.0003	0.02
	Father retired	0-1	0.0001	0.01
	Father a student	0-1	0.001	0.03
	Father not present at time of birth	0-1	0.03	0.16
	Father left between 0 and 7	0-1	0.05	0.21
	Father left between 7 and 11	0-1	0.05	0.21
	Father left between 11 and 16	0-1	0.07	0.26
Extended controls: Age 7	Financial hardship	0-1	0.08	0.27
	Mother reads to child (7)	0-2	1.33	0.73
	Father reads to child (7)	0-2	1.08	0.80
	Goes out with mother (7)	0-2	1.84	0.40
	Goes out with father (7)	0-2	1.65	0.58
	Dad plays role in child's life (7)	0-2	1.48	0.69
	Mother worked f/t before age 5	0-1	0.09	0.29
	Mother worked f/t between 5 and 7	0-1	0.10	0.30
	Mother reads at home (7)	0-2	1.63	0.64
	Father reads at home	0-2	1.80	0.50
	Mother's interest in child at school	0-2	1.21	0.73
	Mother 'over-interested'	0-1	0.03	0.17
	Father's interest in child at school	0-2	1.14	0.79
	Father 'over-interested'	0-1	0.02	0.13
	Parents want child to stay at school	0-1	0.82	0.38
	Family moves since child's birth	0-22	1.22	1.50
	Number of schools age 5-7	1-11	1.26	0.63

	Infant school	0-1	0.47	0.50
	Junior school	0-1	0.46	0.50
	Other LEA school	0-1	0.03	0.16
	Independent school	0-1	0.03	0.18
	Special School	0-1	0.003	0.06
	Nursery class in school?	0-1	0.08	0.27
	Top stream	0-1	0.03	0.18
	Middle stream	0-1	0.01	0.12
	Bottom Stream	0-1	0.02	0.13
	All infants in one class	0-1	0.05	0.21
	Family Groupings	0-1	0.05	0.22
	One class per year, or parallel	0-1	0.39	0.49
	By age within years	0-1	0.35	0.48
	Other arrangement	0-1	0.09	0.29
	% of fathers in social class I and II	0-100	24.93	20.81
	% of fathers in social class V	0-100	21.10	16.79
Age 11:	Financial hardship last year	0-1	0.11	0.31
	Outings with mum - 0 low, 2 hi	0-2	1.85	0.38
	Outings with dad - 0 low, 2 hi	0-2	1.78	0.45
	dad plays big part - 0 low, 2 hi	0-2	1.69	0.47
	Ma over concerned	0-1	0.04	0.20
	Ma's interest in education	0-2	1.21	0.75
	Pa over concerned	0-1	0.04	0.19
	Pa's interest in education	0-2	1.11	0.79
	Parents want kid to stay at school?	0-1	0.76	0.43
	Family moves since birth	0-9	1.64	1.72
	No of schools since 5	0-9	1.74	0.99
	Junior school dummy	0-1	0.47	0.50
	Combined school dummy	0-1	0.45	0.59
	Other school dummy	0-1	0.02	0.15
	Independent school dummy	0-1	0.04	0.19
	Special school dummy	0-1	0.02	0.13
	Top stream	0-1	0.13	0.34
	Middle stream	0-1	0.10	0.29
	Bottom stream	0-1	0.10	0.29
	Unstreamed	0-1	0.67	0.45
Age 16	Financial problems last year	0-1	0.10	0.30
	Father's pay £20 - 29 a week	0-1	0.31	0.46
	Father's pay £30 - 39 a week	0-1	0.36	0.48
	Father's pay £40 - 49 a week	0-1	0.16	0.37
	Dad's pay £50 a week or more	0-1	0.13	0.34
	Mother over concerned	0-1	0.02	0.15
	Mother's interest in education	0-2	1.20	0.77
	Father over concerned	0-1	0.03	0.17
	Father's interest in education	0-2	1.16	0.79
	Family moves since birth	0-9	1.90	1.90
	No of schools since 11	0-6	1.25	0.52
	Comprehensive school dummy	0-1	0.59	0.42
	Independent school dummy	0-1	0.03	0.18
	Grammar school dummy	0-1	0.11	0.31
	Secondary Modern school dummy	0-1	0.21	0.41
	Technical school dummy	0-1	0.01	0.07
	Direct Grant school dummy	0-1	0.02	0.15
	Special school dummy	0-1	0.02	0.13
	Other type of school dummy	0-1	0.01	0.10

TABLE A11: RELATIONSHIP BETWEEN SIBSHIP SIZE AND OUTCOMES

	Sibship size	Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English 'O' level result	Maths 'O' level result	Number of 'O' levels	Highest qualification (23)
(A) No additional controls	2	0.0669	0.1327	0.0051	0.1676	0.0026	0.1197	0.0706	0.2230	0.1696	0.0775
		(2.24)	(4.30)	(0.16)	(5.33)	(0.08)	(3.48)	(1.65)	(3.71)	(3.10)	(2.38)
	3	-0.0718	0.0413	-0.1927	-0.0171	-0.1866	-0.0573	-0.1338	-0.0832	-0.1272	-0.1138
		(-2.33)	(1.29)	(-6.00)	(-0.53)	(-5.48)	(-1.62)	(-3.01)	(-1.33)	(-2.24)	(-3.38)
	4	-0.2429	-0.0154	-0.4062	-0.1754	-0.3873	-0.1884	-0.4200	-0.4016	-0.5225	-0.2926
		(-7.23)	(-0.44)	(-11.71)	(-5.00)	(-10.45)	(-4.90)	(-8.66)	(-5.86)	(-8.33)	(-7.99)
	5	-0.3971	-0.0693	-0.6074	-0.3746	-0.6319	-0.3778	-0.7004	-0.7781	-0.8990	-0.4862
		(-9.91)	(-1.67)	(-14.87)	(-9.06)	(-14.61)	(-8.42)	(-12.02)	(-9.35)	(-11.75)	(-11.19)
	6	-0.5144	-0.1803	-0.7373	-0.4895	-0.7893	-0.5509	-0.9337	-1.1030	-1.2295	-0.6394
		(-10.63)	(-3.61)	(-15.08)	(-9.89)	(-14.91)	(-10.03)	(-12.99)	(-10.60)	(-12.82)	(-12.33)
	7	-0.6447	-0.1921	-0.7397	-0.5284	-0.9077	-0.5536	-1.0878	-1.2671	-1.4924	-0.6487
		(-10.44)	(-3.01)	(-11.96)	(-8.44)	(-13.91)	(-8.18)	(-11.81)	(-9.38)	(-11.73)	(-10.02)
	8	-0.7912	-0.2563	-0.8593	-0.6350	-1.0336	-0.7212	-1.0701	-1.3407	-1.6979	-0.7995
		(-9.98)	(-3.13)	(-10.59)	(-7.73)	(-12.02)	(-8.09)	(-8.93)	(-7.54)	(-9.78)	(-9.41)
	New sibs	-	-	-0.1374	-0.1066	-0.1240	-0.0898	-0.1546	-0.1806	-0.2414	-0.1180
				(-8.13)	(-6.23)	(-9.17)	(-6.40)	(-8.37)	(-6.83)	(-9.77)	(-8.61)
	Female	0.2563	-0.0971	-0.0011	-0.0524	-0.0296	-0.2085	0.2802	-0.3050	0.1831	0.0869
		(15.85)	(-5.81)	(-0.07)	(-3.12)	(-1.68)	(-11.43)	(12.00)	(-9.25)	(6.07)	(4.93)

TABLE A3 (CONTINUED)

	Sibship size	Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English 'O' level result	Maths 'O' level result	Number of 'O' levels	Highest qualifica-tion (23)
(B) Standard family controls	2	0.0057	0.0864	-0.0562	0.0898	-0.0573	0.0375	-0.0259	0.0913	0.0214	-0.0081
		(0.20)	(2.84)	(-1.92)	(3.03)	(-1.84)	(1.18)	(-0.65)	(1.63)	(0.44)	(-0.28)
	3	-0.1233	0.0006	-0.2490	-0.0848	-0.2375	-0.1343	-0.2276	-0.2085	-0.2644	-0.1981
		(-4.08)	(0.02)	(-8.24)	(-2.77)	(-7.39)	(-4.12)	(-5.49)	(-3.57)	(-5.23)	(-6.53)
	4	-0.2649	-0.0301	-0.4197	-0.1975	-0.3999	-0.2215	-0.4455	-0.4377	-0.5464	-0.3198
		(-8.07)	(-0.88)	(-12.88)	(-5.98)	(-11.46)	(-6.25)	(-9.85)	(-6.83)	(-9.80)	(-9.71)
	5	-0.3761	-0.0511	-0.5696	-0.3360	-0.5822	-0.3430	-0.6554	-0.7227	-0.7981	-0.4413
		(-9.63)	(-1.25)	(-14.86)	(-8.65)	(-14.29)	(-8.29)	(-12.07)	(-9.28)	(-11.72)	(-11.29)
	6	-0.4591	-0.1337	-0.6543	-0.3969	-0.6935	-0.4501	-0.8007	-0.9210	-0.9943	-0.5182
		(-9.71)	(-2.71)	(-14.24)	(-8.53)	(-13.91)	(-8.89)	(-11.95)	(-9.47)	(-11.62)	(-11.10)
	7	-0.5990	-0.1534	-0.6808	-0.4527	-0.8355	-0.4815	-0.9853	-1.1200	-1.2640	-0.5597
		(-9.94)	(-2.44)	(-11.73)	(-7.70)	(-13.60)	(-7.72)	(-11.45)	(-8.86)	(-11.15)	(-9.60)
	8	-0.7060	-0.1802	-0.7665	-0.5236	-0.9364	-0.6155	-0.9158	-1.1252	-1.3750	-0.6608
		(-9.15)	(-2.24)	(-10.08)	(-6.80)	(-11.62)	(-7.52)	(-8.23)	(-6.81)	(-8.98)	(-8.67)
	New sibs			-0.0845	-0.0605	-0.0875	-0.0442	-0.0962	-0.1010	-0.1431	-0.0686
				(-5.28)	(-3.73)	(-6.84)	(-3.40)	(-5.53)	(-4.05)	(-6.45)	(-5.52)
	Female	0.2488	-0.1041	-0.0128	-0.0618	-0.0393	-0.2172	0.2701	-0.3141	0.1556	0.0794
		(15.85)	(-6.36)	(-0.83)	(-3.94)	(-2.39)	(-13.01)	(12.47)	(-10.25)	(5.83)	(5.03)

TABLE A3 (CONTINUED)

	Sibship size	Reading test (age 7)	Maths test (age 7)	Reading test (age 11)	Maths test (age 11)	Reading test (age 16)	Maths test (age 16)	English 'O' level result	Maths 'O' level result	Number of 'O' levels	Highest qualification (23)
(C) Extended controls	2	0.0138	0.0906	-0.0850	0.0508	-0.0736	0.0156	-0.0257	0.0764	0.0301	0.0044
		(0.50)	(3.07)	(-3.21)	(1.96)	(-2.60)	(0.57)	(-0.65)	(1.36)	(0.67)	(0.15)
	3	-0.0438	0.0534	-0.1961	-0.0350	-0.1650	-0.0670	-0.1162	-0.0697	-0.0716	-0.0886
		(-1.52)	(1.74)	(-7.14)	(-1.30)	(-5.64)	(-2.36)	(-2.82)	(-1.19)	(-1.54)	(-3.01)
	4	-0.1073	0.0779	-0.2692	-0.0468	-0.2520	-0.0843	-0.2379	-0.1469	-0.2092	-0.1313
		(-3.40)	(2.31)	(-9.00)	(-1.60)	(-7.86)	(-2.71)	(-5.24)	(-2.28)	(-4.05)	(-4.07)
	5	-0.1690	0.0909	-0.3504	-0.1061	-0.3738	-0.1421	-0.3295	-0.2523	-0.2900	-0.1640
		(-4.48)	(2.25)	(-9.94)	(-3.08)	(-9.99)	(-3.91)	(-6.11)	(-3.26)	(-4.63)	(-4.31)
	6	-0.1784	0.0693	-0.3863	-0.1135	-0.4115	-0.1841	-0.4063	-0.4361	-0.3913	-0.1827
		(-3.90)	(1.42)	(-9.13)	(-2.75)	(-8.94)	(-4.12)	(-5.97)	(-4.38)	(-4.85)	(-3.94)
	7	-0.2656	0.0809	-0.3649	-0.1303	-0.5161	-0.1790	-0.4771	-0.4726	-0.5194	-0.1904
		(-4.57)	(1.30)	(-6.88)	(-2.52)	(-9.21)	(-3.29)	(-5.66)	(-3.80)	(-5.06)	(-3.40)
	8	-0.2867	0.1183	-0.4078	-0.1452	-0.5972	-0.3117	-0.4686	-0.5695	-0.6088	-0.2354
		(-3.85)	(1.49)	(-5.87)	(-2.14)	(-8.14)	(-4.37)	(-4.21)	(-3.38)	(-4.25)	(-3.16)
	New sibs			-0.0406	-0.0123	-0.0495	-0.0053	-0.0254	-0.0044	-0.0110	-0.0182
				(-2.75)	(-0.86)	(-4.23)	(-0.47)	(-1.48)	(-0.18)	(-0.55)	(-1.53)
	Female	0.2345	-0.1163	-0.0497	-0.1012	-0.0682	-0.2531	0.2192	-0.3773	0.0651	0.0343
		(15.81)	(-7.34)	(-3.53)	(-7.37)	(-4.58)	(-17.48)	(10.30)	(-12.47)	(2.69)	(2.28)

TABLE A4

Sibship size and birth order	Estimated percentage….								
	Of being in in top 25% in reading at 7	Of being in in top 25% in maths at 7	Of being in in top 25% in reading at 11	Of being in in top 25% in maths at 11	Of being in in top 25% in reading at 16	Of being in in top 25% in maths at 16	With O levels or better by age 23	With a levels or better by age 23	Having a degree by age 23
Only child	22.00	15.04	33.09	25.05	26.86	28.38	23.32	37.54	7.55
Elder of 2	23.66	20.42	32.54	31.37	29.00	34.59	27.41	47.39	10.17
Younger of 2	21.84	21.38	32.54	28.75	29.00	31.00	27.41	47.39	10.17
Eldest of 3	20.67	18.16	27.16	27.63	25.72	31.28	22.27	40.51	6.23
Middle of 3	18.57	21.52	19.58	22.06	17.68	25.77	18.20	32.55	6.08
Youngest of 3	18.14	17.79	23.31	22.33	19.04	23.89	15.13	29.69	3.53
Eldest of 6	8.74	15.35	12.10	13.77	10.86	5.14	8.76	18.59	2.19

The estimated probabilities in Table A4 were obtained using the same methodology as in the body of the paper (using standard family controls), but using outcome measures with a more intuitive appeal, and converted into probabilities: thus, the estimated probability of reaching a certain level in test scores or educational outcomes may be compared between groups.