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Intelligence, Income, and Education as Potential Influences on a Child's Home Environment: A (Maternal) Sibling-Comparison Design

Alexandria Ree Hadd and Joseph Lee Rodgers
Vanderbilt University

The quality of the home environment, as a predictor, is related to health, education, and emotion outcomes. However, factors influencing the quality of the home environment, as an outcome, have been understudied—particularly how children construct their own environments. Further, most previous research on family processes and outcomes has implemented between-family designs, which limit claims of causality. The present study uses kinship data from the National Longitudinal Survey of Youth to construct a maternal sibling-comparison design to investigate how maternal and child traits predict the quality of home environment. Using a standard between-family analysis, we first replicate previous research showing a relationship between maternal intelligence and the quality of the home environment. Then, we reevaluate the link between maternal intelligence and the home environment using differences between maternal sisters on several characteristics to explain differences between home environments for their children. Following, we evaluate whether child intelligence differences are related to home environment differences in the presence of maternal characteristics. Results are compared with those from the between-family analysis. Past causal interpretations are challenged by our findings, and the role of child intelligence in the construction of the home environment emerges as a critical contributor that increases in importance with development.

Keywords: home environment, sibling-comparison design, intelligence

How is a child's home environment constructed? The child may elicit the home environment, parents and caregivers may create it, or both may interact in its construction. The creation of a child's home environment is obviously an important and complex process, but one that has been explored primarily in terms of parental influences, with little attention to child influences. In this study, we reverse the usual direction of evaluation and consider the home environment as an outcome of child–maternal characteristics instead of a predictor of child outcomes. We evaluate how maternal and child characteristics, including intelligence, education, and income, combine to influence individual differences in the construction of the home environment. To evaluate how parents and children collaborate to construct the home environment, we use a maternal sibling-comparison design and sibling fixed-effects analyses, which provide extra control over bias and confounds compared with traditional between-family designs.

Past Conceptual Frameworks

The home environment has been viewed through two distinct conceptual frameworks. Turkheimer and Waldron (2000) drew on earlier work by Plomin and colleagues (e.g., Rowe & Plomin, 1979) and Goldsmith (1993) to distinguish between objective and effective child environments. The objective environment is what the researcher sees and studies; an objective environmental element shared by multiple siblings is considered the same across siblings. In contrast, the effective environment is the environment that creates child outcomes. Effective environments may differ across children, even if the objective environment is identical. For instance, children may respond differentially to a divorce, a family move, or to apparently identical parental discipline.

The second framework emerges from behavior genetic (BG) research. Within behavior genetics, nonshared environmental influences are environmental processes that lead to divergent sibling outcomes, by definition. Shared environmental influences are those that lead to similar sibling outcomes, also by definition. Examples are easy to construct: Factors related to birth order (nonshared influences) can lead older siblings to behave differently from younger siblings. Alternatively, an authoritarian parental style (a shared influence) contributes to sibling similarity. It should be noted that these definitional influences in BG research may be either objective or effective and may shift, depending on the perspective. Thus, some objective, shared environmental influences may function as nonshared influences and vice versa. For example, an authoritarian discipline style may appear to be a shared influence, but if one child is given more parental leeway, the discipline style may in fact be a nonshared influence.

However, neither of these BG definitional influences can be used to create a precise definition of the home environment; rather, shared and nonshared influences define the environment indirectly, indicated by either similarities or differences in child outcomes. Behavioral geneticists have acknowledged the difficulty with these classifications of environmental influences; the shared

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Alexandria Ree Hadd and Joseph Lee Rodgers, Department of Psychology and Human Development, Vanderbilt University.

Correspondence concerning this article should be addressed to Alexandria Ree Hadd, Department of Psychology and Human Development, Vanderbilt University, 230 Appleton Place #552, Hobbs 202C, Nashville, TN 37203. E-mail: alexandria.r.hadd@vanderbilt.edu

environment may appear to be conceptually peripheral to the nonshared environment, and yet the nuanced character of the nonshared environment makes its causal factors difficult to identify (Bouchard & McGue, 2003). Further, the nonshared environment is literally a residual term in the traditional BG model. Even within Turkheimer and Waldon's (2000) distinction between objective and effective environments, the causal factors that contribute to the quality of the home environment are not referenced, either explicitly or implicitly.

Though neither of these frameworks may usefully define the child's environment, a widely used measurement instrument, the Home Observation for Measurement of the Environment (HOME) Inventory, can provide such definitional grounding. We operationalize the home environment in reference to the HOME. The HOME is used to "assess the quality of stimulation and support available to a child in the home environment" (Bradley et al., 1989, p. 219), but the HOME is not unidirectional in terms of the flow of influence from parent to child. Some items measure how parents construct the environment for their child (e.g., "Mom's voice conveys positive feeling about child"; "Family encourages child to start and keep doing hobbies"). Other items assess the child's contribution to the construction of their own home environment (e.g., "Child reads for enjoyment"). Still other items are bidirectional or neutral about the source of influence on the home environment (e.g., "Whole family gets together with relatives or friends").

In line with the HOME, we view the home environment as partly physical, partly social, and partly nurturant. The home environment correlates with but is conceptually distinct from constructs such as socioeconomic status, parenting style, social support, and family characteristics. In particular, there is a clear view in the original development of the HOME that multiple actors (parents, children, siblings, etc.) contribute to the development of the child's home environment.

The Child's Role in the Home Environment

Past research on the home environment typically regards the home environment as an influence on child development and primarily constructed by the parents. The home environment has been uniquely linked to child health outcomes, achievement and cognitive measures, educational and behavioral outcomes, and psychological development (Baharudin & Luster, 1998; Davis-Kean, 2005; Gottfried, 1984; Pinto, Pessanha, & Aguiar, 2013; Rodgers, Rowe, & May, 1994; Weitzman, Gortmaker, & Sobol, 1992; Whitley et al., 2011). Even the HOME, which includes items that assess children's participation in the home environment, was originally developed as a screening tool to identify features of the home environment that might place the child at developmental risk (Bradley & Caldwell, 1977).

Although caregivers obviously play a key role in the creation of the home environment, the role that children play in constructing their home environments is often downplayed or unexplored. For example, the positive relationship between the home environment and child intelligence as an outcome has been well-established (Bacharach & Baumeister, 1998; Baharudin & Luster, 1998; Bradley et al., 1989, 1993; Brooks-Gunn, Klebanov, & Duncan, 1996; Luster & Dubow, 1992; Yeates, MacPhee, Campbell, & Ramey, 1983). Typically, the relationship can only be asserted to be correlational (i.e., not necessarily causal), but often this relationship is recast as the home environment contributing to child intelligence. Only a few studies account for the fact that children participate in constructing their own environments. For instance, Rodgers et al. (1994) investigated the influence of nonshared environment on child intelligence, but acknowledge in their discussion the potential for reciprocal causation, that children's intelligence may, in fact, cause nonshared environment.

At a broader level, developmentalists and behavior geneticists have a longstanding appreciation of child-initiated environmental influences (e.g., Scarr & McCartney, 1983). When the environment emerges because of heritable traits within the child, the correlation between the heritable trait and systematic features of the environment is called a gene–environment correlation (G–E). G–E occurs when variance in children's environment corresponds to genetic variance. G–E may be active, when a heritable trait leads directly to environmental features. For example, an aggressive child may choose to watch war movies when given TV options. G–E may be passive, when parents construct a family environment and also pass on heritable traits to their children that interact with that environment. For example, an aggressive parent may buy war movies for their child. Finally, G–E may be evocative, when variance in family environmental outcomes emerges in response to heritable traits in children. For example, an aggressive child may demand that their parent buy them war movies. In each example, there will be a gene-environment correlation between the child's biological disposition toward aggression and war movie consumption, but the causal etiology leading to the correlation is different in each case. Only through evocative and active G–E does the child play a direct role in their consumption of war movies. Scarr and McCartney (1983) posit that children create more of their environments as development progresses, but many studies imply the etiology of family environments to be passive without sufficiently exploring the active or evocative processes children may contribute.

Maternal Characteristics and the Home Environment

The relationship between maternal intelligence and quality of home environment has been well established (Bacharach & Baumeister, 1998; Baharudin & Luster, 1998; Longstreth et al., 1981; Luster & Dubow, 1992; Yeates et al., 1983). Generally, higher intelligence mothers are associated with higher quality home environments, with the zero-order correlation between maternal intelligence and home environment around .40 in the literature. This relationship has been examined in conjunction with correlates of maternal intelligence, including maternal education, income, socioeconomic status, and race/ethnicity, and persists even when such correlates are accounted for. Explanations posit that the greater personal resources available to higher intelligence mothers allow for the creation of better home environments, even once related qualities (i.e., greater wealth, more stable living environments, stronger social support networks, etc.) have been accounted for. For instance, physical health (Gottfredson & Deary, 2004) and personality traits such as openness to experience (Soubelet & Salthouse, 2011) may be positively related to intelligence, and such resources may promote higher quality home environments through greater energy and engagement with the child and environment. Resources also likely include some of confounds that the design in the current study addresses, including ancestral genetic vitality and long-term financial contributions from previous generations.

Such research helps elucidate the maternal influences of the home environment, but de-emphasizes the child's own influence in their environment. Few studies outside of the behavioral genetics literature investigate how children and parents interact to construct the home environment. Baharudin and Luster (1998) evaluated home environments (using the HOME) with maternal and familial predictors, including maternal intelligence and child gender, and found that higher intelligence mothers and female children were associated with higher quality home environments. Whitley et al. (2013) found that parental intelligence significantly predicted TV viewing habits and frequency of injuries, such that children of smarter parents watched less TV and incurred fewer injuries, even after controlling for confounding child and family characteristics. A more recent study on children's media consumption found that the interaction between child factors and parental factors significantly predicted time spent using media (Lauricella, Wartella, & Rideout, 2015). Although these examples give nod to the joint roles of parent and child influence in the home, the emphasis within these studies is still largely on the role parents play in constructing the home environments.

A separate problem in the current trend of maternal intelligence–home environment research is the overreliance on correlational and between-family analyses, which limits causal claims. For example, in a study of the link between maternal intelligence and quality of the home environment, maternal intelligence could be the direct causal factor: smarter moms utilize their intelligence to create better home environments. This interpretation is often used (e.g., Bacharach & Baumeister, 1998). Alternatively, maternal intelligence may be acting as an indirect measure of maternal education, income, or other family level factors that are the true causal influences. Further, maternal factors can also be indirect measures of child factors contributing to the quality of the family environment (e.g., child intelligence) that, when left out of appropriate analyses of the home environment, can manifest their influence through the maternal factors (e.g., maternal intelligence) to which they are most highly related. In the current study, we use a cross-generational sibling-comparison design to create the potential for stronger causal assertions, and to measure and distinguish potential causal contributors to the home environment.

The Rise of Sibling-Comparison Designs

As has been argued in detail (e.g., Garrison & Rodgers, 2016; Lahey & D'Onofrio, 2010; Rutter, 2007; Scarr & McCartney, 1983), particular care must be taken in studies of familial environmental effects with regards to causation. Specifically, a factor that is either heritable, environmental, or both cannot be said to cause an outcome unless design, analysis, and logic support the legitimacy of the causal inference. Even then, appropriate threats to internal validity must be considered and evaluated. Unfortunately, in familial research, basic statistical adjustment using linear covariates, blocking, or other mechanisms is unlikely to be sufficient to rule out enough threats to internal validity to support drawing causal conclusions. As one well-known example, a great deal of past birth order research has been based on designs that perfectly confound within-family variance (variance across multiple members per household) and between-family variance (variance across multiple members each from different households; see Rodgers, Cleveland, van den Oord, & Rowe, 2000, for extensive discussion, and Wichman, Rodgers, & MacCallum, 2006, for a demonstration of this logic). This type of confound often occurs in studies using between-family designs, in which a single member of a household is used as a respondent. For many studies, whose goals involve measuring outcomes at the between-family level, between-family designs do not pose a problem. However, for studies in which intrafamilial processes are important, there is an ecological fallacy created by using such between-family designs. When real within-family variance is simply not present within a sample, as in between-family designs, a researcher cannot distinguish within-family variance from between-family variance. Stronger designs, including sibling-comparison designs, have been evaluated and implemented with success (see Lahey & D'Onofrio, 2010, and Rodgers et al., 2000 for extensive treatment). These designs offer substantially greater control of nuisance variance, selection bias, and other threats to internal validity than can be achieved in typical between-family designs.

The greater control of nuisance variance and selection bias in studies that implement sibling-comparison designs can result in substantially different, but more causally sound, conclusions than comparable research implementing between-family designs. For instance, in studies of birth order effects on child intelligence (Rodgers et al., 2000), father absenteeism effects on adolescent sexual behavior (Ryan, 2015), and smoking-during-pregnancy effects on child conduct problems (D'Onofrio et al., 2008), relationships that had apparently been well-established through previous between-family studies were shown to be greatly attenuated (or even to disappear) once sibling-comparison designs were implemented. In other cases, such as a recent study on the relationship between paternal age and child outcomes, previously established relationships were found to be much stronger (D'Onofrio et al., 2014). Logically, the previous findings emerged from between-family variance but were misattributed to parental influence or other processes operating within the family.

The benefits that emerge from the sibling-comparison design accrue because of the natural matching that occurs when considering sibling pairs. Siblings from the same household share many, but not all, environmental and genetic factors. More importantly, full siblings from the same household share all ancestral variance, starting with their shared parents and then backward through all previous generations. Sibling comparison controls for unobserved heterogeneity caused by family background differences, eliminating such confounds when sibling outcomes diverge. Further, sibling matching allows a convenient avenue to study how differences in a familial predictor relate to differences in an outcome. In other words, sibling-comparison designs can be used to separately model the contributions of factors that differ between families and within families. Addressing such empirical questions is impossible at worst, and suspect at best, in between-family research.

To emphasize the value of this control, we note that when two siblings from an intact household are compared with one another on any outcome, it is impossible that differences between them emerged from ancestry or between-family processes; only processes emerging from their own specific family are contenders to explain sibling differences. On the other hand, when two unrelated individuals differ (on, say, an achievement measure) the cause of the difference may lie in between-family processes (e.g., differences in parental income or intelligence), within-family processes (e.g., an outstanding teacher for one observed sibling but not for other unobserved siblings), or both. It is a risk to posit the location of such between-family differences, but a risk engaged by hundreds of previous researchers, apparently without full awareness.

The Present Study

In light of the causal advantages demonstrated by sibling-comparison designs and the gap in the literature concerning the etiology of the quality of the home environment, the present research is developed in two separate studies to investigate influences on the home environment. We conduct analyses that allow maternal and child predictors to compete to explain variance in quality of home environments. Both studies consider how potential causal factors differentially predict the quality of home environment over several developmental time points in childhood and early adolescence.

Study 1 uses between-family samples and analyses typically implemented in this literature to replicate results that would follow investigating between-family differences in home environments. We follow and compare the results of Study 1 with Study 2, in which we implement a sibling-comparison design, with mothers as siblings, using the same data. Study 2 leverages the matched pairs inherit in sibling designs to create difference scores for maternal characteristics, child intelligence, and quality of home environment. The resulting analyses on difference scores in Study 2 allow stronger causal conclusions to be drawn than those in Study 1.

Study 1

Method

Data. The present study used data from the National Longitudinal Survey of Youth (Bureau of Labor Statistics, 2015a, 2015b), from both the original 1979 sample of adolescents (the NLSY79), and the children of the females in the NLSY79 (the NLSY-Children or NLSYC). The NLSY79 began in 1979 as a national probability sample of households, with 12,686 respondents from 8,770 households in the first year. Data collection continued annually until 1986, after which biennial surveys were administered; response rates remained above 90% into the 1990s and continue to be over 70% as of 2012. The NLSY79 respondents were between the ages of 14 to 22 at first interview. Data on various health, education, vocation, and adjustment outcomes were assessed longitudinally from 1979 until the present, including extensive information on family development and birth histories for all NLSY79 respondents.

In 1986, data from all biological children born to females in the NLSY79 were collected in separate surveys. By 2012, nearly 5,000 female NLSY79 respondents had given birth to over 11,500 children over the study period, and female childbearing was completed by 2012, when NLSY79 respondents were aged 47 to 55. By combining information from the NLSY79 and NLSYC, a merged dataset can be developed that includes rich measures of family and parenting behaviors and psychological measures of both parents and children.

Kinship links. Kinship links for the NLSY79 and NLSYC data sets were completed in 2013 (see Rodgers et al., 2016, for background and discussion). Explicit indicators of the sibling status (e.g., twin, full-, half-, or adoptive-sibling status) were included in the two questionnaires for the first time in 2006. Using the explicit indicators, along with maternal information to infer relatedness in cases of missing data and inconsistencies, 5,038 kinship pairs in the NLSY79 (95% of the total possible pairs) and 16,083 (100% of the possible pairs) in the NLSYC have been identified. In addition, over 20,000 kinship links have been defined using cross-generational information from the two data sets, including mother-daughter/son, aunt-niece/nephew, and cousin pairs. In the current study, we use the identified maternal sibling pairs from female sisters in the NLSY79, and their children (i.e., identified cousins) from the NLSYC dataset. Researchers interested in using the NLSY79 and/or NLSYC kinship pairs can find those (along with extensive documentation and coding support) at http://liveoak.github.io/NlsyLinks/.

Sample construction. Eligible members for the present studies include female NLSY79 respondents who have 1) at least one full-sibling sister identified in the NLSY79 and 2) at least one child assessed between 1986 and 2012 in the NLSYC. Only first-born children of the NLSY79 respondents and observations with complete data were included in the present study. Over 3,000 children are identified as cousins in the NLSYC, but given the above restrictions, the actual sample is substantially smaller.

Within a given pair of maternal sisters, one mother will have a higher intelligence (as assessed using the Armed Forces Qualifying Test [AFQT]; see following text) relative to her sister. Such higher intelligence mothers, along with their children, constitute our "Sample MHigh" and are referred to as *MHigh mothers* throughout, whereas the lower intelligence mothers and their children constitute "Sample MLow" sample (see Figure 1) and are referred to as *MLow mothers*. (e.g., suppose that Jill and her daughter Tanya, are a single mother–child observation in Sample MHigh, and Jill's sister Janice and Janice's son Toby, are a single observation Sample MLow.) Sample sizes range between 293 (293 mothers and their 293 first-born children) and 423 for Sample MHigh and MLow. Sample MHigh and MLow are relatively similar to each other (see Table 1), as expected given the relatedness of mothers across the two samples (e.g., sisters Jill and Janice are similar because of both shared environmental and shared genetic influences, as are cousins Tanya and Toby).

Sample MHigh and MLow are each between-family (Jill/Tanya in Sample MHigh come from a different family than all other mother-child observations in Sample MHigh) and disjoint (Jill/Tanya only appear in Sample MHigh and never in Sample MLow). Although the samples are similar to each other, analyses are conducted on each set separately. In addition to these two samples, a third sample (Sample MRandom) was constructed by randomly selecting one mother from each maternal sister pair. Sample MRandom more closely approximates random sampling techniques typical in between-family research. Random selection into Sample MRandom was done without consideration of the completeness of the data for either the mother or child. Overall, 49.2% of Sample MRandom was selected from Sample MHigh (i.e., 49.2% of the sample consisted of the higher intelligence mom and her child in the maternal sister pair), but due to missing data this percentage varies from 47.6% to 51.1% across models.

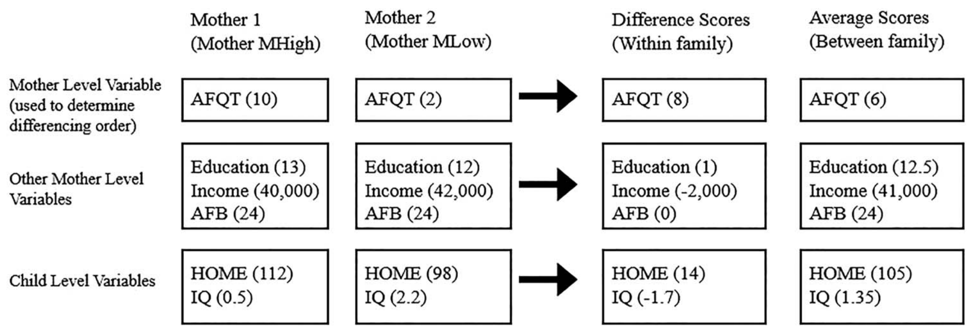

Figure 1. Sample construction for Study 1 and Study 2. On the left, the two between-family samples (Sample MHigh [i.e., higher intelligence mothers, along with their children] and MLow [i.e., lower intelligence mothers, along with their children]) used in Study 1 are shown. Typical values on variables appear in parentheses. On the right, the construction of difference and average scores, used in Study 2, are shown. In parentheses are examples of scores calculated from subtracting the MLow mother's score from her sister's, the MHigh mother's, score. Difference scores represent within family differences, whereas averages represent between family differences.

The repetition of analyses on the disjoint, but dependent, MHigh and MLow samples allows evaluation of the robustness of the results. This is especially valuable given the lack of even between-family inquiries into construction of the home environment with both maternal and child predictors. The repetition of the analyses on Sample MRandom is also valuable, as the results of the analyses may more closely align with results from a tradition sampling mechanism and will be a compromise between the MHigh and MLow results.

In addition, children were drawn from the longitudinal NLSY sample design at three different time points (4 to 5 years old, 8 to 9 years old, and 12 to 13 years old) to investigate predictors of the home environment over development. The 2-year window for each time point allowed for the maximum possible sample sizes given the biennial NLSYC survey schedule. Most children (approximately two thirds, with variability due to missing data) were included in two or three of the time points evaluated; attrition, unsystematic missing data, and ineligible birth years produce differences in sample participants across the three time points. For example, a child born in 1980 could not be assessed at the first time point (4 to 5 years old), and a child born in 2005 could not be assessed at the third time point (12 to 13 years old). Further, each time point aggregates children born across several decades; for example, the 4- to 5-year-old samples include children born between 1980 and 2008. Constructing our samples this way does not capitalize on the benefits of a strictly longitudinal design, but it does optimize sample size and mitigates generational effects that can plague purely cross-sectional or longitudinal designs.

Table 2 presents means and standard deviations for maternal and child characteristics (described below) for the total sample of mothers in the NLSY79 with first-born children in the NLSYC. Some observations for specific analyses had missing data and were excluded; sensitivity analyses were conducted to detect differences between means for the smallest sample used (ages 4 to 5 with complete observations for mother pairs and their children) and the total sample. For the total sample, 32% of maternal sisters are black, 18% are Hispanic, and 50% are White/non-Black/non-Hispanic. For the smallest sample, 19% of maternal sisters are black, 18% are Hispanic, and 63% are White/non-Black/non-Hispanic. Children in the total Sample MHigh are 47% female (53% female in Sample MLow); children in the smallest Sample MHigh are 46% female (54% female in Sample MLow). Mothers in the total Sample MHigh began childbearing on average at 24 years old (M = 24.10, SD = 5.59); mothers in the total Sample

Table 1
Correlations Between Paired Observations in Sample MHigh and MLow

Predictors	Time invariant	Age 4 to 5	Age 8 to 9	Age 12 to 13
Mom IQ[a]	.88**			
Maternal education		.61*	.58**	.61**
Family income		.15	.18**	.30**
AFB[a]	.37**			
Child IQ		.18**	.17*	.40**
HOME		.37**	.30**	.25**

Note. MHigh = Higher intelligence sisters from maternal sibling pair; MLow = Lower intelligence sisters from maternal sibling pair; HOME = The Home Observation for Measurement of the Environment Inventory; AFB = age at first childbirth.
[a] Variables were only measured once: Mom IQ in 1980 and AFB as mother's age at birth of firstborn child. Correlations for these variables are equal across all time points.
* $p < .01$. ** $p < .001$.

Table 2
Means of Raw Variables for Sample MHigh, MLow, and MRandom

Predictors	Sample MHigh (*SD*)	Sample MLow (*SD*)	Sample MRandom (*SD*)
Mom IQ[a]	7.30 (19.80)	−5.43 (20.70)	1.14 (21.38)
Maternal education	Age 4 to 5: 13.72 (2.32) Age 8 to 9: 13.51 (2.37) Age 12 to 13: 13.58 (2.36)	Age 4 to 5: 13.04 (2.20) Age 8 to 9: 12.76 (2.22) Age 12 to 13: 12.79 (2.24)	Age 4 to 5: 13.36 (2.28) Age 8 to 9: 13.10 (2.37) Age 12 to 13: 13.13 (2.39)
Family income	Age 4 to 5: 44,924 (69,021) Age 8 to 9: 49,278 (75,438) Age 12 to 13: 60,685 (79,571)	Age 4 to 5: 44,616 (99,790) Age 8 to 9: 40,036 (74,692) Age 12 to 13: 42,634 (45,717)	Age 4 to 5: 42,296 (67,996) Age 8 to 9: 41,603 (62,070) Age 12 to 13: 47,420 (46,104)
AFB[a]	24.10 (5.59)	23.44 (5.64)	23.80 (5.74)
Child IQ	Age 4 to 5: .22 (1.15) Age 8 to 9: .15 (1.03) Age 12 to 13: .14 (1.01)	Age 4 to 5: .03 (.97) Age 8 to 9: .00 (1.02) Age 12 to 13: –.04 (.99)	Age 4 to 5: .05 (1.03) Age 8 to 9: .03 (1.05) Age 12 to 13: –.02 (1.02)
HOME	Age 4 to 5: 99.93 (14.33) Age 8 to 9: 100.62 (14.39) Age 12 to 13: 101.24 (14.47)	Age 4 to 5: 96.99 (15.35) Age 8 to 9: 97.72 (15.54) Age 12 to 13: 97.93 (16.07)	Age 4 to 5: 97.57 (15.10) Age 8 to 9: 99.04 (15.43) Age 12 to 13: 99.63 (15.21)

Note. MHigh = Higher intelligence sisters from maternal sibling pair; MLow = Lower intelligence sisters from maternal sibling pair; MRandom = Randomly selected mother from each maternal sibling pair; AFB = age at first childbirth; HOME = The Home Observation for Measurement of the Environment Inventory.
[a] Variables were only measured once: Mom IQ in 1980 and AFB as mother's age at birth of firstborn child. Means and standard deviations are equal across time points.

MLow were slightly younger at childbirth ($M = 23.44$, $SD = 5.64$). Mothers in the smallest Sample MHigh began childbearing slightly older ($M = 25.82$ years old); mothers in the smallest Sample MLow were comparable to the smallest Sample MHigh ($M = 25.41$ years old). Differences between the smallest and total sample on other variables are similarly small, but the smallest samples tend toward slightly more educated, higher income mothers than the total samples.

Measures. Table 2 presents means and standard deviations for maternal intelligence (as measured by the AFQT) and child intelligence (measured as a composite of Peabody Individual Achievement Test [PIAT] subscales), maternal education, family income and home environment (as measured by the HOME-SF) across the three time points separately for Samples MHigh, MLow, and MRandom. Sample MHigh generally has higher (i.e., better) scores on all variables, but the differences are slight. Means and standard deviations are generally consistent across the three time points; however, the standard deviations for family income increase for Sample MHigh and decrease for Sample MLow. The means for Sample MRandom fall between those for Sample MHigh and MLow.

Maternal intelligence (AFQT). The NLSY79 administered the Armed Services Vocational Aptitude Battery to participants in 1980. Scaled scores on select subscales (arithmetic reasoning, word knowledge, paragraph comprehension, and numerical operations) were used to create an approximated score for the AFQT. The AFQT has been used in past research as a proxy for maternal intelligence (Baharudin & Luster, 1998; Luster & Dubow, 1992; Rodgers et al., 2000). In 1980, respondents were 15 to 23 years old at the time of testing, creating the need for age standardization. Thus, mothers' age at testing was partialed from AFQT to age-standardize intelligence scores before analyses. AFQT scores in Table 2 are reported in this residualized form.

HOME. The Home Observation for Measurement of the Environment (HOME) Inventory uses a blend of self-report and administrator observation to measure the quality of a child's home environment (Caldwell & Bradley, 2003). Items were developed to assess characteristics of the child's home environment that would motivate appropriate child development, such as parental support and warmth, access to engaging or enriching environments, and safety of the home environment. Four versions of the HOME are administered for different age groups (ages 0 to 2, 3 to 5, 6 to 9, and 10 to 14) to appropriately assess the quality of home environment at different developmental stages. The NLSY administers a shortened form of the HOME (HOME-SF), with items chosen for high reliability and validity (Mott, 2004). Items from the three versions of the HOME-SF used in the current study appear in Table 3. Total HOME-SF scores are defined by summing across all items, which are scored dichotomously, then total scores are standardized to have a mean of 100 and a standard deviation of 15 within each age group for each assessment year.

Other maternal predictors. Maternal education was measured as self-reported years of educational attainment at the time of HOME-SF assessment; if no educational attainment was reported for the desired assessment year (which was unusual), the last reported educational attainment was imputed forward to the necessary year. Family income was measured as self-reported total earnings in dollars for all members of the mother's household in the assessment year; if the income report was missing for the desired assessment year, the income reported for the nearest prior assessment year was used. Mother's age at first childbirth (AFB) was measured as the self-reported age of the mother when her child was born, as all included children are firstborns. Extensive research supports the association between maternal intelligence, AFB, maternal education, income, and quality of home environment (Bacharach & Baumeister, 1998; Baharudin & Luster, 1998; Deary, Strand, Smith, & Fernandes, 2007; Neiss, Rowe, & Rodgers, 2002).

Child intelligence (PIAT). The NLSYC provides several measures of general cognitive ability. This study utilized a composite of the three subscales of the PIAT, a widely used measure of cognitive

Table 3
HOME-SF Items

HOME-SF item description	3 to 5 years	6 to 9 years	10 to 14 years
Child has 10+ children's books (20 for ages 10 to 14 years)	S	S	S
Mother reads to child three times/week or more	S	S	
Child taken to grocery store (one time/week or two to three times/month)	S		
Child eats meal with both mother and father(-figure) one time/day or more	S	S	S
Mom reports no more than one spank during last week	S	S	
Mom spontaneously vocalized to/ conversed with child two times or more	O	O	O
Mom showed physical affection to child	O	O[a]	O[a]
Mom did not spank child	O		
Home/building is safe	O	O	O
Family subscribes to at least one magazine	S		
Child has use of record/CD player and five or more records/CDs/tapes	S		
Child helped to learn numbers at home	S		
Child helped to learn alphabet at home	S		
Child helped to learn colors at home	S		
Child helped to learn shapes and sizes at home	S		
Child has some choice in foods for breakfast and lunch	S		
TV is on in home less than 5 hr/day	S		
Non-harsh discipline if child hits, swears at, or speaks in anger	S	S	S
Child taken to museum in last year	S	S	S
Child expected to make his/her bed		S	S
Child expected to clean his/her room		S	S
Child expected to clean up after spills		S	
Child expected to bathe him/herself		S	
Child expected to pick up after him/herself		S	S
Child expected to keep shared living areas clean and straight			S
Child expected to do routine chores			S
Child expected to help manage his/her own time			S
Musical instrument in home child can use		S	S
Family gets daily newspaper		S	S
Child reads several times/week for enjoyment		S	S
Family encourages child to start and do hobbies		S	S
Child receives lessons or belongs to sports, music, art organization, etc.		S	S
Child taken to musical or drama performance in past year		S	S
Family visits with family or friends 2 to 3 times/month		S	S
Child spends time with father(-figure) four times/week		S	S
Child spends time with father(-figure) outdoors one time/week		S	S
When watching TV, parent discusses program with child		S	S
Mom encouraged child to contribute to conversation		O	O
Mom answered child's questions or requests verbally	O	O	O
Mom introduced interviewer to child by name	O	O	O
Mom's voice conveyed positive feeling about child	O	O	O
Home is not dark	O	O	O
Home is reasonably clean	O	O	O
Home is minimally cluttered	O	O	O

Note. Items for the Home Observation for Measurement of the Environment-Short form (HOME-SF) versions were administered tochildren 3 to 5 years old, 6 to 9 years old, and 10 to 14 years old are shown. S Indicates an item is self-reported by the mother of the child, O indicates the item is observed by the HOME-SF administrator. Items are scored dichotomously. The table is reproduced in part from the NLSY website (nlsinfo.org). A complete list of HOME-SF items can be found online in Appendix A of the NLSYC Codebook Supplement (https://www.nlsinfo.org/content/cohorts/nlsy79-children/other-documentation/codebook-supplement/appendix-home-sf-scales).
[a] Item recorded but not used in scoring the HOME-SF for these versions.

ability. The PIAT is administrable to a broad age range, and scores are age standardized against national norms. The PIAT includes one quantitative reasoning scale (PIAT-Math) and two distinct verbal reasoning scales (PIAT-Reading Recognition and PIAT-Reading Comprehension). The PIAT was administered to NLSYC respondents every survey year that respondents were between the ages of 5 and 14 at the time of survey; thus, most NLSYC respondents have multiple PIAT scores, obtained at different points throughout their childhood. Because of its recognition and age coverage within the NLSYC, the PIAT was considered the best suited cognitive measure for the current study. PIAT scores closest to the time of HOME administration were used; for ages 8 to 9 and 12 to 13, these were the PIAT scores obtained from the same survey year as the HOME score. For age 4 to 5, about half of children were ineligible to take the PIAT during the year of the HOME assessment because they were four at time of survey. For these children, their PIAT score from the next round of testing two years later, when they were approximately 6 years old, was used.

Principal component analysis (PCA) was used to create a composite child intelligence score, which represented an optimal linear combination of the three PIAT subscales. For age 4–5, the first principal component accounted for 84.3% of the variance in PIAT scores; component loadings for the subscales were .843, .948, and .958 for the PIAT math, composition, and recognition subscales respectively. For age 8 to 9, the first principal component accounted for 79.6% of the variance in PIAT scores; component loadings were .847, .913, and .915, respectively. For age 12 to 13, the first principal component accounted for 76.5% of the variance in PIAT scores; component loadings for the subscales were .846, .887, and .890, respectively. Child intelligence scores were kept in standardized form ($M \approx 0$, $SD \approx 1$; see Table 2).

Analyses. Two multiple linear regression models were used to assess the influence of maternal characteristics and child intelligence on the quality of a child's home environment. Model 1 includes maternal characteristics only to predict the home environment. Model 2 adds child intelligence to the maternal predictors in Model 1 to explore how child intelligence explains home environment after maternal characteristics have been considered. The specific regression models are:

$$HOME_i = B_0 + B_1MIQ_i + B_2ED_i + B_3INC_i + B_4AFB_i + e_i \quad \text{Model 1}$$

$$HOME_i = B_0 + B_1MIQ_i + B_2ED_i + B_3INC_i + B_4AFB_i + B_5CIQ_i + e_i \quad \text{Model 2}$$

where MIQ = Maternal intelligence (as measured by AFQT), ED = Maternal education, INC = family income, AFB = mother's age at childbearing, CIQ = Child intelligence (as measured by a composite of PIAT subscales).

Standardized regression coefficients are reported to compare relative effect sizes of predictors in each model. The proportion of variance explained (R^2) for each model is also reported to assess how well each model explains variability in home environments. Models 1 and 2 are fit to all three between-family samples, MHigh, MLow, and MRandom, and as a result, all of the variance in these analyses is between-family variance; if there is meaningful within-family variance, it is embedded within the between-family variance. Because these samples confound within- and between-family variance, the results of these analyses should be interpreted with the appropriate caution to causal inference due to between-family designs. However, these analyses demonstrate how results can vary by design and set the stage for Study 2, which implements a sibling-comparison design.

Results

Model 1 regresses home environment on maternal intelligence, maternal education, and family income within three between-family samples (see Table 4). The standardized regression coefficients for maternal intelligence are higher than those for maternal education, AFB, and family income across all time points and for all three samples, Sample MHigh, MLow, and MRandom. However, as children age, maternal intelligence coefficients decrease. The opposite trend occurs for family income coefficients. As children age, income coefficients increase, until income is a significant predictor of home environment by age 12 to 13. The trends in coefficients are similar in Sample MHigh and MLow, indicating stability of these patterns of results across different between-family samples. As expected, the coefficients estimated from Sample MRandom are consistent with the estimates from MHigh and MLow. All significant regression coefficients are positive, indicating that higher-scored maternal characteristics are associated with more positive home environments. A significant proportion of variance is explained at each time point, with $R^2 \approx .2$ for all except age 8 to 9 in Sample MHigh.

Model 2 adds child intelligence to the predictors in Model 1 (see Table 4). Maternal intelligence coefficients significantly predict home environment for all three samples, as in Model 1, but decrease as children age. Child intelligence coefficients increase as children age and significantly predict home environment by age 12 to 13. However, the proportion of variance explained in home environments by Model 2 is not qualitatively greater than that explained by Model 1 in any sample. All significant regression coefficients are positive, suggesting that more intelligent mothers and more intelligent children have higher quality home environments.

Table 4
Standardized Regression Coefficients Predicting HOME Scores

	Sample MHigh						Sample MLow						Sample MRandom					
	Age																	
	4 to 5		8 to 9		12 to 13		4 to 5		8 to 9		12 to 13		4 to 5		8 to 9		12 to 13	
Predictors	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
Mom IQ	.38**	.35**	.26**	.25**	.31**	.23**	.47**	.48**	.45**	.40**	.30**	.13	.49**	.46**	.45**	.41**	.36**	.23**
Education	.13	.13	.04	−.01	.11	.10	.02	−.04	.02	−.00	.07	.08	.04	−.01	−.05	−.08	.02	.01
Income	.05	.05	.09	.09	.16*	.14*	.03	.04	.07	.07	.20**	.16*	.06	.08	.12	.10	.22**	.17*
AFB	−.00	−.01	.05	.07	−.06	−.09	−.02	−.03	−.07	−.05	−.09	−.05	−.02	−.02	−.08	−.06	−.03	−.02
Child IQ		.10		.12*		.19**		.08		.14†		.28**		.08		.16*		.25**
R^2	.24**	.24**	.13**	.15**	.19**	.21**	.23**	.23**	.21**	.24**	.20**	.25**	.27**	.26**	.20**	.24**	.25**	.28**
n	349	309	423	396	381	355	343	293	403	375	369	348	347	303	409	385	375	350

Note. Each observation indicates a mother–child pair; $N = 349$ indicates 349 mothers and their 349 first-born children. M1 = Model 1; M2 = Model 2; HOME = The Home Observation for Measurement of the Environment Inventory; MHigh = Higher intelligence sisters from maternal sibling pair; MLow = Lower intelligence sisters from maternal sibling pair; MRandom = Randomly selected mother from each maternal sibling pair; AFB = age at first childbirth.
† $p = .01$. * $p < .01$. ** $p < .001$.

Study 1: Discussion

We note that if our study stopped at this point—as many studies based entirely on between-family designs have in the past—we would interpret maternal intelligence as being a critical contributor to the construction of the home environment. This is true for all ages, and for both the MHigh and MLow mothers. We would also conclude that other maternal characteristics, such as maternal education, may have a positive influence on the home environment, but mother's age at first birth (AFB) does not have a strong influence in the presence of other strong maternal and child characteristics. We would also conclude that as children approach adolescence, family income and child intelligence begin to have significant influence on the home environment.

However, the inference that causal influence passes directly from mother characteristics to the home environment may be spurious. For example, it may not be that higher intelligence mothers create higher quality home environments, but that some third variable (unobserved heterogeneity from mothers' ancestry, neighborhood resources, etc.) causes both higher maternal intelligence and better home environments. Hence, we continue to Study 2, which implements a maternal sibling-comparison design. This design can largely (though not completely, as discussed) control for selection bias, and strengthens causal claims about the relationship between maternal and child intelligence and home environment compared with a between-family design.

Study 2

Method

Data. The primary objective of Study 2 was to determine the effect of maternal and child characteristics on the child's home environment, net of unobserved heterogeneity due to genetic and environmental effects from the mother's ancestry. Specifically of interest, so as to strengthen causal inference compared with past between-family studies, was relating differences in maternal characteristics and child intelligence from full-sibling sister pairs of mothers to differences in home environments. Therefore, for these analyses, we implemented an extension of within-dyad differencing (see Kenny, Kashy, & Cook, 2006, p. 72 for more details on the analytic approach and both Jaffee, Van Hulle, & Rodgers, 2011 and Garrison & Rodgers, 2016, for practical demonstrations). Alternatively, in some methodological settings, this design is referred to as a sibling fixed-effect analysis.

A dataset of difference and average scores of maternal characteristics, intelligence and home environment was constructed from the samples MHigh and MLow that were used in Study 1 (see Figure 1). Difference scores were created by subtracting observations in MLow from their matched (i.e., sibling comparison) observations in MHigh. For instance, in Study 1, Jill and her daughter Tanya were a single observation in Sample MHigh, and Jill's sister Janice and Janice's son Toby were an observation in Sample MLow. In Study 2, Jill, Janice, Tanya, and Toby all comprise a single observation. Difference scores for this observation are constructed by subtracting Janice's (and Toby's) scores on relevant variables from Jill's (and Tanya's) scores. Average scores were arithmetic means of observations across pairs from MLow and MHigh. Because a single observation requires complete data on four individuals, rather than two in Study 1, final sample sizes are slightly smaller in Study 1 than Study 2, and range between 162 observations (648 individuals) to 303 observations (1,212 individuals).

Measures. Scores on maternal intelligence (measured with the AFQT), maternal education, family income, child intelligence (measured as a composite of PIAT subscales), and home environment (measured with the HOME-SF), as described in Study 1, were used in Study 2. Difference and average scores on variables were calculated using the matched pairs inherent in the sibling comparison designs. Difference scores were used to capture within family variability on variables, and average scores were used to capture between-family variability.

Table 5 presents the means and standard deviations for the difference and average variables. The means and standard deviations are generally consistent across all time points. Difference scores are typically smaller than they would be for random

Table 5
Means (SD) of Difference and Average Variables

Predictors	Age 4 to 5	Age 8 to 9	Age 12 to 13
Difference			
Mom IQ[a]	12.93 (10.12)	12.93 (10.12)	12.93 (10.12)
Education	.64 (2.02)	.71 (2.11)	.69 (2.04)
Income	3,517.67 (112,305)	9,985.49 (92,148)	15,219.54 (80,142)
AFB	.66 (6.31)	.66 (6.31)	.66 (6.31)
Child IQ[b]	.23 (1.32)	.14 (1.31)	.18 (1.11)
HOME	3.27 (16.08)	2.75 (17.21)	2.59 (18.04)
Average			
Mom IQ[a]	1.03 (19.64)	1.03 (19.64)	1.03 (19.64)
Education	13.62 (2.04)	13.21 (2.04)	13.16 (2.06)
Income	47,343.26 (65,004)	45,466.46 (55,166)	51,142.75 (51,263)
AFB[a]	23.77 (4.64)	23.77 (4.64)	23.77 (4.64)
Child IQ[b]	.11 (.79)	.10 (.78)	.05 (.85)
HOME	100.00 (11.79)	100.16 (11.76)	99.87 (11.66)

Note. AFB = age at first childbirth; HOME = The Home Observation for Measurement of the Environment Inventory.
[a] Variables were only measured once, and so scores are the same across time points. [b] Child IQ variable represents first principle component score for three PIAT subscales.

pairs, because maternal sisters and their children are similar to each other. However, the mean difference between maternal intelligence is both substantively (12.93 AFQT points difference, Cohen's $d = .63$) and statistically (paired $t = 31.49$, $p < .0001$) meaningful. Although there is substantial variability in the differences between maternal sisters and cousins, and the differences between maternal sister pairs in intelligence are smaller than the differences that would be observed between two randomly selected mothers, the mean difference between the MHigh and MLow mothers establishes that the maternal differences are large enough to potentially generate differences in child outcomes, assuming there is a link between maternal intelligence and child characteristics. Maternal intelligence difference scores are non-negative by construction, and the means of all other difference scores are positive (though small) because of the positive relationship between maternal intelligence and the other variables.

Analyses. Two multiple linear regression models are used to explain variance of within-family differences in the quality of home environment using the difference and average scores of maternal and child variables. These models explicitly measure within-family differences at the mother level. If maternal intelligence is directly causing differences in home environments, then the MHigh mother should tend to create a higher quality home environment than the MLow mother. Model 1 explains variance in home environment differences from maternal characteristics only, and Model 2 adds child intelligence to the predictors in Model 1. Average scores for all variables are included in the analyses to account for between-family differences. Regression analyses are performed for each time point to investigate how predictors explain variance in home environment difference scores over time. Standardized regression coefficients are used to compare relative effect sizes among variables. The proportion of variance explained (R^2) is also reported. The specific regression models are:

$$\begin{aligned} HOMEdiff_i = {} & B_0 + B_1 AFQTdiff_i + B_2 EDdiff_i + B_3 INCdiff_i \\ & + B_4 AFBdiff_i + B_5 AFQTavg_i + B_6 EDavg_i \\ & + B_7 INCavg_i + B_8 AFBavg_i \\ & + B_9 HOMEavg_i + e_i \qquad \text{Model 1} \end{aligned}$$

$$\begin{aligned} HOMEdiff_i = {} & B_0 + B_1 AFQTdiff_i + B_2 EDdiff_i + B_3 INCdiff_i \\ & + B_4 AFBdiff_i + B_5 PIATdiff_i + B_6 AFQTavg_i \\ & + B_7 EDavg_i + B_8 INCavg_i + B_9 AFBavg_i \\ & + B_{10} PIATavg_i \\ & + B_{11} HOMEavg_i + e_i \qquad \text{Model 2} \end{aligned}$$

where *diff* indicates a variable is a difference score between mother or cousin pairs and *avg* indicates the variable is an average score.

Results

Table 6 presents standardized regression coefficients and R^2 values for Model 1 and Model 2. Differences in maternal intelligence do not significantly predict differences in home environment, nor do maternal intelligence averages. No predictors in Model 1 remain significant after implementing the sibling-comparison design. However, in Model 2, child intelligence difference coefficients increase in magnitude over time, and are significant by age 8 to 9; this finding aligns with results from the between-family analyses in Study 1, as does the significance of family income in the model by age 12 to 13. The significant coefficients are positive, indicating that larger child intelligence and family income differences within mother pairs predicts larger home environment differences. The proportions of variance explained in Models 1 and 2 are also substantially reduced compared with the results in Study 1.

Table 6
Standardized Regression Coefficients for HOME Difference Scores

	Age 4 to 5		Age 8 to 9		Age 12 to 13	
Predictors	M1	M2	M1	M2	M1	M2
Difference						
Mom IQ	.09	.14	.04	.02	.09	.08
Education	.08	.05	.05	.04	.02	.03
Income	−.06	−.06	.04	.05	.22	.23*
AFB	−.09	−.07	−.13	−.11	−.15	−.14
Child IQ		.06		.18*		.22**
Average						
Mom IQ	.01	−.02	−.20	−.15	−.08	.05
Education	.03	.02	.03	.03	.06	−.02
Income	−.06	−.09	−.02	.00	−.18	−.17
AFB	.05	.04	.08	.04	.06	.03
Child IQ		.17		−.09		−.03
HOME	−.05	−.07	−.02	.00	−.05	−.07
R^2	.03	.07	.05	.08	.06	.12*
n	217	162	303	271	247	220

Note. M1 = Model 1; M2 = Model 2; HOME = The Home Observation for Measurement of the Environment Inventory; AFB = age at first childbirth.
* $p < .01$. ** $p < .001$.

Study 2: Discussion

The present study was conducted to investigate the different factors that affect the quality of a child's home environment, with particular focus on maternal and child intelligence. In Study 1, maternal and child characteristics competed to explain variance in home environments in a between-family design. Importantly, we reversed the directional flow commonly implemented in child intelligence-home environment research. In Study 2, we explored the same questions in Study 1 in the context of a sibling-comparison design to better distinguish the causal mechanisms that contribute to the home environment.

In Study 1, the between-family analyses showed a consistent and significant relationship between maternal intelligence and quality of home environment; this relationship persisted with maternal education, age of child-bearing, and family income present in the model. Given this pattern of results, these other maternal characteristics appeared to be distal influences on the home environment, and maternal intelligence perhaps a more direct influence. However, when the analyses were repeated using the sibling-comparison design in Study 2, the relationship between maternal intelligence and home environment was reduced to nonsignificance. This finding suggests that the significant maternal intelligence-home environment relationship in Study 1 was driven by differences between families. Notably, there is substantially greater variance in maternal intelligence between families than within families. However, if maternal intelligence were a strong, direct causal influence, we would expect maternal intelligence differences to show up in the sibling-comparison analyses.

So what are the between-family processes that have such a direct and strong relationship to the quality of the home environment? There are of course many variables not included in these analyses that differ between families that could be contenders. Examples may include maternal psychological health, parental authority, parental religiosity, presence of grandparents, and quality of neighborhood support (Dunifon & Kowaleski-Jones, 2007; Pachter et al., 2006). A more obvious explanatory variable that we have not explicitly accounted for is heritability. If the genes that contribute to differences in intelligence in a between-family study overlap with those that contribute to heritability in the HOME, then genetic variance could be a spurious variable (see Cleveland, Jacobson, Lipinski, & Rowe, 2000, for further development of this logic in relation to the HOME). Because genetic variance is substantially reduced (though not eliminated) in a sibling-comparison design, our findings would suggest that the bigger genetic differences between families compared with within families may contain at least part of the answer to explaining our findings. Using biometrically informed data with kinship information (e.g., the NLSY79, NLSYC, Add Health) could help resolve this issue in future research.

As directly evaluated within the current study, another potential path through which maternal intelligence could (passively) influence the quality of the home environments is through the child's intelligence. Smarter moms are probabilistically likely to produce smarter children, and hence the between-family maternal intelligence-home environment relationship could be driven by differences in child intelligence between families. If this is the case, then the family environment is largely evocative, derived from influences passing directly from the child. Study 1 lent plausibility to this theory: as children aged, the child intelligence-home environment relationship strengthened at the between-family level. This pattern of results is consistent with previous findings (Yeates et al., 1983) and past theory (Scarr & McCartney, 1983) and was explored further in Study 2.

In Study 2, the sibling-comparison results for child intelligence mirrored the pattern of results found in Study 1. Though the effects were attenuated, the child intelligence-home environment relationship remained significant for the last two time points. Further, differences in maternal intelligence were positively related to differences in home environment, but not statistically significant, for all time-points. These are the most important findings from the current study, to underline the critical role that children's intelligence plays in the construction of the home environment, even controlling for maternal intelligence.

It is worth noting that the proportion of variance explained decreased substantially from Study 1 to Study 2. This reduction is a product of several mechanisms. First, the ancestral and unobserved environmental factors that the sibling-comparison design is intended to control cannot explain variance in the outcome that they might otherwise explain in a between-family design. Second, although difference scores have been advocated for use in dyad-structured data (e.g., Kenny, Kashy, & Cook, 2006), difference scores are not often implemented for multiple generations. The advantages and disadvantages of this approach are discussed in the next section, but such construction of difference scores likely account for some of the reduced fit in the regression models. Still, a clear pattern of results was observed in the data; this lends support to the validity of this type of sibling-comparison design in evaluating causal assertions.

The take-home patterns from this study are much more nuanced than in previous research. Further, they are coherent and sensible in relation to how we think family dynamics are likely to occur at the within- and between-family level. Among two maternal sisters, the higher intelligence mother is likely to create a higher quality family environment at the earliest time point (age 4 to 5). But by ages 8 to 9, and especially by ages 12 to 13, the intelligence of the child replaces the intelligence of the mother in defining the quality of the home environment. To be very clear about the source of these differences, we are comparing the intelligence of the child born to the higher intelligence mother to the intelligence of the child born to the lower intelligence mother, and find that the size of the intelligence differences between these cousins significantly relates to the size of differences in the quality of the home environment at these two older ages, as the mothers' intelligences fades in importance. We note that this maternal intelligence difference could be emerging from either genetic or nonshared environmental differences, and our design is not genetically informed in such a way to distinguish these causal explanatory processes. The NLSY contains differing levels of kinship relatedness, and a follow-up study could use genetically informed data to potentially help answer the question of whether genetic or environmental variability is causal in explaining these interesting patterns. Examples of past studies that have implemented the logic of between- versus within-family explanatory variance in a biometrical design include Harden and Mendle (2011), who used the Add Health data, and Rodgers et al. (2008), who used Danish twin data. In both of those studies, findings of significant shared environmental variance were linked to between-family interpretations.

Limitations: Study 1 and Study 2

The sibling-comparison design is used to control for confounds emerging from ancestral and genetic influences of environmental predictors. The disadvantages of sibling-comparison designs have been documented elsewhere, particularly the tradeoff of increased variability (and, hence, loss of precision in effect estimates) for less bias in estimates in sibling fixed-effect analyses (e.g., see Gilman & Loucks, 2014). We begin our discussion of limitations with the observation that a null result does not always mean a null effect: maternal intelligence may have an effect on quality of home environment after child intelligence has been accounted for—and there is sufficient reason to expect this to be the case—but our design may lack the power to detect this effect. In part this lack of power may be explained by the relatively small differences between maternal sisters' intelligences, as discussed in the following text.

In Study 2, the sibling-comparison design was implemented at the maternal level, whereas the home environment was measured at the child-level. The result is somewhat greater variability between child pairs—including child intelligence and home environment—than between mother pairs, as demonstrated in Table 1. One source of the additional variance is heritable traits from children's fathers contributing to child outcomes. Because the NLSY has no information available on the fathers of the NLSYC, their contribution cannot be evaluated. A similar problem for causal interpretation of gene-environment interactions in children-of-twin designs has been noted by Harden et al. (2007). This additional variance may be one potential reason why child intelligence more strongly predicts home environment scores than maternal intelligence in Study 2.

One way to avoid this variability is to use a traditional sibling-comparison design at both maternal and child levels; that is, we could have considered how differences between child intelligence of siblings from the same mother predicted differences in home environments. This design would reduce the genetic and unmeasured environmental variability further than the implemented design—and indeed, reducing such variability is the strongest motivation for implementing sibling-comparison designs. However, the traditional sibling-comparison design would not allow us to investigate how differences in child intelligence predict differences in home environment in models that also included differences in maternal intelligence, because all maternal factors would be identical for siblings. We felt that allowing for the competition between maternal intelligence and child intelligence was interesting and compelling enough to warrant the current sibling-comparison design implemented at the maternal level. Further, similar offspring-of-sibling designs have been proposed to study familial factors while controlling for other heritable traits (D'Onofrio et al., 2013).

It is also worth noting the implicit assumption of linear association that lies behind using difference scores. We assume that, if there is a positive causal relationship between a predictor and outcome, then greater difference between two individuals on the predictor corresponds to a similarly large difference between the two individuals on the outcome. This pattern of results would not hold for more complex nonlinear and/or interactive relationships. However, this assumption is implicit in regression, analysis of variance, and many other statistical techniques.

An additional weakness inherent within our design is the potential for reciprocal causation. Each panel of our design is between-family, and is therefore subject to some (though not all) of the criticisms that we develop about such designs in our introduction. Logically, a within-family difference cannot influence a between-family effect, though a between-family effect can influence a within-family difference (if, e.g., higher intelligence families had larger sibling intelligence differences). Thus, the average variables within our models in Study 2 are not subject to reverse causation. There is potential for reverse causation in the difference scores, however. We cannot logically rule out the possibility that home environment differences at least partially cause child intelligence differences. This type of reverse causation can be investigated in future research in the context of a different design than the one we used; that design would rely on sibling (rather than maternal) differences by using time-lagged measures of child intelligence and home environment differences.

We conclude our treatment of weaknesses by noting the remarkable strengths of the NLSY for addressing topics related to the home environment. Because the child's home environment is naturally and automatically a "two-generational issue," the two-generational structure built into the NLSY79 and NLSYC provide a direct accounting of those cross-generational features. Further, the longitudinal structure allowed us to create replications at three points in time using the reliable and valid HOME-SF. Finally, the within-family structure of the NLSY79 and NLSYC, including reliable kinship links, supported the implementation of the sibling-comparison design.

Conclusion

The present two studies explored the predictors of the quality of the home environment. Maternal characteristics, such as intelligence, may be useful in predicting quality of home environments between families, but their utility diminished in within-family settings. Child intelligence, however, remained a meaningful predictor of quality of home environment even within families, especially in late childhood and early adolescence. This result provides evidence of the evocative role of children within their home environments. Future studies should investigate more intentionally the direction of causality between child intelligence and the home environment.

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