Explaining Sibling Differences in Achievement and Behavioral Outcomes: The Importance of Within- and Between-Family Factors

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Abstract

Most research on child behavioral and cognitive outcomes focuses on the impact of variables measured across families—holding a number of other characteristics constant. More recently, family fixed effects approaches have been deployed to examine the impact of a number of family characteristics that vary over time on child outcomes. These have included parental age, income, and even family size. An assumption of these models is the constancy of unmeasured family background effects over time and across children. We test this assumption by predicting the difference in child outcomes between siblings by a number of family demographic and economic characteristics. We also use family fixed effects to assess the importance of a number of child-specific measures on these outcomes, including birth weight, birth order and gender. Results show that overall, sibling correlations in early childhood behavioral and cognitive outcomes are weaker than might be expected by social reproduction models, ranging from .284 for reading passage comprehension to .441 for broad reading score, with math, behavioral and other verbal measures falling within that range. Siblings from families where the household head's occupational prestige is greater tend to turn out more similarly on these measures, while other family background characteristics do not seem to consistently predict sibling resemblance. Finally, within-family sibling comparisons reveal that first born children generally outperform their younger siblings on age-adjusted tests, but other child-specific measures such as gender and birth weight are not consistently significant across outcomes.

Explaining Sibling Differences in Achievement and Behavioral Outcomes: The Importance of Within- and Between-Family Factors

Sociologists, social epidemiologists and developmental psychologists have long recognized the importance of both family environment and socio-economic conditions for healthy child development.[1] The typical approach of researchers in this vein is to control for a number of key background variables – such as race, maternal age or education – and then focus on the marginal effect of one or more socio-economic inputs such as income, family size or neighborhood characteristics (for a review, see, e.g., Hauser 1994). Child outcomes studied with this methodology run the gamut from birth weight to verbal ability to mortality.

This research tradition is vast and cannot be done justice in the brief space here. That said, this literature is perhaps best summarized in a cumulative, life-course framework over childhood (Bronfenbrenner 1979). Starting with birth, much research has shown that African American race, lower income, and lower maternal education lead to a greater risk for delivering a low birth weight baby, due to both prematurity and intrauterine growth retardation (Gortmaker 1979; Starfield *et al*. 1991; Cramer 1995; Stockwell, Goza and Roach 1995). This higher incidence of low birth weight among the low SES population partially, but not completely, accounts for the higher infant mortality rates among this group (Gortmaker 1979; Tresserras, Canela, Alvarez, Sentis and Salleras 1992; Cramer 1995). If children survive the first year of life, those from lower SES

[1] During the late 1970s, the British government commissioned a report on social inequalities in health. One of the major conclusions of the Black report – as this study came to be known – was that "biological programming" of adult health status occurs to a great extent during the fetal and infant states of development (Vagero and Illsley 1995: 220). Social scientists have since paid increasing attention to the consequences of poverty and social inequality early in the life course (for a review see, e.g., Aber, Bennett, Conley and Li 1997).

families face increased risks of childhood mortality, primarily due to increased chance of accidental death (Mare 1982; Wise, Kotelchuck, Wilson and Mills 1985).[2]

Aside from increased mortality rates, children from low SES families suffer from other health and developmental risks as well (Egbuonu and Starfield 1982; Wise and Meyers 1988). For instance, there is an inverse relationship between child blood lead levels and SES (Mahaffey, Annest and Roberts 1982; Quah, Stark and Meigs 1982; Klerman and Parker 1990; Brody *et al*. 1994). Likewise, Korenman and Miller (1997) showed that lower SES children are more likely to exhibit low height-for-age (stunting) or low weight-for-height (wasting), two reliable indicators of nutritional status which, in turn, predict other health outcomes (Martorell and Ho 1984; Miller, Fine and Adams-Taylor 1989; Elo and Preston 1992). Others have shown an effect of SES on children's number of bed days and school absences (McGaughey, Starfield, Alexander and Ensminger 1991), on acute illnesses (Starfield 1991) and on chronic conditions such as asthma (Ernst, Demissie, Joseph, Locher and Becklake 1995).

In addition to physical health problems, children from poor families tend to experience worse mental health and display more behavioral problems than their non-poor counterparts, particularly when poverty is long-term (McLeod and Shanahan 1993; Campbell 1995). Low SES may also affect cognitive development. For example, a number of researchers have found that income is positively correlated with child cognitive indicators such as the Peabody Individual Achievement Tests and the Peabody

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[2] These increased risks may be compounded by the more limited access to health services on the part of this population (Newacheck and Halfon 1986; Perrin, Homer, Berwick *et al.* 1989; St. Peter, Newacheck and Halfon 1992).

Picture Vocabulary Test (Duncan, Brooks-Gunn and Klebanov 1994; Korenman, Miller and Sjaastad 1995; Chase-Lansdale, Gordon, Brooks-Gunn and Klebanov 1997).

<u>Global Effects of Family Background: Fixed Effects and Latent Variable Models</u>

A cloud hanging over all these research findings is the issue of unobserved heterogeneity—otherwise known as selection bias. How can we know that it is indeed the marginal, causal impact of, for example, parental income that causes these gradients in child outcomes and not some other, unmeasured factor that correlates with both parental income and child outcomes (for example, skill). Indeed, Mayer (1997) uses a variety of methods—such as pre- and post- income comparisons and comparisons of income from various sources (that may be more or less correlated with relevant unobservables)—and finds that traditional models overstate the impact of income or poverty on child outcomes.

Another common approach to deal with the issue of "lurking variables" is to use sibling fixed effects models. This approach examines within-family variance to factor out background characteristics and determine the more "pure" or marginal effects of specific socio-economic inputs (see, e.g., Mayer 1997: 95-6). For example, Duncan, Yeung, Brooks-Gunn, and Smith (1998) compare siblings to determine the marginal effect of income differences over the course of their childhood on educational attainment. They find a significant effect for income at ages 0-5 – in contrast to previous studies that had posited income during adolescence as being the most important. Rosenzweig and Wolpin (1994) use a similar approach to determine the marginal effect of parental educational increases. Conley and Bennett (2000) use this approach to model birth weight as both cause and effect of SES. The impact of maternal age at birth has also been examined using this strategy (see, e.g., Geronimus and Korenman 1993a, 1993b; Hoffman, Foster and Furstenburg, 1993; Rosenzweig and Wolpin 1995). The efficacy of Head Start preschool has been tested using family-fixed effects models (Currie and Thomas 1995). Even the impact of family size has been studied using this approach (Guo and VanWey 1999).

In the present study, we will build on this work in several ways. First, we will model variation in the strength of family background effects. That is, we will seek to model systematic variation in the common, inter-family variance in child developmental outcomes that is thrown away in fixed effect models. This common-family variance may display its own pattern of variability across the population and even over time within the same families. This helps answer the question of whether within-family variance is constant across family types. Second, we will adopt the sibling-fixed effects approach to child cognitive and behavioral measures for which it has not been typically used. Additionally, the within-family variables we will model will not be parental characteristics that vary over time—as has typically been done in the literature—but rather child-specific factors such as birth weight, gender, age and birth order.

While this approach of modeling sibling variability has not been extensively used in the literature on child health and development, it has been applied to adult outcomes such as IQ or educational success (see, e.g., Taubman 1977; Jencks *et al*. 1979; Scarr and Weinberg 1978; Hauser and Mossel 1985; Hauser and Sewell 1986; Hauser and Wong 1989; Solon, Corcoran, Gordon and Laren 1991; Kuo and Hauser 1995). Some researchers have used a similar approach to parcel out genetic and environmental influences on child outcomes and have met with various criticisms.[3] That is not the agenda of the current study, which views the common family background (genetics, culture, economic resources and so on) as a single unit for study. From these over-arching objectives, a series of specific research questions emerge:

1. What types of developmental outcomes tend to cluster within families (high between-family variance) and which tend to be unique to individuals regardless of their family of origin (high within-family variance)?

2. Do certain family structures exhibit more "clustering" of behavioral and developmental outcomes than others do? For example, do children from single-parent households emerge relatively closer in behavioral and developmental outcomes than do those from two-parent households? McLanahan and Sanderfur (1994) have shown that children from single-parent families have lower average levels of cognitive functioning than those from two-parent families (though much of this effect is due to lower economic resources in these households). But this is different from asking whether the outcomes of children from single-parent homes are more similar to each other than are those of

[3] This line of research in the tradition of behavioral genetics attempts to parcel out genetic and environmental components of the effect of family background on social outcomes using twin and other kin comparisons. A host of outcomes have been examined in this context, ranging from cognitive ability (Plomin 1988) to mental health (Gottesman and Shields 1982; Kendler and Robinette 1983; Reich *et al*. 1987) to behavioral outcomes such as delinquent behavior (Rowe 1983) to the socio-economic (Behrman, Hrubec, Taubman and Wales 1980; Behrman, Pollack and Taubman 1995); for a general review of this research tradition, see Plomin (1986), Plomin and Daniels (1987) or Plomin, DeFries and Loehlin (1989). However, these studies have been criticized for not taking account of differences in the genetic-environmental covariance among different kin and/or the degree of assortive mating in the population (see, Goldberger 1977, 1979). We will not be attempting to "unravel" the knot of common genes and environment but rather, will be estimating the overall, combined impact of family background.

children from dual parent families.[4] This effect may be due to a lack of social control and stability in the form of the second parent (resulting in greater outside influences and randomness in lone parent families – see, e.g., Teachman, Day, Carver, Call and Paasch 1998). On the other hand, with a single role model, children may turn out more cognitively similar when changing family environment is held constant. The same can be asked of family size: Does a larger family lead to greater family socialization—or, on the other hand—more randomness due to a lack of social control due to divided parental attention? (It could also be the case that the more complex social networks within larger families lead to greater differences.)

Likewise, do siblings spaced more closely together tend to resemble each other more in behavioral and developmental outcomes than do those spaced further apart? Some research has shown that siblings spaced more closely together evince a greater strain on family resources and thus lead to lower average cognitive functioning (Steelman and Powell 1989; Powell and Steelman 1990, 1993). How does spacing affect the variance (or relative variation) among siblings' outcomes? One hypothesis would suggest that close spacing yields less variability since siblings would experience critical family transitions (such as income shocks and the like) at similar times in the course of their development (Hogan 1978; Elder and Caspi 1988). There also may be more interdependence (i.e. cross-socialization) among those who are not too far apart in age. The alternative hypothesis is that the closer siblings are in age, the more they are in direct competition with each other (Stafford 1987) and the more they will diverge in their

[4] Kuo and Hauser (1995) address this issue somewhat in terms of "intact" versus "non-intact" families and find that brothers (they do not analyze women) tend to resemble each other less (educationally) in non-intact families. Their measure is a single, retrospective question. The data we will analyze contain continuous information of the family structure, to allow for a more nuanced view.

outcomes since small differences in abilities become magnified (Sulloway 1996). Closely spaced siblings may also seek out different niches within the family.

3. How do family resources affect the developmental "spread" between siblings? Our motivating hypothesis is that among families that are disadvantaged, we should observe greater sibling disparities (i.e. lower correlations). Previous qualitative work (Conley 2004), which examined adult outcomes, has suggested that among disadvantaged households, sibling disparities tend to increase since limited opportunities and resources may evince parenting strategies that accentuate sibling differences by directing family resources to the one (or few) sibling(s) for whom upward mobility is most likely. This research also suggested that among families that were well-endowed with class resources (and were racially privileged as well), parents often invested more heavily in those offspring they saw as having the worst chances for success in the education system and/or labor market—in a compensatory fashion. Put another way, disadvantaged families were seen to be behaving efficiently (investing more in the offspring for whom they expect higher returns) thus reinforcing sibling differences, whereas better-off families appeared to be behaving inefficiently (investing more in the kid for whom they expect lower returns), thus compensating, i.e. trying to bring about more equity in the outcomes of offspring.

With this in mind, we hypothesize that blacks have lower sibling correlations than non-blacks; that siblings whose mothers have completed fewer years of education have lower correlations than do those whose mothers have completed more years of schooling; and that those with larger families have lower sibling correlations than do those with smaller families. Of course, the empirical observation of such a pattern does not constitute sufficient evidence to confirm the theory about differences in parental investment. It could also reflect other dynamics such as differential distributions of ability within families of various subpopulations; the greater or lesser influence of outside forces, such as school or peer effects (to the extent that they differ across siblings); or differences in measurement error across subpopulations. That said, rejection of this hypothesis would cast serious doubt on the qualitative inference that different class-based parenting strategies exist (or at least that they have the consequences noted).

Such a hypothesis stands in contrast to the theoretical prediction of Becker and Tomes (1986) who posited that with capital constraints, low-income parents may not be able to optimally invest in their children's human capital. Such under-investment may lead to higher degrees of sibling resemblance at lower incomes since "high ability children from poor families may receive the same low level of education as a sibling with lower academic ability, compressing their earnings compared with similarly different siblings from a prosperous family" (Mazumder and Levine 2003: 16). This prediction, however, is based on the notion of capital (and credit) constraints with respect to the cost of formal schooling. For our early childhood developmental measures this may be less of an issue than it would be for ultimately, completed schooling.

4. Finally, given patterns of sibling resemblance and difference in child outcomes, what predicts which siblings thrive and which do not? Here we will rely on a number of individual characteristics that have been shown to matter to varying degrees in other contexts to individual outcomes within families. For example, Conley and Bennett

(2000) and Conley, Strully and Bennett (2003) have argued, using sibling fixed effects models, that birth weight is an important predictor of educational attainment. Their outcome is measured at age 19, however. What about the impact of birth weight differences between siblings on earlier cognitive measures? Since these measures come at a time when premature or small birth weight babies have had less time to "catch up," effects may be more pronounced for the early childhood measures we will examine. On the other hand, early childhood measures demonstrate greater degrees of measurement error, suggesting an attenuation of coefficients.

And what about birth order? Most studies on birth order have focused on either personality based measures or on adult socioeconomic outcomes (see, e.g., Conley 2004 for a review of this literature). Fewer (if any) have examined early childhood cognitive and behavioral measures. Even more important is the fact that these studies typically do not use within-family (i.e. sibling fixed effects) comparisons; thus they often may be conflating sibship size effects with parity effects. One recent study uses an instrumental variable (sex mix of the first two children) to examine the effect of family size increases on sibling educational outcomes, and finds that with the transition from two to three children, the middle child is the one that suffers from less parental monetary investment and greater academic risk of being held back a grade (Conley and Glauber 2004). However, the outcome measures for this study are less than ideal—particularly since the academic progress measure is such a rare event (measured as occurring among less than one percent of the children in the sample). We will test the middle child hypothesis with respect to behavioral and cognitive outcomes.

Data and Methods

Our analysis draws on data from the Panel Study of Income Dynamics (PSID), which is a nationally representative sample of households and individuals in the United States. The PSID began in 1968 and presently continues to follow families and individuals. The PSID collects information from both individuals and families, primarily focusing on economics and demographics, including income, employment, family composition, and residential location. Research (Fitzgerald, Gottschalk, & Moffitt 1998) indicates that when the weights are used, the sample is representative of individuals and families in the United States.

We also use data from the Child Development Supplement (CDS) to the PSID. Until 1997, information collected by PSID researchers about young children in PSID households was limited to age, sex, and schooling. However, with a grant from the National Institute of Child Health and Human Development, researchers for the PSID were able to collect extensive data regarding children's home environment, family, time-use at home and school, school and daycare environment, and other cognitive, behavioral, physical, and emotional measures for up to two randomly selected children aged 0 to 12 living in PSID households.. The CDS surveys were administered during the school year from March 1997 through December 1997. In total, 2,380 households containing 3,563 children were surveyed with a response rate of 88%. In order to make the sample representative of American children under the age of 13 in 1997, survey weights were added to the dataset.

We restrict our analyses to black and white children. The PSID includes an oversampling of low-income, black families, which permits the comparison of black and white families. Other racial and ethnic groups, however, do not have adequate samples for inclusion in the analysis. The analysis is also restricted to children aged 6 to 12 in most models, and children aged 3 to 12 in some models, depending on the outcome variable of interest. Finally, we restrict our analysis to sibling pairs. As mentioned earlier, in the CDS, a maximum of two children per household were included. Households with only one child selected for the survey are excluded.

Our analysis will include two types of models. First, to capture between-family effects, OLS regressions of various sibling differences will be used. The main dependent variables of interest for these models include sibling differences in cognitive and behavioral outcomes. In each model, several variables will be used to explain sibling differences on the various indicators. The influence of sibling differences in age, sex, and birth weight will be considered, as well as family background indicators, including race, family structure, maternal education, family income and wealth, head's occupational prestige, and mother's work hours. Since each "case" in these models represents a sibling pair, family weights constructed specifically for use with the CDS will be used in the analyses.

Second, to capture within-family effects, fixed effects models will be used. The fixed effects models permit one to investigate the influence of within-family sibling differences on individual outcomes. In these analyses, the influence of sibling differences in birth order, gender, and birth weight on the achievement, behavioral, and time use outcome variables are considered. Since these models control for fixed family-level effects, variables that are the same for both siblings in a family, including most family background indicators like family income, wealth, and parental education, drop out of the analysis. Clustering will be used in these models to account for the non-independence of cases resulting from the nesting of sibling pairs in families. The child-level weight for the CDS will also be used in the analysis.

Measures

Child cognitive outcomes are measured using the Woodcock-Johnson Revised (WJ-R) Tests of Achievement (Woodcock & Johnson 1989). The WJ-R test is a measure of children's achievement. A Letter-Word Identification test and an Applied Problems test were given to children aged 3 to 12. A Passage Comprehension test and a Calculation test were given to children aged 6 to 12. In addition, for children aged 6 to 12, the Letter-Word and Passage Comprehension tests were combined to create a Broad Reading score. Likewise, the Calculation and Applied Problems tests were combined to create a Broad Math score for children aged 6 to 12.

Behavioral outcomes are measured using the Behavior Problems Index (BPI), which is a scale that is used to measure the occurrence and intensity of children's behavior problems (Peterson & Zill 1986). For each child, the primary caregiver was asked whether 30 problem behaviors were often, sometimes or never true for the child. The scale is based on these responses.

Sibling Differences are measured by taking the absolute difference of the values of the two siblings on a particular variable. For sex, dummies are used to represent the different sex compositions of the sibling pairs, with opposite sex siblings the suppressed category. Birth order indicators, measured by dummies for oldest and youngest children, are included in the fixed effects models. For models including families with only two siblings, only the oldest dummy is included and the youngest child category is suppressed. For models including sibling pairs who have at least three siblings in the family, both the oldest and youngest dummies are included, with middle child as the suppressed category.

Basic demographic information is drawn from the CDS, including child's age (the difference of which is our measure of spacing)[5], sex, race, and birth weight. In addition, several family characteristics are included in the analysis. Dummies are created for family structure, which include single parent household, both-biological parents present (omitted), and other family type. Also, the average number of hours that the mother works per week is included, as well as a dummy for mothers who are not working. Finally, a measure for the number of children under the age of 18 living in the household is included.

Socioeconomic measures are based on several indicators. Most studies measuring socioeconomic status define it as being solely income or parental education (Jeynes 2002). Because socioeconomic status is a much richer concept, it is measured more comprehensively in the present study by mother's education, head's occupational prestige score, average income, and average wealth. Mother's (or primary caregiver's) education is a measure of the years of completed education, top coded at 17 years signifying any graduate work completed. Occupational prestige of the household head is measured using a prestige scale based on the Hodge-Siegel-Rossi Prestige Scores (Hodge, Siegel and Rossi 1966). The General Social Survey updated the scale to correspond with the 1970 U.S. Census occupational classification scheme, which is what the PSID uses to classify

[5] Albeit, only spacing between the two focal children in the survey; ideally, we would have preferred a measure of variance for all the children in the household.

occupations (General Social Survey 2004). Nonworking heads are given a zero on the prestige scale. A dummy is also used to capture nonworking heads.

Total family income is measured using a five-year average of total family income adjusted to 1997 dollars using the Consumer Price Index. These data were collected from the 1993 to 1997 waves of the PSID. A five-year average of total family income is used because multiple year indicators of family income have been shown to be more reliable than single year indicators (Duncan 1988). Average income was bottom-coded at zero dollars and scaled by 10,000. The natural logarithm was taken from the final average to adjust for skewness in the distribution. Finally, average wealth is measured by averaging the total family net worth in 1994 and 1999, the years in which the PSID includes a wealth supplement. Wealth is measured by summing the total assets of the family, including home, real estate, bank accounts, stocks and bonds, vehicles, and farm/business and subtracting the family's debts, excluding mortgages. Average wealth was adjusted to 1998 dollars and bottom-coded at zero. The natural logarithm of the average wealth was taken to adjust for skewness in the distribution. Finally, a dummy was created for those families with no wealth.

Results

Behavioral and Achievement Outcomes

Sibling difference models were estimated to capture between-family effects on sibling differences in achievement and behavioral outcomes. Table 1 presents the sibling correlations for the various achievement and behavioral problem outcome variables, as well as age and birth weight. As evident in the table, there is quite a bit of variation between siblings on the achievement and behavioral indicators, with correlations ranging from .284 on the Passage Comprehension scores to .441 for the Broad Reading scores. The following models attempt to shed light on these sibling differences, using sibling characteristics, family background, and family SES variables as explanatory factors.

[Table 1 about here]

Table 2 presents the descriptive statistics for the variables used in these models. Using OLS regression, sibling differences in the outcome variables are regressed on sibling differences in demographics, including age, birth weight, and the sex composition of the sibling pair, as well as constant family background characteristics, including race, family structure, and number of siblings, and family SES measures, including maternal (or primary caregiver) education, family income and wealth, head's occupational prestige and work status, and maternal (or primary caregiver) work hours. The sibling means for each outcome variable are controlled in each model.

[Table 2 about here]

The first outcome of interest is sibling differences in the Behavioral Problems Index. The model in Table 3 suggests that our sibling and family background factors explain some of the sibling differences in behavioral problems. Having two female siblings significantly increases sibling differences in behavioral problems, on average, by more than one point on the BPI, relative to male-female sibling pairs. Thus, sisters tend to have larger differences in behavior problems, with a 7.03 point difference on average, compared to brother-sister sibships, which have a 5.88 point difference on average. With all the control variables held at the means, female-only sibships have sibling differences in behavior problems that are almost 20 percent larger than male-female sibships. On the other hand, brothers have significantly smaller sibling differences in behavioral problems compared to brother-sister sibships. On average, the sibling differences on the BPI are more than one point smaller for brothers relative to brother-sister sibships. At the means for all the control variables, male-only sibships have a 5.85 point difference on the BPI, compared to a 7.05 point difference for male-female sibships. Male-only sibships have about a 17 percent smaller sibling difference in BPI scores on average relative to male-female sibships.

Concerning family background characteristics, number of siblings is significant, with each additional sibling increasing sibling differences on the BPI index by more than half a point. Children with only one sibling have about a six point difference on the BPI index (at the means of the control variables), while children with three siblings have a more than seven point difference on the BPI index, an increase of almost 20 percent.

[Table 3 about here]

Family SES measures are not successful in explaining sibling differences in behavior problems. The sibling BPI mean variable is significant and positive. Thus, siblings with higher average behavioral problem scores tend to have larger sibling differences. Overall, the model is fairly successful in explaining sibling differences in BPI, accounting for approximately 27 percent of the total variance in sibling differences in behavioral problems. In sum, sibling and family background characteristics appear to be more important than family SES in explaining sibling behavioral problem differences. The importance of controlling for sibling means on the BPI index is also evident.

Turning to sibling differences in reading outcomes, presented in Table 4, the models are not as successful in explaining sibling differences in these achievement tests. In terms of sibling factors, only sibling difference in birth weight appears to positively and slightly increase sibling differences in the Letter-Word Assessment, with each additional pound of difference in birth weight leading to an increase of about one and a half points on the sibling differences for the Letter-Word Assessment. Siblings with a one pound difference in birth weight have sibling differences in the assessment that are about 10 percent larger siblings with no difference in birth weight (an increase from 14.91 to 16.42 points about the means).

Like sibling background characteristics, family characteristics do not consistently explain sibling differences in the reading assessments. Race and nontraditional family structure appear to be significant in explaining sibling differences on some of the reading scores. Black sibling pairs, on average, have sibling differences on the Passage Comprehension test that are almost five points smaller than white sibling pairs. Thus, sibling differences for black siblings are more than 27 percent smaller than white sibling differences (a decrease from 17.38 to 12.65 points about the means). Also, nontraditional family structure increases sibling differences on the Broad Reading test by more than 8 points, relative to traditional families with both parents present. On average, this is an increase of more than 80 percent (from 10.19 to 18.42 points about the means).

As in the case of the BPI models, family SES seems to be of limited importance in explaining sibling differences in the various reading test scores. Head occupational prestige is significant, with higher prestige generally leading to smaller sibling differences in the Letter-Word Assessment scores. This effect is best illustrated by examining the difference between specific occupations and their influence on sibling differences in the Letter-Word Assessment. For instance, we could compare the effects of occupations with a prestige score of 30, including file clerks, painters, and construction and maintenance workers, with occupations with a prestige score of 60, including veterinarians, chiropractors, and authors. Siblings with household heads holding the latter occupations have sibling differences that are almost 30 percent smaller than siblings with a household head employed as a painter or a file clerk (from 18.36 to 12.96 points about the means).

The sibling means for the Letter-Word Assessment and the Passage Comprehension test are significant. Siblings with higher mean test scores have significantly larger sibling differences on the Letter-Word Assessment, but smaller differences on the Passage Comprehension test.

[Table 4 about here]

In sum, our sibling, family background, and family SES measures are not especially successful in explaining sibling differences in these reading test outcomes. While we have found some between family differences that explain sibling differences in some of the reading outcomes, there does not appear to be a strong and consistent pattern. None of the models explains more than ten percent of the variance in sibling differences in reading scores.

Unlike the reading models, there is a more consistent pattern of between family differences explaining sibling differences in the various math achievement outcomes. The results of these models are presented in Table 5. In general, the sibling and family background characteristics provide limited explanation for sibling differences in math scores. Two sibling characteristics significantly explain sibling differences in some math assessment scores. Sibling age difference negatively influences sibling differences in the Calculation test. Each additional year of sibling age difference decreases sibling differences on the Calculation test by more than one point. When holding other variables at their means, a sibling age difference of four years decreases sibling differences on the Calculation test by almost 15 percent compared to a sibling difference of two years (from 16.93 to 14.41 points about the means). Also, sibling difference in birth weight has a positive influence on sibling differences in Applied Problems scores. Each additional pound for sibling difference in birth weight increases sibling differences in Applied Problems by almost one and a half points. An increase in birth weight differences from 0 to 2 pounds would yield about a 20 percent increase in sibling differences on the Applied Problems test (from 14.03 to 16.77 about the means). Concerning family characteristics, none of the family background indicators is significant in explaining sibling differences in math outcomes.

[Table 5 about here]

In contrast to the sibling and family background factors, family socioeconomic status proves to be relatively important in considering sibling differences in math outcomes, but different socioeconomic indicators appear to operate in different ways. Head's occupational status appears to have the most consistent influence on sibling differences in math assessment scores. Head occupational prestige negatively influences sibling differences in all three math outcomes. Using our prior example, children with household heads who work as a veterinarian, author, or chiropractor have sibling differences in Broad Math scores that are about 38 percent smaller relative to children with heads working as a file clerk or construction worker (from 19.76 to 12.26 about the means).

Interestingly, sibling pairs with a nonworking head of household also have reduced differences in Applied Problems and Broad Math scores, by about 6 points and 10 points respectively, relative to siblings with a working head of household. Setting the control variables at their means, siblings with a nonworking head have sibling differences in Broad Math scores of about 21 points, compared to siblings with working heads who have about an 11 point difference on those scores, a decrease of approximately 47 percent. The negative coefficient for nonworking head combined with the negative coefficient for occupational prestige suggests a possible curvilinear relationship between occupational status and sibling differences in math outcomes, with those heads of household at the extremes (high occupational prestige and unemployed) begetting smaller sibling differences in math outcomes, while those heads in the middle or low prestige range tend to have a positive effect on sibling differences in math outcomes. Obviously, this result is suggestive rather than conclusive.

Both average income and wealth are significant in explaining sibling differences in some of the math outcomes. The log of average income has a positive and significant effect on sibling differences in Broad Math scores. Thus, siblings with higher family incomes tend to have larger differences for that test outcome. An increase in average log income from one standard deviation below the mean to one standard deviation above the mean yields a 52 percent increase in sibling differences in Broad Math scores (from 12.70 to 19.32 points about the means). Average wealth also significantly increases sibling differences in Applied Problems scores. An increase in average log wealth from one standard deviation below mean wealth to one standard deviation above the mean increases sibling differences in Applied Problems scores by about 60 percent (from 11.86 to 18.94 about the means).

On the other hand, having no wealth also significantly increases sibling differences in Applied Problems and Broad Math scores. Siblings in families with no wealth tend to have much larger test score differences than siblings in families with at least some wealth. This difference amounts to almost ten points on the Applied Problems test and almost sixteen points on the Broad Math test. Holding the control variables at their means, siblings of parents with at least some wealth have about an 8 point difference on Broad Math scores, while siblings of parents with no wealth have an almost 24 point difference in those scores, an increase of almost 200 percent. Since both the log of average wealth and the no wealth coefficients are significant in a positive direction on some of the math outcomes, this also suggests a possible curvilinear relationship between wealth and sibling differences in math outcomes, with those at the lowest and highest ends of the wealth continuum having larger sibling differences than those with more average levels of wealth. Again, this finding is merely suggestive, not conclusive.

In addition, the primary caregiver's weekly work hours coefficient is also significant. Siblings with mothers (or primary caregivers) who work more hours tend to have smaller sibling differences in Applied Problems scores than siblings with mothers who work less. When the control variables are at their means, siblings with a mother working part-time at 15 hours a week have about a 17 point difference in Applied Problems scores, while siblings with a mother working full-time at 40 hours a week have an almost 14 point difference on the scores, a decrease of about 19 percent. Finally, note that the sibling test means for the Applied Problems and Broad Math scores are significant and negative.

In sum, family SES measures appear to be more successful in explaining sibling differences in various math outcomes. Nevertheless, there is no conclusive finding that higher family SES has a positive or negative influence on sibling differences in math outcomes. Instead, the different SES indicators appear to operate in different ways, and some of the SES indicators may have a curvilinear relationship with sibling differences in math outcomes. Overall, the math models explain between eight and twelve percent of the variance in sibling differences on the math assessments.

[Table 6 about here]

Given the findings of significant between family effects on sibling differences in achievement and behavioral outcomes, we now investigate possible within family differences influencing sibling differences in behavior problems and achievement. We run fixed effects models for each of the behavioral and achievement outcomes. Since these are family fixed effects models, any common family factors that sibling pairs share drop out of the models. Thus, only individual sibling characteristics are examined, including birth order, sex, and birth weight. The descriptive statistics for the variables included in the models are presented in Table 6.

[Table 7 about here]

The results for the first family fixed effects models are presented in Table 7. In addition to clear between family effects on sibling differences in some of the achievement and behavioral outcomes, there are also within-family effects on sibling achievement and behavioral differences. As evident in the BPI model, sisters are significantly less likely than their brothers to have behavioral problems. With the control variables at their means, brothers have a BPI of about 41, while their sisters have a BPI of about 39, a decrease of almost 5 percent.

In terms of achievement, oldest siblings, on average, score higher than youngest siblings on the Letter-Word Identification, Broad Reading and Applied Problems Assessments. On the Letter-Word test, oldest siblings score more than seven points higher than their younger siblings. This amounts to a more than seven percent increase in Letter-Word test scores (from 101.24 to 108.92 about the means). For the Broad Reading and Applied problems tests, the oldest sibling effect is slightly smaller, increasing their scores about four percent compared to their youngest or middle siblings (about the means).

[Table 8 about here]

In order to tease out different effects for both oldest and youngest siblings relative to their middle siblings, we constructed additional models, but restricted the sample to children who have at least two siblings. The results are presented in Table 8. In several respects, the results are similar to those in the previous models. Sisters are still less likely than their brothers to have behavioral problems. About the means, the effect is similar, with sisters having almost a 5 percent decrease in the BPI relative to their brothers.

In addition, the oldest sibling advantage is still present on the Letter-Word, Broad Reading, and Applied Problems test scores, relative to middle siblings. Moreover, youngest siblings score about 4 points less than their middle siblings on the Letter-Word assessment. About the means, oldest siblings have about a nine percent increase in their Letter-Word scores relative to their middle siblings (from 100.46 to 109.7). For the Broad Reading and Applied Problems scores, oldest siblings score about seven percent higher than their middle siblings when the control variables are at their means. Finally, youngest siblings score about 4 percent lower on the Letter-Word test relative to their middle siblings (from 107.10 to 103.06 about the means). Given the positive coefficient for oldest siblings and the negative coefficient for youngest siblings in the Letter-Word model, the relationship between birth order and Letter-Word score appears to be linear, with oldest siblings scoring better than middle siblings and middle siblings scoring better than youngest siblings.

In these restricted models, birth weight also becomes significant for the Passage Comprehension and Broad Reading tests. Children with a higher birth weight relative to their siblings have a test score advantage over their lower birth weight siblings. Each pound advantage over the lower birth weight sibling yields a more than three point advantage on these test scores. A sibling with a two pound birth weight advantage over his or her sibling yields Passage Comprehension and Broad Reading test scores that are more than 6 percent higher than those of the lower birth weight sibling (about the means).

In sum, the fixed effects models suggest that oldest siblings have an advantage over their younger siblings on several of the math and reading tests. In addition, higher birth weight siblings appear to have an advantage over their lower birth weight siblings on some of the reading tests, but this finding is only significant in the sample of children with two or more siblings. Finally, the findings show that sisters are less likely than their brothers to have behavioral problems.

Time Use

Given the significant findings from the sibling behavior and achievement models, additional analyses are conducted to investigate possible sibling differences in time use which might help explain these and other outcomes. To this end, we examine if siblings differ significantly in their time spent with kin (non resident family that is not the siblings' parent, step-parent, or step-sibling) or their time in organized activities (e.g. team sports, dance lessons, etc.).[6] While siblings have correlations of about .75 for the total time spent with kin per week, sibling correlations for organized activities are much lower, at approximately .55 (not shown).[7] To further assess these differences, models

[6] Data measuring children's use of time were obtained from the CDS time diaries. These "time diaries" are chronological reports of a child's time use during a 24 hour period. Children, or their primary caregivers (depending on the age of the child), recorded their activities for one random weekday and one random weekend day using an open ended format. In addition to recording the starting and ending time of an activity, the children also reported who they were with, where they were at the time, and if they were doing a secondary activity.

[7] Tables are available from the authors upon request.

similar to those for the behavioral and achievement outcomes are run. Although between family differences such as wealth and occupational prestige explain some sibling differences, the fixed effects models indicate that no within family characteristics, such as birth order or birth weight, are successful in predicting time use. Thus, the results of the time use models are not consistent with the results of the behavioral and achievement outcomes. While within family characteristics are successful in explaining sibling differences in the behavioral and achievement models, these measures do not adequately predict sibling differences in time use.

Discussion

Most research on child behavioral and cognitive outcomes focuses on the impact of variables measured across families—holding a number of other characteristics constant. More recently, family fixed effects approaches have been deployed to examine the impact of a number of family characteristics that vary over time on child outcomes. These have included parental age, income, and even family size. An assumption of these models is the constancy of unmeasured family background effects across children. We test this assumption by predicting the difference in child outcomes between siblings by a number of family demographic and economic characteristics. We also use family fixed effects to asses the importance of a number of child-specific measures on these outcomes, including birth weight, birth order and gender.

Results show that overall, sibling correlations in early childhood behavioral and cognitive outcomes are weaker than might be expected by social reproduction models, ranging from .284 for reading passage comprehension to .441 for broad reading score, with math, behavioral and other verbal measures falling within that range. The behavioral problems index demonstrates a sibling correlation of .395; the broad math score sibling correlations is .376; and, as already mentioned, the broad reading score intra-class correlation is .441. This is a relatively narrow range that should not be over interpreted. The differences could stem from the fact that reading is more sensitive to parental environmental influences than is math or behavioral problems; however, this is pure speculation. The differences, in fact, may be entirely due to measurement error variability in the sample.

Given this significant overall degree of disparity within families on these developmental outcomes, we next modeled the difference by family background characteristics. This was done by predicting the difference in score between the two sample siblings, holding constant the mean level (though excluding the mean score from the analysis does not change the results). In general, most background predictors were not consistently predictive across models or outcomes. However, parental occupational prestige is an exception in this regard. Siblings from families where the household head's occupational prestige is greater tend to turn out more similarly on cognitive measures, particularly math scores (however, there does not appear to be an effect of occupational prestige on the behavioral problems index). Class, SES, or social status (whichever underlying theoretical variable parental occupational prestige is reflecting), would seem to buy equality within the home, a finding that is consistent with the qualitative research of Conley (2004), where he argued that low status families invest most heavily in children who they deem to have the most promise (thereby exacerbating differences) while advantaged families tend to invest more heavily in those they deem "laggards" in an effort to "buy" equality of outcomes. We should be tentative, however, in accepting this hypothesis since the actual economic variables—family income and wealth—were generally not significant. However, we must keep in mind that we were controlling for a host of economic and associated variables, making their potential marginal impact small.

Finally, within-family sibling comparisons reveal that first born children generally outperform their younger siblings on age-adjusted tests, but other child-specific measures such as gender and birth weight are not consistently significant across outcomes. This finding merits further attention in the child development literature, since previous birth order research has typically confounded sibship size effects with parity and/or not examined developmental outcomes, instead focusing on personality measures (or adult socioeconomic outcomes).

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Table 1. Sibling Correlations

Variable	Correlation	N (sibling pairs)
Age	0.607	680
Birth weight	0.560	673
Behavior problems index	0.395	635
Letter-word score	0.394	525
Passage comprehension	0.284	321
Broad reading score	0.441	321
Calculation	0.322	317
Applied problems	0.335	521
Broad math score	0.376	317

Table 2. Descriptive Statistics for Sibling Difference Models of Behavior and Achievement Outcomes

Variable	N (Sibling pairs)	Mean	SD
Background characteristics			
Birth Weight (individuals)	1350	7.48	1.35
Sibling difference in birth weight (lbs)	673	0.91	0.88
Age (individuals)	1360	7.59	2.60
Sibling difference in age	680	2.89	1.59
Race			
Black (white omitted)	680	0.19	0.39
Gender			
Same gender siblings: girls	680	0.25	0.43
Same gender siblings: boys	680	0.29	0.45
(opposite sex siblings omitted)			
Family Characteristics			
Single parent household	680	0.24	0.43
Other family	680	0.07	0.25
(both biological parents omitted)			
Number of hours worked per week, primary caregiver	680	27.28	19.59
No work hours for primary caregiver	680	0.24	0.43
Number of children	680	2.62	0.85
SES Measures			
Mother's education	676	13.34	2.16
Occupational prestige of head of household	655	39.48	17.56
Head no work dummy	655	0.06	0.24
Natural logarithm of 5-year average income	671	1.46	0.81
Natural logarithm of average wealth	677	9.55	3.81
No wealth dummy	677	0.11	0.32
Behavioral and Achievement Outcomes			
Behavioral problem index			
sibling difference	635	6.45	6.30
sibling mean	635	39.98	6.82
Letter-word identification			
sibling difference	525	15.66	13.19
sibling mean	525	105.48	15.02
Passage comprehension			
sibling difference	321	15.01	11.88
sibling mean	321	105.99	12.78
Broad reading			
sibling difference	321	14.30	11.78
sibling mean	321	106.45	14.70
Calculation			
sibling difference	317	15.67	13.37
sibling mean	317	103.22	14.29
Applied problems			
sibling difference	521	15.40	12.30
sibling mean	521	109.48	13.83
Broad math			
sibling difference	317	16.01	13.43
sibling mean	317	107.42	15.45

Table 3. Sibling Difference Models for Behavior Problems Index (BPI)

	Model 1	
Background Characteristics		
Age, sibling difference	-0.01	
	(.14)	
Same sex siblings: girls	1.15	*
	(.55)	
Same sex siblings: boys	-1.20	*
	(.54)	
Birth weight, sibling difference (lbs)	-0.03	
	(.26)	
Family Characteristics		
Black	-0.44	
	(.67)	
Single parent	-0.46	
	(.68)	
Other family	-0.47	
	(1.01)	
Sibling number	0.57	*
	(.27)	
SES Measures		
Mother's education	0.06	
	(.13)	
Head occupational prestige	-0.01	
	(.02)	
Nonworking head	1.77	
	(1.23)	
Log of average income	0.37	
	(.49)	
Log of average wealth	0.16	
	(.17)	
No wealth dummy	1.73	
	(1.73)	
Primary caregiver work hours per week	0.02	
	(.02)	
Primary caregiver not working	0.10	
	(.88)	
BPI mean	0.45	***
	(.03)	
Constant	-16.43	
	(2.87)	
R^2	0.27	
N (individual)	1204	
N (sibling pairs)	602	

*p<.05, **p<.01, ***p<.001

Note: Standard errors in parentheses.

Table 4. Sibling Difference Models for Reading Assessments

	Letter-Word Assessment		Passage Comprehension		Broad Reading	
Background Characteristics						
Age, sibling difference	-0.07		-0.14		-0.45	
	(.38)		(.54)		(.54)	
Same sex siblings: girls	0.16		1.62		1.10	
	(1.48)		(1.67)		(1.68)	
Same sex siblings: boys	1.48		1.45		1.85	
	(1.4)		(1.67)		(1.68)	
Birth weight, sibling difference (lbs)	1.51	*	1.13		1.53	
	(.68)		(.82)		(.82)	
Family Characteristics						
Black	-0.32		-4.73	*	-2.94	
	(1.81)		(2.18)		(2.19)	
Single parent	2.84		-0.54		3.10	
	(1.88)		(2.29)		(2.29)	
Other family	4.13		5.73		8.23	**
	(2.58)		(3.32)		(3.31)	
Sibling number	0.50		-0.14		1.16	
	(.73)		(.92)		(.94)	
SES Measures						
Mother's education	0.66		0.68		0.50	
	(.35)		(.41)		(.41)	
Head occupational prestige	-0.09	*	-0.06		-0.10	
	(.05)		(.06)		(.06)	
Nonworking head	-5.01		4.51		-0.57	
	(3.29)		(4.54)		(4.56)	
Log of average income	-0.70		0.43		0.86	
	(1.4)		(1.66)		(1.66)	
Log of average wealth	0.01		0.23		0.10	
	(.46)		(.54)		(.55)	
No wealth dummy	-1.15		5.25		0.96	
	(4.61)		(5.59)		(5.62)	
Primary caregiver work hrs/week	0.04		0.02		-0.05	
	(.05)		(.06)		(.06)	
Primary caregiver not working	-1.60		-1.99		-4.19	
	(2.25)		(2.84)		(2.85)	
Test mean	0.21	***	-0.12	*	0.03	
	(.05)		(.06)		(.06)	
Constant	-14.70		17.19		3.57	
	(7.48)		(9.67)		(9.15)	
R^2	0.08		0.08		0.06	
N (individual)	1006		620		620	
N (sibling pairs)	503		310		310	

*p<.05, **p<.01, ***p<.001
Note: Standard errors in parentheses.

Table 5. Sibling Difference Models for Math Assessments

	Calculation Assessment		Applied Problems		Broad Math	
Background Characteristics						
Age, sibling difference	-1.26	*	0.37		-0.94	
	(.62)		(.34)		(.6)	
Same sex siblings: girls	-0.33		-0.60		-1.22	
	(1.97)		(1.29)		(1.92)	
Same sex siblings: boys	-2.75		1.71		-0.50	
	(1.91)		(1.24)		(1.87)	
Birth weight, sibling difference (lbs)	-0.01		1.37	*	-0.33	
	(.94)		(.6)		(.92)	
Family Characteristics						
Black	-3.01		1.36		-1.46	
	(2.51)		(1.6)		(2.44)	
Single parent	1.66		2.39		4.70	
	(2.62)		(1.65)		(2.54)	
Other family	1.05		0.97		2.59	
	(3.78)		(2.26)		(3.67)	
Sibling number	-0.38		-0.47		-0.92	
	(1.05)		(.63)		(1.03)	
SES Measures						
Mother's education	0.70		0.31		0.31	
	(.47)		(.31)		(.46)	
Head occupational prestige	-0.14	*	-0.12	**	-0.25	***
	(.07)		(.04)		(.06)	
Nonworking head	-9.59		-6.01	*	-9.91	*
	(5.18)		(2.92)		(5.07)	
Log of average income	-0.33		0.49		4.09	*
	(1.9)		(1.23)		(1.86)	
Log of average wealth	0.49		0.93	*	1.10	
	(.63)		(.41)		(.61)	
No wealth dummy	5.87		9.88	*	15.87	**
	(6.45)		(4.05)		(6.29)	
Primary caregiver work hrs/week	0.01		-0.13	***	-0.12	
	(.07)		(.04)		(.07)	
Primary caregiver not working	0.76		-2.00		-2.45	
	(3.33)		(2.)		(3.25)	
Test mean	-0.12		-0.09	*	-0.14	*
	(.06)		(.04)		(.06)	
Constant	24.19		17.44		27.07	
	(10.23)		(6.67)		(9.84)	
R^2	0.07		0.08		0.12	
N (individual)	610		998		628	
N (sibling pairs)	305		499		305	

*p<.05, **p<.01, ***p<.001

Note: Standard errors in parentheses.

Table 6. Descriptive Statistics for Sibling Fixed Effects Models

Variable	N	Mean	SD
Behavior problems index	1305	39.97	8.19
Letter-word score	1077	105.08	18.17
Passage comprehension	837	105.90	15.96
Broad reading	837	106.19	17.40
Calculations	832	103.42	17.79
Applied problems	1072	109.34	17.09
Broad Math	831	107.42	18.96
Oldest	1320	0.32	0.47
Middle	1320	0.28	0.45
Youngest	1320	0.40	0.49
Female	1360	0.47	0.50
Birth weight	1350	7.48	1.35

Table 7: Sibling Fixed Effects Models for Behavior and Achievement Outcomes

	BPI	Letter-Word Identification	Passage Comprehension	Broad Reading	Calculation	Applied Problems	Broad Math
Oldest	0.81	7.68 ***	1.27	4.41 **	-0.64	4.01 **	1.05
	(0.61)	(1.43)	(1.84)	(1.72)	(2.14)	(1.37)	(2.12)
Female	-1.82 **	2.81	2.95	3.20	-1.38	-2.62	-2.58
	(0.65)	(1.65)	(2.01)	(1.91)	(2.45)	(1.68)	(2.38)
Birth weight (lbs.)	0.78	0.88	1.62	1.97	-1.70	0.11	-0.36
	(0.49)	(1.25)	(1.41)	(1.53)	(1.34)	(0.93)	(1.22)
Constant	34.75	94.75	91.29	88.03	116.62	108.48	110.80
	(3.72)	(9.59)	(10.91)	(11.86)	(10.74)	(7.05)	(9.56)
N (Individuals)	1246	1024	559	557	553	1017	549
R^2	0.72	0.72	0.66	0.74	0.67	0.70	0.70

*p<.05, **p<.01, ***p<.001

Note: Robust standard errors in parentheses.

Table 8: Sibling Fixed Effects Models for Behavior and Achievement Outcomes (Children with Two or More Siblings)

	BPI	Letter-Word Identification	Passage Comprehension	Broad Reading	Calculation	Applied Problems	Broad Math
Oldest	-1.49	9.24 ***	2.26	6.73 *	3.67	7.72 **	5.92
	(1.12)	(2.46)	(3.21)	(3.20)	(4.28)	(2.59)	(4.15)
Youngest	-1.05	-4.04 *	1.84	-1.30	1.61	-1.46	0.67
	(0.84)	(2.01)	(2.35)	(2.16)	(2.55)	(2.22)	(2.76)
Female	-1.90 *	3.44	3.69	3.85	-1.34	-2.98	-2.53
	(0.86)	(2.09)	(2.47)	(2.40)	(3.34)	(2.32)	(3.19)
Birth weight (lbs)	0.64	1.54	3.34 *	3.41 *	-0.82	1.37	0.89
	(0.64)	(1.44)	(1.38)	(1.51)	(1.74)	(1.16)	(1.57)
Constant	36.79	88.97	75.16	74.51	106.65	97.71	97.85
	(4.82)	(11.01)	(10.91)	(11.84)	(13.81)	(9.06)	(12.55)
N (Individuals)	752	622	349	347	348	616	344
R^2	0.73	0.73	0.70	0.75	0.66	0.70	0.69

*p<.05, **p<.01, ***p<.001

Note: Robust standard errors in parentheses.