Child Cognitive Achievement Gaps: The Role of Family Structure and Maternal Locus of Control in Parental Investment

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Abstract:

Little exploration has been done to determine the impact of family structure on parental investment decisions and how gaps in children's cognitive achievement are affected in turn. To examine the role of family structure, this paper estimates the production function for children's cognitive achievement using a value-added specification with instrumental variables estimation. A novel feature of this research is that variation in family structure and maternal locus of control are exploited in an effort to account for the endogeneity of parental investment and children's cognitive performance. Applying my methodology to data from the National Longitudinal Survey of Youth 1979 and the corresponding Child/Young Adult survey from 1988 to 2004, I find that family structure has a substantial impact on parental investment. The impact of maternal locus of control on parental investment is modest, except for separated/divorced mothers living with new partners. Gaps in parental investment due to family structure and maternal locus of control consequently contribute to reading achievement gaps, but the same conclusion cannot be made for math achievement. I additionally find that ordinary least squares estimates are biased downward due to the failure to account for feedback effects between investment and achievement, but the differences with instrumental variables estimates are not as pronounced as expected.

I. Introduction

The importance of the early formation of cognitive and non-cognitive skills to future socioeconomic success has become a well-accepted fact. However, work is still required to understand the creation and persistence of gaps in child outcomes, as children grow up in unique environments that affect their development. Given that family structure is a major part of a child's life over which the child has no control, researchers have sought to understand its role in child development. Gaps in cognitive achievement on the basis of family structure are apparent for children as young as six and seven years old. According to data from the National Longitudinal Survey of Youth Child/Young Adult cohort (NLSY C/YA), the gaps in achievement on math tests and on reading tests between six- to seven-year-old children in non-blended households with two parents and those in single-mother households are approximately 0.30 and 0.25 standard deviations, respectively.[1] By the ages of eight and nine years, these gaps grow by 20-55%, yielding a gap of 0.36 standard deviations for math scores and 0.39 standard deviations for reading scores. Gaps between children in non-blended households and those in blended households are not as large at ages six to seven but can increase by as much as 165% by the ages of eight to nine years.

To examine the achievement gaps that arise between children from different family structures, this paper estimates the production function for children's cognitive achievement using instrumental variables (IV) estimation. Instead of treating family structure as a direct determinant of cognitive achievement as is standard in the literature, I adopt the view that family structure impacts the formation of cognitive skills only through its influence on parental investments. The adoption of this view is supported by the results of initial tests that indicate family structure has no direct effect on children's cognitive achievement, which consequently allows family structure to be used as an instrument for parental investments. In conjunction with maternal locus of control, this allows me to address the issue of endogenous parental investments when estimating child achievement. At the same time, IV estimation isolates the parental investment problem from the cognitive achievement production function for determining the impact of family structure on children's cognitive achievement through the investment channel.

There is substantial evidence in the literature that family structure affects child outcomes related to both cognitive and non-cognitive skills.[2] Disparate outcomes for children in non-intact family structures are often attributed at least in part to a lack of resources, such as time and money, especially for single parents.[3] Some researchers argue that the differences in child outcomes have more to do with the selection of parents into certain family structures – low-income, low-educated, and racialized individuals tend to select into non-intact family structures.[4] These researchers find that the effects of family structure shrink or disappear if selection is properly addressed. Despite results that suggest family structure matters in terms of what parents can provide for their child,

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[1] These gaps and the following gaps are calculated using data on the sample in my analysis. Similar gaps in the reading and math achievement of elementary school children between two-parent and single-parent households are reported by Magnuson and Berger (2009) using NLSY data, and in reading achievement for these groups by Milne et al. (1986) using data from the Sustaining Effects of Title I. Larger reading and math achievement gaps are reported by Carlson and Corcoran (2001) using NLSY data.

[2] See Lee and McLanahan (2015); Magnuson and Berger (2009); Ram and Hou (2003); Thomson, Hanson, and McLanahan (1994); and Astone and McLanahan (1991).

[3] See Ram and Hou (2003); Thomson, Hanson, and McLanahan (1994); Astone and McLanahan (1991); and Milne et al. (1986).

[4] See Hannan and Halpin (2014); Bjoerklund, Ginther, and Sundstroem (2007); Aughinbaugh, Pierret, and Rothstein (2005); and Carlson and Corcoran (2001).

none of these papers consider that underlying gaps in parental investments may drive cognitive achievement gaps between children from different family structures.

Just including family structure by itself as a predictor of parental investments may provide an incomplete view of its role in these decisions. Much of the investment gap can likely be explained by differences in resources, as suggested by existing evidence. For this reason, I also consider the role of a non-cognitive skill of the parents called locus of control (LC) in parental investment decisions. In turn, this effect may vary across family structures. LC is defined as the extent to which an individual believes they have control over their own life outcomes. The incorporation of LC in social science research has recently grown. LC has been used to explain individuals' financial investment decisions, job search efforts or sorting into certain jobs, and behaviour in romantic relationships, as it encompasses the control an individual believes they have over returns to their actions.[5] Despite the apparent role of LC in determining the investment of one's time and money, to the best of my knowledge there exists only one study on the role of LC in parental investment decisions and its link to child outcomes.[6] Based on Cunha's (2015) subjective rationality model (parents invest in their child based on their subjective beliefs about the returns to those investments), Lekfuangfu et al. (2016) find that maternal LC strongly predicts a mother's attitudes toward parenting style and time investments, which consequently affect actual investments. Building on these results, I exploit the confluence of the effects of parental LC and family structure in parental investment decisions in my empirical approach for modeling children's cognitive achievement.

The canonical empirical model for children's cognitive achievement is that of Todd and Wolpin (2003, 2007), which has been largely advanced by Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2010). The evidence in these papers supports a value-added specification for the production function of child skill formation. Research in this area often focuses on the issues of the endogeneity of inputs and the multiplicity of inputs when using the value-added specification.[7] A less thoroughly examined issue with the empirical implementation of the child skill production function is the endogeneity of parental inputs and skill formation. That is, parental investments are responsive to the performance of a child. If parents make investments and observe a change in their child's skills, they may adjust their investments accordingly. Addressing this issue, Del Bono et al. (2016) augments the value-added specification of Todd and Wolpin (2003, 2007) with a generalized method of moments framework that utilizes a rich history of inputs and outcomes as instruments. They find persistent feedback effects that indicate parental investments respond positively to child outcomes.

My empirical approach provides insight into the role of family structure and parental LC in the child skill formation process while addressing the issue of endogenous parental investments. Incorporating IV estimation into the value-added specification for the production function of the cognitive achievement of children allows me to estimate a parental investment equation in addition to the production function. In this way, I am able to quantify the impact of family structure on

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[5] See Heywood, Jirjahn, and Struewing (2017); McGee and McGee (2016); and Caliendo, Cobb-Clark, and Arne (2015) for papers on LC and labour market outcomes. See Rabbani et al. (2021); Pinger, Schäfer, and Schumacher (2018); and Salamanca et al. (2016) for papers on LC and financial investment decisions. See Lee and McKinnish 2019; Cirakoglu 2006; and Myers and Booth 1999 for papers on LC and behaviour in romantic relationships.

[6] Although there is not research on this topic in particular, there is substantial research on the relationship between parental LC and parenting styles, mostly in the psychological literature.

[7] See Del Bono et al. (2016); Dickerson and Popli 2016; Lekfuangfu et al. (2016); Fiorini and Keane 2014; and Coneus, Laucht, and Reu 2012; Cunha, Heckman, and Schennach (2010); Cunha and Heckman (2008); and Todd and Wolpin (2003, 2007).

parental investments and observe how it translates to gaps in achievement on cognitive tests. This feature separates my research from the literature in which family structure explicitly enters child outcome equations often with insignificant or imprecise results.[8] Further novelty in my approach is the use of maternal LC as an instrument for cognitive achievement, which allows to explore how maternal LC impacts investments in school-age children and by how much that can affect a child's performance on cognitive tests. I also consider how the effect of maternal LC on parental investment may vary across women in different family structures by interacting the instruments in the parental investment equation.

Using data from the National Longitudinal Survey of Youth 1979 cohort (NLSY79) and the linked NLSY C/YA study to estimate the child cognitive achievement production function, I find the following results. First, family structure plays a significant role in parental investment: single-mother households and blended households are estimated to invest less in their children than non-blended households with two parents. Furthermore, maternal LC significantly impacts a mother's investment in her child but only modestly, and this effect is different for mothers in blended households. As a result of the gaps in parental investment between family structures, children with single mothers perform considerably worse on cognitive tests compared to children whose mothers have spouses/partners. Achievement gaps are also present between children with married/cohabiting mothers and those with cohabiting separated/divorced mothers, but the differences are modest. Finally, compared to the IV results, I find the ordinary least squares (OLS) estimates of the effect of parental investments on children's test scores are biased downward.

The rest of the paper is as follows. Section II presents a conceptual framework for child skill formation and the approach used for its empirical implementation. Section III describes the data used in this analysis and provides descriptive statistics for the sample of children. Section IV presents and discusses the empirical results from estimating the production function for children's cognitive achievement. Section V concludes.

II. Modeling and Estimating the Production Function for Children's Cognitive Achievement

i. A Conceptual Framework for Child Skill Formation

Primarily drawing from Todd and Wolpin (2003, 2007), I represent the process of child skill formation by a production function that uses inputs to produce skills in the nature of Ben-Porath (1967). In this framework, parents are the decision makers for endogenous inputs instead of children and they invest in their child's development because of altruism toward them.[9] Additionally, schooling inputs are treated as implicit.[10]

Following Cunha and Heckman (2007), skills can be cognitive and non-cognitive. Let $\theta_{i,t}^{k}$ denote the skill stock of type k of child i at time t, where $t \in \{1, 2, 3, \ldots\}$ and $k = c$ for cognitive skills or $k = q$ for non-cognitive skills. Cognitive skills evolve over periods with the current period being defined as the time between the current time t and the end of the last period $t - 1$. Non-cognitive skill stocks are treated as exogenous over time, and cognitive skills depend on the child's

[8] See Hannan and Halpin (2014); Magnuson and Berger (2009); Bjoerklund, Ginther, and Sundstroem (2007); Aughinbaugh, Pierret, and Rothstein (2005); Ram and Hou (2003); and Carlson and Corcoran (2001).

[9] Note that altruism explains why parents invest in their child at all but not how much they choose to invest.

[10] This paper focuses on the early child development branch of the literature, which is concerned with the relationship between family inputs and child development. See Todd and Wolpin (2003, 2007) for a summary of the education production function literature and for insight on how early child development and education production functions can be integrated to better understand the child skill formation process.

current non-cognitive skill stock.[11] A child's cognitive skills at time t are produced by a combination, determined by the function f_t, of the child's cognitive skill stock generated by the end of the last period, the child's non-cognitive skill stock in the current period, investments in the child's skills made by parents in the current period I_t, and a vector of parental characteristics h that are assumed to be constant over time. Skill stocks at $t = 0$ can be interpreted as the child's ability endowment, which is determined before birth and is in part heritable through genetics. By having the cognitive skill stock at the current time depend on its stock from the last period, cognitive skills always implicitly depend on the ability endowment. Additionally, the function f is time-variant so that the impacts of inputs may depend on the period. An intuitive explanation of this feature is that if periods coincide with certain developmental stages in a child's life, particular investments (or the ability endowment and parental characteristics) may be more or less productive at certain stages. For example, a parent reading to a child at ages four to six is likely more productive than a parent reading to a child in their teenage years. Combining this information, the production function is given by

$$\theta^c_{i,t} = f_t(\theta^c_{i,t-1}, \theta^q_{i,t}, I_t, h). \tag{1}$$

ii. Value-Added Specification with Instrumental Variables Estimation

In order to empirically implement (1), I estimate the relationship between inputs in the skill formation process and children's cognitive achievement as measured by test scores using the commonly adopted value-added specification for children's cognitive achievement.[12] Let $test\ score_{i,t}$ be the observed test score of child i at time t. The child's test score is a linear function of a lagged test score of the child observed at the end of the previous period, the observed behaviour of the child in the current period $behave_{i,t}$, contemporaneous measures of parental investments $invest_{i,t}$, and a vector of time-invariant characteristics of the child's parent (or parents) $parent_i$. This relationship is given by

$$test\ score_{i,t} = \alpha_t test\ score_{i,t-1} + \beta_t behave_{i,t} + \gamma_t invest_{i,t} + \rho_t\ parent_i + e_{i,t}, \tag{2}$$

where the error term $e_{i,t}$ encompasses measurement error in skill stocks and investments, unobserved or omitted information on inputs, and endogeneity between input choices and child outcomes.

According to Todd and Wolpin (2003, 2007), the assumptions required for (2) to hold are the following. First, the effects of observed inputs geometrically decline with the time since the application of the input and the rate of decline is the same for each input so that lagged inputs need not be included as regressors in (2).[13] Furthermore, all omitted inputs from any period are uncorrelated with included inputs and with the lagged test score and observed current behaviour.

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[11] While non-cognitive skills are included because of their importance to cognitive development, I do not model the evolution of non-cognitive skills as cognitive skills develop because cognitive skills are less important to non-cognitive skill formation (Cunha and Heckman 2008).

[12] See Todd and Wolpin (2003, 2007) for a comprehensive summary of the most commonly adopted specifications for children's cognitive achievement in the child development literature.

[13] Assumption 1 can be relaxed if data on historical inputs are available so that additional regressors for lagged inputs can be included in (2), which is known as the value-added plus lagged inputs specification. This specification is preferable to the restricted value-added specification, but I adopt the restricted one due to sample size issues that occur when including data on lagged inputs.

Finally, the effect of the child's ability endowment geometrically declines at the same rate at which input effects decline so that the ability endowment need not be included as a regressor in (2).

Since parents likely make input decisions based on the performances of their child as they observe them and observation may happen in between periods rather than only at the end of periods, strict exogeneity between inputs and cognitive achievement may not hold. For example, if periods are defined as school years and end-of-year report card grades are used to measure children's cognitive achievement, parents may change investment behaviour based on mid-year information such as progress reports, regular tests and assignment grades, and parent-teacher conferences throughout the school year.[14] Whether the relationship between the children's cognitive achievement and parental investments is one of reinforcement or compensation is unclear. On the one hand, if a child is performing relatively well, parents may invest more in that child because they believe their investments are more productive. On the other hand, parents may invest more in a child with relatively poor performance because they believe the child needs extra help. In either case, $E(e_{i,t} \mid invest_{i,t}) \neq 0$ due to simultaneity bias from current achievement impacting parental investment choices. Hence, OLS estimates would be biased.

In order to address the endogeneity between children's test scores and parental investments in the value-added specification, I employ IV estimation. The instruments of choice are family structure, parental LC, and the interaction between these two variables. First, consider that children living in different family structures may receive systematically different investments from their parents because of differences in available resources, as well as in the levels of cooperation and stability in parents' relationships. For example, single parents have less total time available than a two-parent household, which may result in smaller time investments made by single parents relative to the combined time investment made by two parents. Furthermore, separated or divorced parents may have to coordinate investments with their child's other parent, and miscommunication or limited cooperation may result in smaller or larger investments relative to those of parents living in the same household.

Recognizing that there is heterogeneity among parents within family structures types, I include parental LC and its interaction with family structure in order to provide greater insight into parental investment decisions. On the LC scale internalizing individuals tend to believe their own actions influence their life outcomes while externalizing individuals tend to believe luck is more influential. Drawing from Cunha's (2015) subjective rationality model and the results of Lekfuangfu et al. (2016), I posit that this belief plays a role in how parents invest in young children. Internalizing parents may believe investments in their child earn returns, and hence they may be more inclined to invest in their child. In contrast, externalizing parents may believe the opposite and invest less in their child. However, these effects may differ across family structures. For example, internalizing single parents may invest even more relative to internalizing parents of other family structures in order to compensate for the absence of the child's other parent.

Suppose each child has at least one parent but only one parent is the principal decision maker for parental investment choices. Let LC_i be the measure of the principal decision maker's LC. Additionally, let $family_{i,t}$ be the family structure type in which the child lives in the current period, where there are J types indexed by j. The variable $family_{i,t}$ has the value of one if the child's family structure is of type j and zero otherwise for each j. For each j, the interaction between LC_i

[14] As will be discussed in Section III, the NLSY data only allow the shortest possible period length to be two years. Thus, it is very likely that the NLSY data miss intermittent information on children's achievement received by parents in between test administration.

and $family_{i,t}$ is their product. The child's test score when $invest_{i,t}$ is replaced with its estimate $invest^{'}_{i,t}$ is given by

$$test\ score_{i,t} = \alpha_t test\ score_{i,t-1} + \beta_t behave_{i,t-1} + \gamma_t invest^{'}_{i,t} + \rho_t\, parent_i + e_{i,t}, \tag{3}$$

where $invest^{'}_{i,t}$ is the estimated level of parental investments given by

$$\begin{aligned} invest^{'}_{i,t} = \pi_t LC_i + \sum_{j=1}^{J-1} \delta_{j,t} family_{i,t} + \sum_{j=1}^{J-1} \varphi_{j,t} family_{i,t} \times LC_i \\ + \alpha^{'}_t test\ score_{i,t-1} + \beta^{'}_t behave_{i,t-1} + \rho^{'}_t\, parent_i + u_{i,t}. \end{aligned} \tag{4}$$

Note that while LC_i, $family_{i,t}$, and their interaction should impact a child's test score through their effects on parental investment, none of these instruments should directly impact a child's test score. A possible exception for family structure would be if household environments are considered to be separate from parental investments. Then varying household environments under different family structures may have a direct role in children's cognitive achievement. In this case, the family structure indicator would be included in both (3) and (4). Consistent with the structure of NLSY data, I consider environments favourable to child development as an investment made by parents. In this case, the exogeneity condition should hold in theory and family structure can be excluded from (3). This is also supported by the results of initial testing, which revealed the direct effects of family structure on children's test scores are insignificant.[15] For this reason, I use the specification above, which only allows family structure to impact test scores through investments.

III. Data and Descriptive Statistics

i. NLSY79 and C/YA Data and Sample

The data used to estimate the production function for children's cognitive achievement are sourced from the NLSY79 and the corresponding NLSY C/YA. The NLSY79 collects information on a sample of 9,964 American youth born between 1957 and 1964, each one having been assigned to one of three subsamples: non-institutionalized civilians; an oversample of Black, Hispanic or Latino, and economically disadvantaged civilians; and a military sample. The survey asks individuals extensive questions on their labour market behaviour, educational experiences, family background and life, personal finances, and various other topics. The NLSY C/YA was subsequently introduced in 1986. It provides information on family background, parenting, and child development for the children of female youth from the NLSY79. The NLSY C/YA sample consists of 11,530 children who were younger than twenty-four years old in 1986 or born later than 1986.

The NLSY C/YA has been widely used for estimating child skill production functions

[15] Table A4 in the Appendix displays the IV regression results of this alternative specification, including OLS estimates for comparison. The reader should refer to Section III to understand the structure of the data and the sample prior to viewing these results. Notice that family structure is not a significant predictor of test scores in each of the subtest regressions with the exception of the marginal significance of the effect of living with a single mother in the reading recognition subtest regression.

because of the measures of skills and inputs available in the dataset.[16] Importantly, the NSLY C/YA provides measures of both the cognitive and non-cognitive skills of the children. To measure cognitive achievement, I use test scores from the Peabody Individual Achievement Test (PIAT), which are available for three different subjects: reading comprehension, reading recognition, and math.[17] The PIAT subtests were administered to children five years of age and older at each biennial household interview. Each of the assessments is comprised of eighty-four multiple choice questions that increase in difficulty from preschool to high school levels. The assessment begins at a basal for each child and continues as long as the child answers questions correctly, terminating once the child reaches a ceiling determined by the number of consecutive incorrect responses. Raw test scores are obtained by subtracting the number of incorrect responses between the basal and ceiling scores from the ceiling item. In addition to data on cognitive skills, the NLSY C/YA provides data on children's non-cognitive skills using the Behavioural Problems Index (BPI). NLSY79 mothers with children at least four years of age were asked twenty-eight questions about the frequency at which their child exhibits certain behavioural problems such that a higher score indicates more frequent or extreme problematic behaviour in a child.

With respect to parental investments, the NSLY C/YA measures the quality of the home environment, based on the quality of cognitive stimulation and emotional support provided to children by their families, using the Home Observation Measurement of the Environment-Short Form (HOME-SF).[18] Questions about HOME-SF items were administered to NLSY79 mothers and the sum of the responses create the HOME-SF score such that greater investments in the home environment result in higher scores. The questions in the survey vary by age. This analysis uses only the version created for 6-9-year-old children (see Table A1 in the Appendix for a list of the items included in this version). While the HOME-SF is commonly used to measure home inputs, two issues that arise with its use in estimating child skill production functions are the endogeneity of inputs and the multiplicity of inputs (Cunha and Heckman 2008). The former issue refers to the fact that, holding household resources fixed, investing more in a certain input means parents may have to reduce investment in at least one other input. The latter issue has to do with the abundance of measures for parental investments, the number of possible inputs often exceeding the number of instruments needed to eliminate input endogeneity and measurement error. Since the focus of this paper is addressing the endogeneity of inputs and outputs in the child skill production function, I use HOME-SF scores to proxy parental investments.[19] While this approach suffices for the scope of this paper, the HOME-SF is likely a noisy measure of parental investments and estimates may be burdened by the endogeneity and multiplicity of inputs, which would require more advanced econometric methods to address.[20]

My approach for eliminating the endogeneity between inputs and outputs in the child skill production function necessitates a measure of parental LC. As such, one of the primary benefits of the NLSY79 data is that it provides the scores of a shortened version of the Rotter Internal-External Locus of Control Scale (RIES), developed by Rotter (1966), for the mothers of the NLSY C/YA

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[16] See, for example, Dahl and Lochner (2012); Cunha, Heckman, and Schennach (2010); Cunha and Heckman (2008); and Todd and Wolpin (2007).

[17] The reading recognition subtest measures a child's ability to recognize and pronounce English words. The reading comprehension subtest measures a child's ability to understand sentences written in English.

[18] The HOME-SF is a subset of the HOME inventory created by Caldwell and Bradley (1984) and contains approximately half of the items included in the original HOME inventory.

[19] Many economists estimating child skill production functions also take this approach. See Todd and Wolpin (2007), Baharudin and Luster (1998); and Parcel and Menaghan (1994).

[20] See Cunha and Heckman (2008) and Cunha, Heckman, and Schennach (2010).

children. As part of the initial round of NLSY79 interviews in 1979, respondents were posed four pairs of two statements from the original sixty-item RIES, each statement reflecting a tendency to either internalize or externalize problems.[21] Respondents would choose the statement closer to their own opinion and then indicated how strongly the statement matched their actual views (see Table A2 in the Appendix for the list of items included in this version of the RIES). Responses to each item are given a score from one, being the most internalizing, to four, being the most externalizing. The total RIES score is the sum of the scores of the individual items such that the RIES scores range from four to sixteen. A limitation is that I do not have RIES scores for the spouses/partners of mothers, who are likely also involved in parental investment choices. In terms of the econometric model presented in the previous section, mothers assume the role of the principal decision makers in investment decisions by default as a result of this limitation.

In creating a cross-sectional sample of children, I include those who were eight to nine years old in any of the even-numbered years between 1988 and 2004, inclusive, and who were residing with their mother in the current survey year.[22] I exclude children in families that are part of the military subsample of the NLSY79, as well as any children without valid responses for inputs or outputs of interest. I take only the first observed child in each household in order to avoid clustering of errors, which may occur if siblings are included. Using information about the marital status of mothers and whether mothers' spouses or partners live in the same household, I sort children into three mutually exclusive types of family structures: never-separated/divorced mothers living with a spouse/partner (referred to as married/cohabiting mothers), mothers living without a spouse/partner (referred to as single mothers), and separated/divorced mothers living with a new partner (referred to as cohabiting separated/divorced mothers).[23] Widowed mothers are excluded from the sample since household dynamics and child development may be much different with a deceased parent.

With NLSY data the shortest possible period length consistent with the framework in the previous section is two years. The timing follows the following sequence. At the beginning of the period, parents observe their child's score from the PIAT administered at the end of the last period when the child was six to seven years old. With this information and knowledge of their resources in the current period, parents make investments in their child's skill development. However, since parents likely receive information about their child's performance during this period, they may adjust investments correspondingly. At the end of the period the children, now eight to nine years old, take the PIAT again, reflecting the change in skills that result from parental investments and other inputs.

Since many of the variables under consideration are measured with scores and results using raw scores may not have clear meanings, I use standardized scores in order to make the results of

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[21] The RIES was only administered during the 1979 interview round and then every other year beginning with the 2014 interview round. I exclude children with mothers without valid RIES scores from 1979 from the sample so that all mothers in the sample have scores from before current parental investment decisions were made. I recognize that some of the mothers were significantly younger at the time of the assessment and that their LC may have changed as they aged. However, Cobb-Clark and Schurer (2013) show that the LC remains relatively stable throughout an individual's life, so timing may not matter.

[22] This period was chosen for the consistency of data collection; the questions and corresponding responses remained, for the most part, consistent between 1988 and 2004. The year 1986 is excluded because 8-9-year-old children in that year do not have lagged test scores.

[23] Mothers in the second category can be separated into never-married mothers and separated/divorced mothers living without a partner. However, their separate effects when regressing parental investment on family structure (and additional controls) are not statistically different from each other when using raw scores and only marginally statistically different when using standardized scores. Thus, I do not make the distinction between those two groups.

my analysis more interpretable. Standardized scores are created by subtracting the mean of the random sample (i.e., excluding the oversample of racialized minorities and economically disadvantaged civilians and the military sample) and dividing by its standard deviation. For the PIAT scores, I standardize scores with respect to age groups so that the standardized current scores are calculated using the scores of eight- to nine-year-old children in the random sample while the standardized lagged scores are calculated using the scores of six- to seven-year-old children in the random sample.

ii. Descriptive Statistics

Tables 1 and 2 present descriptive statistics for the sample of households for child characteristics and maternal and household characteristics, respectively.[24] The primary interest of this paper is to examine the cognitive achievement gaps of children from different family structures on the basis of parental investments. Rows one through six of Table 1 show that, on average, children of married/cohabiting mothers tend to perform better on each subtest than children living in either of the other family structures, and the gaps widen from the ages of six and seven to eight and nine. Children of single mothers perform the worst, on average, among the different family structures. There are also substantial differences in the average HOME-SF scores across family structures shown in Table 2. Compared to the random sample with a mean HOME-SF score of zero, the average HOME-SF score of my sample of households is 0.15 standard deviations lower since it includes economically disadvantaged households and racialized minorities (who are more disadvantaged on average). At the same time, households with married/cohabiting mothers score 0.17 standard deviations greater than the random sample on average, while households with single mothers and those with cohabiting separated/divorced mothers score 0.93 and 0.35 standard deviations lower on average, respectively.

A secondary interest of this paper is to examine the relationship between parental LC and parental investments, and how this relationship may vary with family structure. The statistics displayed in the first row of Table 2 suggest that there may be systematic differences in maternal LC across family structures, as it appears that single mothers and cohabiting separated/divorced mothers tend to have higher RIES scores on average compared to married/cohabiting mothers.[25] This difference indicates that the former two groups of mothers are more externalizing, while the latter group of mothers is more internalizing. Failing to control for the correlation between these two instruments in the estimation of the production function for children's cognitive achievement may bias the effects of LC or family structure or both. Thus, it may be necessary to interact the two variables.

As suggested by the literature, some of the disparities in investment and test performance across family structures can likely be explained by other differences in maternal and household characteristics. The samples of households with single mothers and those with cohabiting separated/divorced mothers appear to lack certain characteristics that we may expect to positively impact both parental investment and children's cognitive performance. For example, the second row of Table 2 shows that these mothers score, on average, in only the twenty-ninth and thirty-seventh percentiles of the Armed Forces Qualification Test (AFQT), respectively, while married/

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[24] Descriptive statistics are reported in standardized values for scored variables. See Table A3 in the Appendix for the corresponding raw values.

[25] Although the average raw scores of married/cohabiting mothers and cohabiting separated/divorced mothers differ by only 0.1 points, the range of RIES scores used by the NLSY79 is quite small. Therefore, small differences in scores may reflect larger differences in LC orientation than expected.

Table 1
Descriptive statistics using standardized scores (child characteristics):
Means and standard deviations (in parentheses), and percentages.

	Entire sample	Married/cohabiting mothers	Single mothers	Cohabiting separated/divorced mothers
PIAT reading recognition standardized score				
Ages 6-7 (lagged)	-0.057	0.017	-0.24	-0.059
	(0.99)	(1.0)	(0.92)	(1.09)
Ages 8-9 (current)	-0.031	0.082	-0.30	-0.12
	(0.98)	(0.99)	(0.90)	(0.95)
PIAT reading comprehension standardized score				
Ages 6-7 (lagged)	-0.039	0.030	-0.22	0.015
	(0.97)	(1.0)	(0.85)	(1.2)
Ages 8-9 (current)	-0.049	0.067	-0.32	-0.13
	(1.0)	(0.98)	(0.97)	(1.0)
PIAT math standardized score				
Ages 6-7 (lagged)	-0.14	-0.046	-0.35	-0.20
	(0.97)	(0.98)	(0.92)	(0.96)
Ages 8-9 (current)	-0.096	0.014	-0.35	-0.22
	(1.0)	(0.99)	(0.97)	(0.96)
BPI standardized score	-0.12	-0.15	-0.06	-0.16
	(0.99)	(0.93)	(1.1)	(1.1)
Child's birthweight (oz.)	116.9	118.4	113.4	114.6
	(20.8)	(20.3)	(21.2)	(22.7)
Percentage:				
Black	27.6	17.7	54.3	20.5
Hispanic	17.4	17.2	16.0	23.1
Percentage eight years old	49.3	48.9	50.4	47.4
Percentage female	50.2	49.8	51.3	48.7
Percentage first born	63.9	68.2	54.3	56.4
N	2069	1416	575	78

cohabiting mothers score in the forty-seventh percentile on average.[26] Furthermore, the third last row of Table 2 shows that the average income of households with married/cohabiting mothers is higher. This may be because there are two sources of income if both a mother and her spouse/partner work. Alternatively, having two adults in the household may give the option of the couple specializing in market and home production so that the partner with the greater earnings potential spends more time working, possibly earning a higher solo income. Another possibility is the selection of people in this subsample. These mothers tend to be more educated and older (so,

[26] The AFQT, a cognitive assessment used to determine eligibility to enlist in the U.S. military, was administered to NLSY79 respondents in 1980. The scores are age-normed in order to be more comparable since the age of respondents ranged from fourteen to twenty-three when taking the test.

Table 2
Descriptive statistics using standardized scores (maternal and household characteristics): Means and standard deviations (in parentheses), and percentages.

	Entire sample	Married/cohabiting mothers	Single mothers	Cohabiting separated/divorced mothers
RIES standardized	0.045	-0.014	0.19	0.021
score	(1.0)	(1.0)	(0.98)	(0.94)
AFQT Percentile score	41.3	46.7	28.7	36.5
	(28.0)	(28.1)	(23.5)	(26.4)
Age at child's birth (years):				
Less than 20	15.4	12.6	22.3	16.7
20 to 29	68.3	69.6	64.2	78.2
Greater than 29	16.1	17.7	13.6	5.1
Educational attainment:				
Less than high school	13.4	10.2	20.7	17.9
High school graduate	46.2	45.0	47.8	55.1
Some college	23.7	24.2	23.0	19.2
College graduate	16.8	20.5	8.5	7.7
HOME-SF standardized	-0.15	0.17	-0.93	-0.35
score	(1.1)	(0.89)	(1.07)	(0.98)
Current annual	54.2	67.9	23.0	36.1
household income ($1000)	(78.7)	(85.9)	(21.1)	(126.8)
Children less than five	0.67	0.73	0.55	0.55
years old	(0.76)	(0.77)	(0.74)	(0.70)
N	2069	1416	575	78

Note. – Household income is expressed in 2004 dollars, calculated using the Consumer Price Index for All Urban Consumers (CPI-U).

they may have more work experience), as seen in rows three to five and rows six to nine, respectively, in Table 2. Hence, they and/or their spouses/partners (if their spouses/partners have similar characteristics) may have greater earnings potential than mothers from other family structures. Another notable difference across family structures is that there is a much higher proportion of racialized minorities among the households with single mothers and those with cohabiting separated/divorced mothers, shown in the fifth and sixth rows from the bottom of Table 1. In particular, more than half of the single mothers are black. Thus, effects may be driven by racial disparities.[27] In the next section, I quantify these relationships using regression analysis.

IV. Empirical Results

To examine the role of family structure and maternal LC in the formation of cognitive skills, as well as to eliminate bias stemming from endogenous parental investment, I use an IV approach to estimate the production function for children's cognitive achievement, given by (2). In implementing IV estimation, I estimate the production function in two stages. Moreover, in order

[27] This is not surprising given the racial marriage divide in the U.S. See Caucutt, Guner, and Rauh (2021) for an examination of this marriage gap.

to see how the production function may change with different types of cognitive skills, I perform the analysis for each of the three PIAT subtest scores provided by the NLSY C/YA. The first stage is the estimation of the parental investment equation given by (4), with investment levels proxied by HOME-SF scores and an additional set of controls for characteristics of the child, mother, and household. The second stage uses the estimates of HOME-SF scores obtained in the first stage in order to estimate the child cognitive achievement equation given by (3), with cognitive achievement proxied by PIAT scores. The same set of control variables from the first stage is included in the second stage regression with the exception of annual household income and its square for each of the subtest regressions, and the number of children younger than five years old in the household for the reading subtest regressions. I make these exclusion restrictions since they should only impact cognitive achievement through their effects on parental investment.[28]

i. First Stage Regression Results

Table 3 reports the first stage regression results using standardized scores.[29] Family structure appears to significantly impact HOME-SF scores. Relative to married/cohabiting mothers, the effect of living in single-mother household is estimated to be a decrease in the household's HOME-SF score by 0.69 standard deviations. For cohabiting separated/divorced mothers, the effect is a decrease of 0.25 standard deviations. The larger difference in HOME-SF scores for single-mother households may be explained by the absence of a spouse/partner to alleviate time and resource constraints for the mother.[30] The same explanation may not necessarily apply to cohabiting separated/divorced mothers. On the one hand, there is another partner in the household who can either directly contribute to investments in the child or alleviate constraints that prevent the mother from investing more in her child. On the other hand, the altruism of the mother's new partner for the child may not be the same as the altruism of the mother or her former partner, potentially negatively impacting investments.[31]

In order to see how mothers may differ in investment decisions apart from differences in resources that stem from family structure, I turn to maternal LC. Consistent with Lekfuangfu et al. (2016), I find externalization significantly impacts HOME-SF scores in a negative way. However, the effect is modest: an increase of one standard deviation in a mother's RIES score induces a decrease of only 0.06 standard deviations in the HOME-SF score. As discussed previously, there are two possibilities for the effect of maternal LC on parental investment. Internalizing mothers may invest more in their child relative to other mothers whose investment decisions may not be as driven by their LC. The opposite is also possible. Externalizing mothers may invest less in their child relative to other mothers. A combination of these effects is also possible. In order to gain insight into what is driving the effect of RIES scores on HOME-SF scores, Figures A1-A3 in the Appendix show plots of the estimated values of HOME-SF scores given RIES scores against the

[28] This was confirmed in initial tests. However, the number of children younger than five years old in the household was an invalid exclusion restriction in the math subtest regression. Therefore, I include it in that regression but not the reading subtest regressions.

[29] See Table A5 in the Appendix for the results using raw scores.

[30] In households with single mothers and cohabiting separate/divorced mothers it is possible that children receive supplementary investments from another parent in a different household, which would likely result in smaller investment gaps than those presented in Table 3. Unfortunately, the NLSY does not provide information on investments made from parents with whom the child does not reside.

[31] Of course, the impact on investment from differences in altruism between the mother's former partner and new partner may not always be negative. It may be the case that some separated/divorced mothers seek out partners who are more willing to invest in their children than their former partner.

Table 3
First stage regression results (standardized scores):
coefficient estimates and standard errors (in parentheses).

	HOME-SF score		
PIAT subtest used for lagged test score	PIAT reading comprehension score	PIAT reading recognition score	PIAT math score
Intercept	0.05	0.05	0.10
	(0.13)	(0.13)	(0.13)
Family structure:			
Single mothers (1)	-0.69***	-0.69***	-0.69***
	(0.05)	(0.05)	(0.05)
Cohabiting separated/divorced mothers (2)	-0.25**	-0.25**	-0.25**
	(0.10)	(0.10)	(0.10)
Mother's RIES score:	-0.06**	-0.06**	-0.06**
	(0.02)	(0.02)	(0.02)
Mother's RIES score x (1)	0.02	0.02	0.01
	(0.04)	(0.04)	(0.04)
Mother's RIES score x (2)	-0.18*	-0.18*	-0.19*
	(0.10)	(0.10)	(0.10)
Lagged test score	0.03	0.03	0.09***
	(0.02)	(0.02)	(0.02)
BPI score	-0.05**	-0.05**	-0.04**
	(0.02)	(0.02)	(0.02)
Child’s/mother’s race:			
Hispanic	-0.18***	-0.18***	-0.17***
	(0.05)	(0.05)	(0.05)
Black	-0.29***	-0.28***	-0.27***
	(0.05)	(0.05)	(0.05)
Nine years old	-0.02	-0.02	-0.07
	(0.04)	(0.04)	(0.04)
Male	-0.05	-0.05	-0.05
	(0.04)	(0.04)	(0.04)
Not first-born	-0.16***	-0.16***	-0.15***
	(0.03)	(0.03)	(0.03)
Birth weight (oz.)	9.41E-4	9.56E-4	8.92E-4
	(9.04E-4)	(9.04E-4)	(9.0E-4)
Mother’s age at child’s birth (years):			
Less than 20	-0.33***	-0.32***	-0.31***
	(0.06)	(0.06)	(0.06)
Older than 29	0.04	0.04	0.05
	(0.05)	(0.05)	(0.05)
Mother’s educational attainment:			
Less than high school	-0.20***	-0.20***	-0.20***
	(0.06)	(0.06)	(0.06)
Some college	0.18***	0.18***	0.17***
	(0.05)	(0.05)	(0.05)
College graduate	0.17**	0.17***	0.15**
	(0.06)	(0.06)	(0.06)

Mother's AFQT percentile	0.42***	0.42***	0.39***
	(0.10)	(0.10)	(0.10)
Current annual household	3.14E-3***	3.13E-3***	2.98E-3***
income ($1000)	(6.46E-4)	(6.47E-4)	(6.46E-4)
Square of annual household	-2.45E-6***	-2.42E-6***	-2.29E-6***
income ($1000)	(6.26E-7)	(6.27E-7)	(6.26E-7)
Number of children in	-0.09***	-0.09***	-0.08***
household younger than five years old	(0.03)	(0.03)	(0.03)
F-statistic	59.53	59.46	60.38

Note. – The base group is female children eight years of age in households with married/cohabiting mothers who are high school graduates, were twenty to twenty-nine years old at the child's birth, and identify as White. Household income is expressed in 2004 dollars, calculated using the Consumer Price Index for All Urban Consumers (CPI-U).
Significance code: '***' for 99% significance, '**' for 95% significance, '*' for 90% significance.

actual values for each subtest regression. These plots provide some support for the linearity of the relationship between RIES scores and HOME-SF scores on both ends of the RIES. That is, households with internalizing mothers tend to have higher HOME-SF scores, while the opposite is true for households with externalizing mothers.

The interaction terms between family structure and maternal LC indicate whether the effect of LC differs across family structures. The effect of maternal LC for cohabiting separated/divorced mothers, but not single mothers, appears to significantly differ from that of married/cohabiting mothers by 0.18-0.19 standard deviations of the HOME-SF score. The total effect of an increase of one standard deviation in a cohabiting separated/divorced mother's RIES score is a decrease of 0.24-0.25 standard deviations in her household's HOME-SF score. Further research into the dynamics of family structure and maternal LC is needed to understand why the effect of LC is different for cohabiting separated/divorced mothers. This could require an empirical approach that jointly determines family structure and parental investments.

Aside from family structure and maternal LC, several other factors influence parental investment, including the cognitive ability and educational attainment of mothers, mothers' age at their child's birth, the child's birth order and number of young siblings, race, and annual household income. Interestingly, parents appear to base investment decisions on the child's current non-cognitive skills but not past cognitive achievement, except for math achievement. In particular, the child's current behaviour significantly impacts HOME-SF scores in a negative way, but the impact is modest. An increase of one standard deviation in the child's BPI score, meaning more frequent or extreme behavioural problems, decreases the HOME-SF score by only 0.04-0.05 standard deviations. While lagged reading test scores are not significant predictors of parental investments, an increase of one standard deviation in a child's lagged math score increases their household's HOME-SF score by 0.09 standard deviations. Considering the endogeneity between children's cognitive achievement and parental investment, this result may suggest that parental investments respond to children's math achievement more than they respond to reading achievement. The effect is positive, which indicates that parents reinforce higher math achievement rather than compensate for poor performance.

ii. Second Stage Regression Results

Having examined how family structure and maternal LC influence parental investment in the first stage, the second stage results provide insight into how much these investments impact the growth in children's scores on cognitive tests among other factors.[32] These results are presented in Table 4, which includes the estimates of the second stage equation using OLS for comparison with the IV estimates.[33]

Recall that I assume family structure only impacts children's cognitive achievement through its influence on parental investment. That is, family structure enters the parental investment equation in the first stage, given by (4), but not the production function for children's cognitive achievement in the second stage, given by (3). The use of this specification is supported by the results of initial testing, which yielded insignificant effects of family structure in the production function.[34] Therefore, I only consider the effect that family structure has on children's test scores through its impact on the household's HOME-SF score as determined in the first stage, and family structure is used as an instrument for parental investment. A test for weak instruments yields F-statistics of approximately forty (forty-five for the math subtest regression) with high statistical significance, indicating at least one of the instruments is strong (Stock and Yogo 2005).[35]

Using the predicted values of HOME-SF scores in the first stage, the HOME-SF is estimated to positively impact reading test scores, as expected, but not math test scores. The results for the reading test scores also differ between the OLS and IV estimates, but the differences are small. According to the IV estimates, an increase of one standard deviation in a household's HOME-SF score increases a child's reading comprehension score by 0.11 standard deviations, only 0.01 standard deviations greater than estimated by OLS. For the same increase in the HOME-SF score, IV estimation yields an increase in reading recognition scores of 0.14 standard deviations while OLS yields an increase of only 0.08 standard deviations.

Although the differences are small, it appears that OLS estimates are biased downward, understating the impact of the HOME-SF scores on children's reading test scores. Parents observe the performance of their child during the two-year period and reinforce relatively high performance by investing more (or reinforce relatively low performance by investing less). The presence of feedback effects is consistent with the findings of Del Bono et al. (2016), but the magnitude is not as pronounced. In this case, it is possible that the differences in OLS and IV estimates are small because of limitations of the HOME-SF scale. Certain items included in the HOME-SF are not the kinds of investments we may expect parents to adjust in response to their child's cognitive performance.[36] For items that parents would likely adjust in response to child performance, the HOME-SF does not always include additional responses for parents to report adjustments.[37]

Another interesting result is the difference in estimates between the reading subtest regressions and the math subtest regression, as a household's HOME-SF score is not a significant predictor of a child's math score. This result may also be related to the types of items included in

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[32] The roles of the included child, maternal, and household characteristics have been extensively researched. Therefore, I only note that the estimates of the effects of these characteristics are as expected and consistent with existing estimates for the most part (see Todd and Wolpin 2007; Cunha and Heckman 2008).

[33] See Table A6 in the Appendix for the results using raw scores.

[34] See Table A4 in the Appendix for the results using the alternative specification that includes family structure in the second stage.

[35] The first stage F-statistics are all approximately 60 as well, which is much greater than the typical first stage F-statistic of ten used when pretesting for weak instruments in IV regression (Stock and Yogo 2005).

[36] For example, if parents observe their child performing relatively well, it is unlikely that they respond by increasing the safety of the child's play environment.

[37] For example, if a family already receives a daily newspaper, parents are unable to report an increase in investment for this item (i.e., subscribing to more newspapers or magazines).

Table 4
Second stage regression results (standardized scores):
coefficient estimates and standard errors (in parentheses).

	PIAT reading comprehension score		PIAT reading recognition score		PIAT math score	
	OLS	IV	OLS	IV	OLS	IV
Intercept	-0.19*	-0.19*	-0.11	-0.10	-0.34***	-0.34***
	(0.11)	(0.12)	(0.10)	(0.10)	(0.11)	(0.11)
HOME-SF score	0.10***	0.11**	0.08***	0.14***	0.03	0.02
	(0.02)	(0.05)	(0.02)	(0.05)	(0.02)	(0.05)
Lagged test score	0.47***	0.47***	0.62***	0.62***	0.53***	0.52***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
BPI score	-0.07***	-0.07***	-0.06***	-0.06***	-0.05***	-0.05***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Child's/mother's race:						
Hispanic	-0.05	-0.05	-0.01	0.006	-0.05	-0.05
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
Black	-0.11**	-0.10*	-0.05	-0.02	-0.15***	-0.16***
	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
Nine years old	0.21***	0.21***	1.67E-4	4.00E-4	0.25***	0.25***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Male	-0.10***	-0.10***	-0.08**	-0.07**	-0.01	-0.005
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Not first-born	-0.07***	-0.07***	-0.05**	-0.04**	-0.05**	-0.06**
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Birth weight (oz.)	4.67E-4	4.00E-4	9.11E-4	0.001	0.001	0.001
	(8.25E-4)	(0.001)	(7.38E-4)	(0.001)	(0.001)	(0.001)
Mother's age at child's birth (years):						
Less than 20	-0.06	-0.05	-0.05	-0.03	-0.02	-0.02
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
Older than 29	0.04	0.04	0.02	0.01	0.14***	0.14***
	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)
Mother's educational attainment:						
Less than high school	-0.08	-0.07	-0.09*	-0.08	-0.04	-0.05
	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
Some college	-0.02	-0.02	-0.04	-0.05	0.05	0.05
	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
College graduate	-0.11**	-0.12**	0.02	-5.00E-4	0.06	0.06
	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.06)
Mother's AFQT percentile	0.57***	0.56***	0.39***	0.35***	0.47***	0.48***
	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.09)
HH05	-	-	-	-	-0.06***	-0.06***
					(0.02)	(0.02)

Weak instruments test F-statistic	-	40.06***	-	40.06***	-	45.06***

Note. – The base group is female children eight years of age in households with mothers who are high school graduates, were twenty to twenty-nine years old at the child's birth, and identify as White. Significance code: '***' for 99% significance, '**' for 95% significance, '*' for 90% significance.

the HOME-SF. Most of the items related to cognitive stimulation in the HOME-SF likely enhance reading skills but few are related to math skills, making it a much noisier measure of investments in math skills. While the first stage regression results suggest that parental investments are more responsive to math skills than reading skills, further work is required to determine for which types of skills feedback effects are stronger with endogenous parental investments. A measure of investment that includes more numeracy-focused activities may be needed to do so.

Finally, to see how differences in family structure translate to test score gaps, I provide a comparison of the HOME-SF and reading comprehension test scores (chosen for the precision of its estimates compared to the other subtest regressions) for different types of children predicted by my econometric model. First, I consider how the scores of the average child with respect to the entire sample would differ depending on the family structure in which they live.[38] The standardized HOME-SF score of the household of the average child in the sample with a married/cohabiting mother is 0.16. If that child instead has a single mother or a cohabiting separated/divorced mother, their household's standardized HOME-SF score would be -0.53 and -0.099, respectively. Using these scores, the estimated reading comprehension score for the average child in the sample is 0.049 if their mother is married or cohabiting, -0.027 if their mother is single, and 0.020 if their mother is separated/divorced and living with a new partner.

While these gaps may seem minor, accounting for the differences in the characteristics of children, mothers, and households across family structures widens the gap in scores.[39] By substituting the average characteristics for a child living in a married/cohabiting mother household, the predicted HOME-SF score is instead 0.39. In comparison, the scores are -0.80 and 0.017 when substituting in the average characteristics for a child living with a single mother and a cohabiting separated/divorced mother, respectively. This translates to reading comprehension scores of 0.14 for the average child with a married/cohabiting mother, -0.32 for the average child with a single mother, and 0.03 for the average child with a cohabiting separated/divorced mother.

Evidently, the households with married/cohabiting mothers surpass households of the alternative family structures in both parental investment and children's cognitive performance. By how much would certain maternal characteristics have to change to close investment and performance gaps between children who only differ by family structure? Two possible channels for closing the gaps are through maternal LC and cognitive ability if these skills are sufficiently malleable, at least before a certain point in her life.[40] Decreasing a cohabiting separated/divorced mother's RIES score from the sample average (0.045) to -0.32 is sufficient to close the investment and reading comprehension score gaps. Replacing a single mother's RIES score with even the lowest possible value (-1.94) is insufficient to close the reading comprehension score gap between

[38] By average child, I mean a child in the base group (with the exception of family structure) with the mean values of each of the continuous variables for child, mother, and household characteristics.

[39] The age and sex of the child are held fixed at eight years old and female.

[40] Another possible channel is through income increases but due to the small effect of income on parental investment, the annual incomes required to close the reading comprehension score gap (and investment gap) between children of married/cohabiting mothers and children of other family structures are very large and unfeasible. Thus, I focus on different channels for closing the parental investment and cognitive achievement gaps.

children of single mothers and married/cohabiting mothers. The HOME-SF score of a single mother only increases to -0.24, resulting in her child's reading comprehension score increasing to 0.0048.

Smaller changes in a mother's cognitive ability may be required since AFQT scores impact both investment and cognitive performance, and the impacts are much larger. Increasing the AFQT score of a single mother to the fifty-first percentile increases her household's HOME-SF score to -0.32. Despite the remaining investment gap, her child's reading comprehension score still catches up to that of a child with a married/cohabiting mother since a mother's AFQT score has a direct effect on her child's test score. Similarly, the AFQT score of a cohabiting separated/divorced mother only has to increase to the forty-third percentile to close the reading comprehension score gap between her child and one with a married/cohabiting mother.

V. Conclusion

This paper investigates the role of family structure and maternal LC in cognitive achievement gaps between children through their influences on parental investment. To do so, I estimate the production function for children's cognitive achievement using a value-added specification with IV estimation. The econometric model and specification are based on Todd and Wolpin (2003, 2007) but draw from certain ideas of Cunha (2015) and Lekfuangfu et al. (2016).

Separating myself from the literature, I consider that gaps in the cognitive achievement of children from different family structures may result from the influence of family structure on parental investments. I also examine the impact of maternal LC on parental investments and determine whether its impact varies across family structures. Additionally, my empirical approach addresses the issue of endogenous parental investments when estimating the production function for children's cognitive achievement. Cognitive skills grow due to investments, but parents may adjust investments after observing their child's performance, which much of the literature ignores. IV estimation allows me to separate the child skill formation process into two stages: parents first make investments in their child and then the child uses the investments and other inputs to produce a cognitive outcome. Family structure and maternal LC, as well as their interaction, are used as instruments for parental investments. Proxying children's cognitive achievement with their scores on cognitive tests, the value-added specification represents the growth in a child's test score from a baseline measure as a result of various inputs. In this way, I am able to examine how family structure and maternal LC indirectly impact cognitive skill formation through the investment channel, while also accounting for the endogeneity of parental investment and children's cognitive achievement.

Applying my methodology to NLSY79 and NLSY C/YA data, I find that both family structure and maternal LC significantly impact household HOME-SF scores and children's reading test scores in turn. With respect to family structure, children with married/cohabiting mothers receive the highest quality investments and achieve the highest on cognitive tests, while investment and achievement deficits are the most pronounced for children of single mothers. With respect to maternal LC, internalizing mothers invest more in their children while the opposite is true for externalizing mothers. Furthermore, I find the impact of maternal LC for cohabiting separated/divorced mothers is statistically different from that of married/cohabiting mothers, which consequently widens the gaps in achievement between these two groups.

There are a few unexpected outcomes of the IV estimation. The differences between the OLS and IV estimates of the impact of HOME-SF scores on reading test scores indicate that there are positive feedback effects between parental investment and children's cognitive achievement.

OLS estimates are biased downward. However, the differences between OLS and IV estimates are fairly small. Moreover, the second stage regression results imply that the investments included in the HOME-SF do not significantly impact math test scores. Thus, I cannot conclude whether maternal LC and family structure also affect the growth of children's math skills. Shortcomings of the HOME-SF in terms of capturing adjustable investments and investments that enhance math skills may be responsible for these results.

There are a few additional caveats worth mentioning. In addition to shortcomings of the HOME-SF scale, the scale for LC used by the NLSY, a shortened version of the original RIES, does not allow for much variation in beliefs. There are only four questions used in the NLSY assessment and the pairs of questions are quite similar. For this reason, my analysis may not capture as large of an impact of maternal LC on parental investments. More advanced econometric methods to address measurement error in parental investments and maternal LC, such as those employed by Cunha and Heckman (2008) may be required. These methods would also account for the issues of the endogeneity of inputs and the multiplicity of inputs, which are not addressed in this analysis. An additional suggestion for improvement is relaxing the first stated assumption of the restricted value-added specification by including lagged parental inputs in the production function. Lagged inputs are not included in my analysis due to sample size issues that arise when eliminating children without complete input histories. I leave these improvements for future research.

Despite these caveats, the empirical results presented in this paper suggest that family structure has a considerable impact on children's cognitive achievement even just through its influence on parental investments. However, the resulting gaps can be mitigated by certain characteristics of a child's mother. Whether these changes to maternal characteristics are achievable is another challenge in itself. Raising the cognitive ability of a mother for the purpose of improving the cognitive skills of her children may very well go back to the quality of investments she received during her own childhood. While efforts to improve the cognitive skills of children today may ensure their future children receive ample investment, possible interventions for current mothers may have to be directed toward increasing their knowledge of effective investments and reducing barriers to providing such investments. As for parental attitudes toward investments in children, Cobb-Clark and Schurer (2013) suggest that an individual's LC is fairly stable over their life cycle, but perhaps active interventions could still be effective after its purported stabilization. Placing more focus on the development of non-cognitive skills such as self-motivation and self-determination in educational and employment settings could have positive implications for individuals' life outcomes, as well as the life outcomes of their own children.

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Appendix

Table A1
List of items included in HOME-SF scale (version for 6-9-year-old children).

Cognitive stimulation (C) or emotional support (E)	Question Text	Mother self-report (M) or interviewer observation (O)
C	About how many books does child have?	M
C	How often do you read aloud to child?	M
E	How often is child expected to make his/her own bed?	M
E	How often is child expected to clean his/her room?	M
E	How often is child expected to clean up after spills?	M
E	How often is child expected to bathe himself/herself?	M
E	How often is child expected to pick up after himself/herself?	M
C	Is there a musical instrument that child can use here at home?	M
C	Does your family get a daily newspaper?	M
C	How often does child read for enjoyment?	M
C	Does your family encourage child to start and keep doing hobbies?	M
C	Does child get special lessons or belong to any organization that encourages activities such as sports, music, art, dance, drama, etc.?	M
C	How often has a family member taken or arranged to take child to any type of museum?	M
C	How often has a family member taken or arranged to take child to any type of musical or theatrical performance within the past year?	M
E	How often does your whole family get together with relatives or friends?	M
E	How often does child spend time with his/her father, stepfather, or father-figure?	M
E	How often does child spend time with his/her father, stepfather, or father-figure in outdoor activities?	M
E	How often does child eat a meal with both mother and father?	M
C	When your family watches TV, do you (or father) discuss programs with him/her?	M
E	Mother response to tantrum – Grounding	M
E	Mother response to tantrum - Spanking	M
E	Mother response to tantrum – Talk with child	M
E	Mother response to tantrum – Give child a household chore	M
E	Mother response to tantrum – Ignore it	M

E	Mother response to tantrum – Send child to room	M
E	Mother response to tantrum – Take away allowance	M
E	Mother response to tantrum – Take away TV, phone, or other privileges	M
E	Mother response to tantrum – Short-time out	M
E	Mother response to tantrum – Other (specify)	M
E	How many times in the past week have you had to spank child?	M
E	Mother encouraged child to contribute to the conversation?	O
E	Mother answered child's questions or requests verbally?	O
E	Mother conversed with child excluding scolding or suspicious comments?	O
E	Mother introduced interview to child by name?	O
E	Mother's voice conveyed positive feeling about child?	O
C	Interior of home is dark or perceptually monotonous?	O
C	All visible rooms of the house/apartment are reasonably clean?	O
C	All visible rooms of the house/apartment are minimally cluttered?	O
C	Building has no dangerous structural or health hazards within a school-ager's range.	O

Source: NLSY C/YA Codebook Supplement Appendix A-2c.

Table A2
RIES assessment statement pairs.

Pair Number	Internal Statement	External Statement
1	What happens to me is my own doing.	Sometimes I feel that I don't have enough control over the direction my life is taking.
2	When I make plans, I am almost certain that I can make them work.	It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.
3	In my case, getting what I want has little or nothing to do with luck.	Many times, we might as well decide what to do by flipping a coin.
4	It is impossible for me to believe that chance of luck plays an important role in my life.	Many times, I feel that I have little influence over the things that happen to me.

Source: NLS79 1979 Questionnaire Section 19.

Table A3
Descriptive statistics using raw scores:
Means and standard deviations (in parentheses), and percentages.

	Entire sample	Married/cohabiting mothers	Single mothers	Cohabiting separated/ divorced mothers
Child characteristics:				
PIAT reading recognition raw score				
Ages 6-7 (lagged)	22.2	22.8	20.6	22.2
	(8.8)	(8.9)	(8.1)	(9.6)
Ages 8-9 (current)	38.6	39.9	35.5	37.6
	(11.4)	(11.6)	(10.4)	(11.1)
PIAT reading comprehension raw score				
Ages 6-7 (lagged)	21.1	21.7	19.7	21.6
	(7.9)	(8.1)	(6.9)	(9.8)
Ages 8-9 (current)	35.7	36.9	32.9	34.9
	(10.4)	(10.3)	(10.1)	(10.4)
PIAT math raw score				
Ages 6-7 (lagged)	19.7	20.5	17.8	19.1
	(8.4)	(8.5)	(8.0)	(8.3)
Ages 8-9 (current)	35.8	37.0	33.1	34.5
	(10.6)	(10.6)	(10.3)	(10.3)
BPI raw score	59.4	57.9	63.2	57.1
	(61.8)	(57.8)	(67.9)	(65.7)
Maternal and household characteristics:				
RIES raw score	8.8	8.6	9.1	8.7
	(2.4)	(2.4)	(2.4)	(2.3)
HOME-SF raw score	202.8	214.2	175.5	196.0
	(37.2)	(31.1)	(37.3)	(34.3)
N	2069	1416	575	78

Table A4
Second stage regression results of alternative specification including family structure (standardized scores): coefficient estimates and standard errors (in parentheses).

	PIAT reading comprehension score		PIAT reading recognition score		PIAT math score	
	OLS	IV	OLS	IV	OLS	IV
Intercept	-0.19*	-0.20*	-0.10	-0.12	-0.34***	-0.33***
	(0.12)	(0.12)	(0.10)	(0.11)	(0.11)	(0.11)
HOME-SF score	0.10***	0.24*	0.07***	0.34***	0.03	-0.005
	(0.02)	(0.13)	(0.02)	(0.12)	(0.02)	(0.14)
Family structure:						
Single mothers	0.01	0.11	-0.02	0.19*	0.01	-0.02
	(0.04)	(0.10)	(0.04)	(0.10)	(0.04)	(0.11)
Cohabiting separated/ divorced mothers	-0.06	-0.02	-0.05	0.04	-0.05	-0.06
	(0.09)	(0.10)	(0.08)	(0.09)	(0.08)	(0.10)
Lagged test score	0.47***	0.46***	0.62***	0.61***	0.53***	0.53***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
BPI score	-0.07***	-0.07***	-0.06***	-0.05***	-0.05***	-0.05***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Child's/mother's race:						
Hispanic	-0.05	-0.03	-0.01	0.04	-0.05	-0.10
	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)
Black	-0.11**	-0.07	-0.05	0.03	-0.16***	-0.17***
	(0.05)	(0.06)	(0.04)	(0.06)	(0.05)	(0.06)
Nine years old	0.21***	0.21***	2.1E-6	0.002	0.25***	0.24***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Male	-0.10***	-0.09***	-0.08**	-0.06**	0.21	-0.006
	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
Birth order	-0.07***	-0.05*	-0.05**	-0.008	-0.05**	-0.06*
	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)
Birth weight (oz.)	4.0E-4	3.0E-4	8.9E-4	0.001	4.6E-4	0.001
	(8.3E-4)	(0.001)	(7.4E-4)	(0.001)	(8.3E-4)	(0.001)
Mother's age at child's birth (years):						
Less than 20	-0.06	-0.01	-0.05	0.04	-0.02	-0.03
	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)
Older than 29	0.04	0.03	0.02	-0.01	0.14***	0.14***
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)
Mother's educational attainment:						
Less than high school	-0.08	-0.05	-0.09*	-0.03	-0.04	-0.05
	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)
Some college	-0.02	-0.05	-0.04	-0.10*	0.04	0.05
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
College graduate	-0.11**	-0.15**	0.02	-0.05	0.06	0.07
	(0.06)	(0.07)	(0.05)	(0.06)	(0.05)	(0.06)
Mother's AFQT percentile	0.57***	0.50***	0.39***	0.25**	0.47***	0.49***
	(0.09)	(0.11)	(0.08)	(0.10)	(0.08)	(0.12)

Number of children in household younger than five years old	-	-	-	-	-0.06*** (0.02)	-0.06*** (0.03)
Weak instruments F-statistic	-	10.06	-	9.96	-	8.98

Note. – The base group is female children eight years of age in households with mothers who are high school graduates, were twenty to twenty-nine years old at the child's birth, and identify as White. Significance code: '***' for 99% significance, '**' for 95% significance, '*' for 90% significance.

Table A5
First stage regression results (raw scores):
coefficient estimates and standard errors (in parentheses).

	HOME-SF score		
PIAT subtest used for lagged test score	PIAT reading comprehension score	PIAT reading recognition score	PIAT math score
Intercept	215.91***	216.52***	212.98***
	(5.88)	(5.86)	(5.83)
Family structure:			
Single mothers (1)	-26.02***	-26.11***	-25.78***
	(5.84)	(5.84)	(5.82)
Cohabiting separated/ divorced mothers (2)	13.60	13.58	15.29
	(13.66)	(13.66)	(13.62)
Mother's RIES score:	-0.84**	-0.84**	-0.81**
	(0.34)	(0.34)	(0.34)
Mother's RIES score x (1)	0.23	0.23	0.19
	(0.61)	(0.61)	(0.61)
Mother's RIES score x (2)	-2.58*	-2.57*	-2.76*
	(1.51)	(1.51)	(1.51)
Lagged test score	0.15	0.11	0.35***
	(0.1)	(0.09)	(0.1)
BPI score	-0.03**	-0.03**	-0.02**
	(0.01)	(0.01)	(0.01)
Child's/mother's race:			
Hispanic	-6.36***	-6.35***	-6.02***
	(1.92)	(1.92)	(1.91)
Black	-9.99***	-9.95***	-9.36***
	(1.87)	(1.87)	(1.86)
Nine years old	-0.71	-0.53	-2.4
	(1.49)	(1.52)	(1.50)
Male	-1.72	-1.78	-1.71
	(1.31)	(1.31)	(1.30)
Not first-born	-5.51***	-5.53***	-5.39***
	(0.89)	(0.9)	(0.89)
Birth weight (oz.)	0.03	0.03	0.03
	(0.03)	(0.03)	(0.03)
Mother's age at child's birth (years):			
Less than 20	-11.39***	-11.35***	-10.98***
	(2.03)	(2.03)	(2.03)

Older than 29	1.51	1.53	1.74
	(1.89)	(1.89)	(1.89)
Mother's educational attainment:			
Less than high school	-7.12***	-7.12***	-7.09***
	(2.16)	(2.16)	(2.16)
Some college	6.33***	6.39***	6.10***
	(1.72)	(1.72)	(1.72)
College graduate	5.83***	5.87**	5.30**
	(2.27)	(2.27)	(2.27)
Mother's AFQT percentile	14.55***	14.7***	13.53***
	(3.42)	(3.42)	(3.40)
Current annual household income ($1000)	0.11***	0.11***	0.10***
	(0.02)	(0.02)	(0.02)
Square of annual household income ($1000)	-8.49E-5***	-8.56E-5***	-8.01E-5***
	(-2.20E-5)	(2.19E-5)	(2.19E-5)
Number of children in household younger than five years old	-3.00***	-3.01***	-2.80***
	(0.89)	(0.89)	(0.89)
F-statistic	59.53	59.46	60.38

Note. –The base group is female children eight years of age in households with married/cohabiting mothers who are high school graduates, were twenty to twenty-nine years old at the child's birth, and identify as White. Household income is expressed in 2004 dollars, calculated using the Consumer Price Index for All Urban Consumers (CPI-U).
Significance code: '***' for 99% significance, '**' for 95% significance, '*' for 90% significance.

Table A6
Second stage regression results (raw scores):
coefficient estimates and standard errors (in parentheses).

	PIAT reading comprehension score		PIAT reading recognition score		PIAT math score	
	OLS	IV	OLS	IV	OLS	IV
Intercept	15.90***	15.21***	14.76***	10.79***	18.53***	19.23***
	(1.68)	(3.28)	(1.67)	(23.29)	(1.62)	(3.15)
HOME-SF score	0.03***	0.03**	0.03***	0.05***	0.009	0.005
	(0.006)	(0.02)	(0.01)	(0.02)	(0.005)	(-0.02)
Lagged test score	0.60***	0.60***	0.81***	0.81***	0.65***	0.65***
	(0.03)	(0.03)	(0.02)	(0.003)	(0.02)	(0.03)
BPI score	-0.01***	-0.01***	-0.01***	-0.01***	-0.01***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Child's/mother's race:						
Hispanic	-0.52	-0.49	-0.07	0.07	-0.53	-0.55
	(0.52)	(0.53)	(0.52)	(0.53)	(0.50)	(0.51)
Black	-1.11**	-1.04*	-0.64	-0.27	-1.64***	-1.70***
	(0.50)	(0.56)	(0.50)	(0.56)	(0.48)	(0.53)
Nine years old	2.18***	2.18***	0.002	0.005	2.62***	2.62***
	(0.40)	(0.40)	(0.41)	(-0.41)	(0.39)	(0.39)
Male	-1.02***	-1.02***	-0.88**	-0.86**	-0.05	-0.06

	(0.35)	(0.36)	(0.35)	(0.36)	(0.34)	(0.34)
Not first-born	-0.72***	-0.70***	-0.55**	-0.43*	-0.56**	-0.58**
	(0.24)	(0.26)	(0.24)	(0.26)	(0.23)	(0.25)
Birth weight (oz.)	0.005	0.005	0.01	0.009	0.01	0.01
	(0.009)	(0.009)	(0.01)	(0.009)	(0.008)	(0.008)
Mother's age at child's birth (years):						
Less than 20	-0.60	-0.55	-0.62	-0.33	-0.17	-0.22
	(0.55)	(0.59)	(0.55)	(0.59)	(0.53)	(0.57)
Older than 29	0.44	0.43	0.23	0.15	1.47***	1.49***
	(0.50)	(0.51)	(0.50)	(0.51)	(0.48)	(0.49)
Mother's educational attainment:						
Less than high school	-0.81	-0.78	-1.07*	-0.88	-0.46	-0.49
	(0.59)	(0.60)	(0.59)	(0.61)	(0.56)	(0.58)
Some college	-0.21	-0.24	-0.44	-0.60	0.48	0.51
	(0.47)	(0.48)	(0.47)	(0.48)	(0.45)	(0.46)
College graduate	-1.18**	-1.22**	0.21	-0.005	0.65	0.68
	(0.60)	(0.62)	(0.60)	(0.62)	(0.57)	(0.59)
Mother's AFQT	5.94***	5.87***	4.52***	4.10***	5.03***	5.10***
percentile	(0.91)	(0.96)	(0.92)	(0.97)	(0.87)	(0.92)
HH05	-	-	-	-	-0.65***	-0.65***
					(0.23)	(0.23)
Weak instruments test F-statistic	-	40.06***	-	40.06***	-	45.06***

Note. – The base group is female children eight years of age in households with mothers who are high school graduates, were twenty to twenty-nine years old at the child's birth, and identify as White. Significance code: '***' for 99% significance, '**' for 95% significance, '*' for 90% significance.

Figure A1
Predicted values of HOME-SF scores given mothers' RIES scores
(reading comprehension subtest regression).

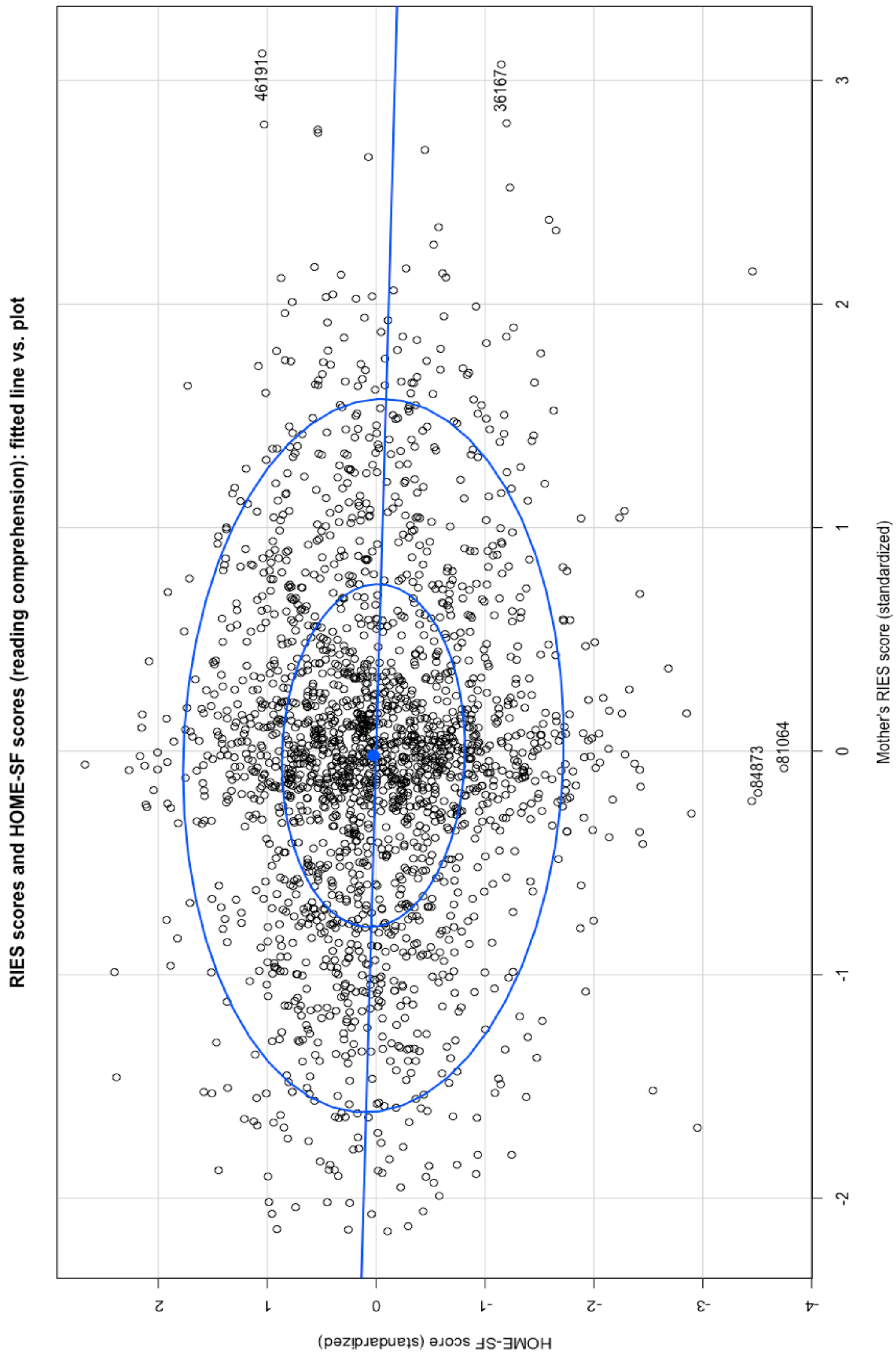

Figure A2.
Predicted values of HOME-SF scores given mothers' RIES scores
(reading recognition subtest regression).

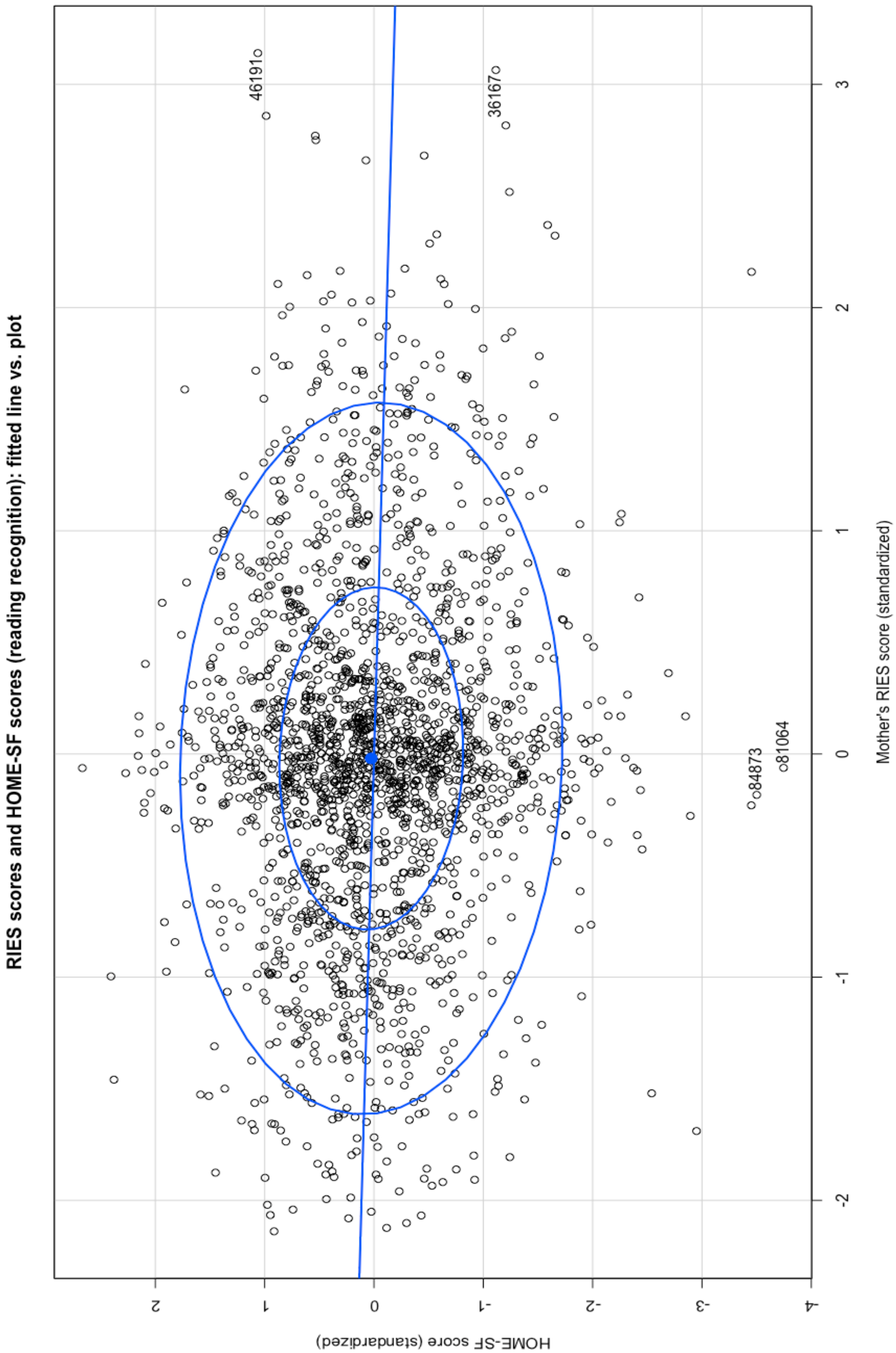

Figure A3.
Predicted values of HOME-SF scores given mothers' RIES scores
(math subtest regression).