Developmental Psychology

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Online First Publication, October 6, 2014. http://dx.doi.org/10.1037/a0038094

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0012-1649/14/$12.00 http://dx.doi.org/10.1037/a0038094

Child Characteristics and Parental Educational Expectations: Evidence for Transmission With Transaction

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Parents' expectations for their children's ultimate educational attainment have been hypothesized to play an instrumental role in socializing academically relevant child behaviors, beliefs, and abilities. In addition to social transmission of educationally relevant values from parents to children, parental expectations and child characteristics may transact *bidirectionally*. We explore this hypothesis using both longitudinal and genetically informative twin data from the Early Childhood Longitudinal Study–Birth and Kindergarten cohorts. Our behavior genetic results indicate that parental expectations partly reflect child genetic variation, even as early as 4 years of age. Two classes of child characteristics were hypothesized to contribute to these child-to-parent effects: behavioral tendencies (approaches toward learning and problem behaviors) and achievement (math and reading). Using behavior genetic models, we find within-twin-pair associations between these child characteristics and parental expectations. Using longitudinal cross-lagged models, we find that initial variation in child characteristics predicts future educational expectations above and beyond previous educational expectations. These results are consistent with transactional frameworks in which parent-to-child and child-to-parent effects co-occur.

Keywords: educational expectations, academic achievement, behavior genetics, transactional processes, expectancy-value model

Supplemental materials: http://dx.doi.org/10.1037/a0038094.supp

Educational attainment predicts key life outcomes, such as income (Day & Newburger, 2002) and health (Montez, Hummer, Hayward, Woo, & Rogers, 2011). *Educational expectations* (i.e., expecting to continue on an educational track, rather than expecting to pursue other vocational options) are associated with actual educational attainment and academic achievement, even after controlling for a number of family and individual confounds (Alexander, Entwisle, & Bedinger, 1994). This result has been found in longitudinal, nationally representative data sets (Jacob & Linkow, 2011), in high-risk samples (Ou & Reynolds, 2008), and even as a mediator of program effects in a randomized controlled experiment (Purtell & McLoyd, 2013). Having reviewed much of this literature, Schneider and Stevenson (1999) concluded, "One of the most important early predictors of social mobility is how much schooling an adolescent expects to obtain" (p. 4). Children are thought to form such educational expectations largely in response to parental inputs (Jacobs & Eccles, 2000; Schneider, Keesler, & Morlock, 2010). However, much work in child development more generally (e.g., Bell, 1968) has highlighted the importance of reciprocal or *transactional* processes between children and environments. Thus, we hypothesize that in addition to parental educational expectations influencing child academic achievement and child academically relevant behaviors, achievement and academic behaviors may reciprocally influence parental educational expectations.

To test our transactional hypothesis, the current study uses a combination of behavior genetic and longitudinal methods. Behavior genetic studies of parenting address whether siblings receive more similar treatment from their parents as a function of their genetic similarity. If siblings who are more genetically similar (e.g., monozygotic compared with dizygotic twins) receive more similar parental expectations, this result is consistent with parents basing their level of expectations partly on genetically influenced characteristics of their children. Longitudinal methods provide complementary information about time-ordered relations. If early child characteristics (e.g., advanced academic ability or socioemotional skills) predict change in expectations across time, then this result is consistent with children actively influencing the parenting they receive. Both analytic frameworks aid in understanding the dynamic interplay between parents and children. The current project demonstrates that both parent-to-child and child-to-parent processes influence academic development and expectations, that these processes both occur even before children enter school and continue for years following school entry, and that the transactional process is sensitive to child motivation and problem behavior.

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Daniel A. Briley was supported by National Institutes of Health (NIH) Training Grant T32HD007081. K. Paige Harden and Elliot M. Tucker-Drob were supported by NIH Research Grant R21HD069772. The Population Research Center is supported by NIH Center Grant R24HD042849. Daniel A. Briley presented initial results from this project at the April 2013 meeting of the Population Association of America.

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Theories of Expectations and Academic Attainment

Sociologists and psychologists have examined the relation between educational expectations and educational attainment in parallel literatures. Building on the sociological work of Blau and Duncan (1967), the *status attainment model* (Sewell & Hauser, 1972, 1980) notes that society is stratified in terms of background characteristics, such as race or socioeconomic status, which in turn reproduce status inequalities in successive generations. However, there are a number of intervening mechanisms between socioeconomic background and academic and occupational success. For example, Sewell and Hauser (1972) hypothesized that the influence of significant others (parents and peers) and academic expectations partially mediates the influence that family background characteristics exert on attained status. Rather than society selecting individuals into various status levels based solely on ascribed factors, individuals can obtain social mobility through social psychological mechanisms (Sewell & Hauser, 1980). For instance, optimistic parental educational expectations may help a child achieve greater academic success than would be predicted simply based on his or her families' socioeconomic background, whereas pessimistic parental educational expectations may influence a child to achieve to a lesser extent. Under this perspective, child academic trajectories and interactions with the educational system reflect the influence of internalized parental beliefs.

The expectancy-value (E-V) model is one of the primary psychological frameworks for understanding the interrelations among psychological characteristics leading to motivation and task success (Eccles & Wigfield, 2002; Nagengast et al., 2011). Under this framework, the primary determinants of motivation to complete a task are the expectation that the task can be completed and the value of completing the task (Jacobs & Eccles, 2000; see also Bandura, 1986; Zimmerman, Bandura, & Martinez-Pons, 1992). In the realm of academic motivation, perceived academic competence and belief in the worth of school represent expectancies and values, respectively. Parents are thought to instill in their children perceptions about the value of schooling and about their children's ability to succeed in school based, in part, on the parents' own expectations regarding the level of credentials their children will obtain. In turn, parental expectations are thought to be sensitive to child development. Parents of children who show promise academically may raise their expectations in response to this new information and provide academic stimulation in the form of increased involvement in the child's school life. Thus, the E-V model implies a highly complex, dynamic, and reciprocal relationship between parents and children. However, as we describe below, this level of theoretical nuance, particularly the role of child characteristics and behaviors in shaping parental expectations, is infrequently incorporated into the empirical literature on expectations.

Transmission of Academic Beliefs

A key component of the empirical work on educational expectations is the assumption of a causal effect of *parental* expectations on children's attainment. Under this assumption, parents instill levels of educational expectations in their children, which are then internalized to inform academic self-concepts. Consistent with this assumption, Gonzalez-Pienda et al. (2002) found that parental expectations were significantly associated with child beliefs regarding competence and academic aptitude. These latter two variables were significantly associated with achievement and mediated the effect of parental expectations. That the associations between parental educational expectations and child outcomes are statistically mediated through child expectations, task value and academic self-concept has been well replicated (Beal & Crockett, 2010; Bleeker & Jacobs, 2004; Fredricks & Eccles, 2002; Frome & Eccles, 1998; Neuenschwander, Vida, Garrett, & Eccles, 2007; Simpkins, Fredricks, & Eccles, 2012). Validating the utility of this line of research, Harackiewicz, Rozek, Hulleman, and Hyde (2012) developed a successful intervention based on the E-V model that instructed parents on effective ways to show their children the value of science-related courses for their life goals. The high school children of parents in the experimental group completed significantly more science coursework than the children in the control group, signifying the importance of parents as academic motivators.

Modeling parents as an exogenous influence on child development, as is common in expectations research, makes intuitive sense when one considers that many of the other influences on academic success are ascribed factors (e.g., socioeconomic status). Supporting this position, Andrew and Hauser (2011) found that adolescent students largely adopt levels of educational expectations based on social background characteristics and adapt to academic feedback (i.e., grades) very modestly. Similarly, Tynkkynen, Tolvanen, and Salmela-Aro (2012) tracked adolescent's trajectories of educational expectations over 5 years as a function of social background and parental expectations. Parental expectations were significantly associated with trajectories of child academic expectations, and importantly, developing along different expectation trajectories resulted in disparities in achievement. In these studies, parental expectations are assumed to take both chronological and causal precedence over child variables, and the dynamic nature of the parent–child relationship and development of expectations may be even more obscured due to the relatively old age of students.

The results of the empirical studies reviewed above have led researchers to draw strong conclusions concerning the transmissive properties of the influence that parents have on their children. For example, the assertion that "educational expectations that parents have for their children represent one of the key mechanisms through which parents influence their children's schooling careers" implies an underlying transmission process (Schneider et al., 2010, p. 253). Jacobs and Eccles (2000) claimed that "the direction of influence for perceptions of competence is from parents to children" (p. 420). Following in this tradition, Simpkins et al. (2012) justified their conceptual model with parenting beliefs and behaviors preceding and independent of child beliefs and behaviors based on past research indicating that "mothers' beliefs shape child development" (p. 1020).

Other expectations studies contain conceptual or path diagrams with similar causal ordering claims but do not test for possible endogeneity of parenting variables (Davis-Kean, 2005; Gonzalez-Pienda et al., 2002). Still other studies (Bleeker & Jacobs, 2004; Frome & Eccles, 1998; Neuenschwander et al., 2007) use initial levels of child achievement as a control for later parental expectancy beliefs, which is in turn used to predict subsequent child achievement. This design is adequate to examine the effect of parental expectations above and beyond previous child achievement, but it is unable to test for dynamic transactions between parents and children across time. Further, these studies do not incorporate initial child characteristics beyond academic achievement as control variables, yet parents may also form expectancy beliefs based on early child academic interest, motivation, or problem behavior. This previous literature has primarily focused on interpreting parent-to-child effects, and an outstanding empirical question is whether parental educational expectations are subject to dynamic and reciprocal feedback from children. Importantly, although such dynamics have been regularly incorporated into *theoretical* publications concerning the E-V model (e.g., Jacobs & Eccles, 2000, p. 423), they have, to date, seldom been explicitly examined in empirical studies of parental educational expectations and child academic development.

Transactional Processes Between Parents and Children

Transaction, as opposed to transmission, represents an elaborated framework for understanding socialization (e.g., Sameroff, 2009; but see also Bronfenbrenner & Ceci, 1994; Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000; Lerner & Busch-Rossnagel, 1981; Scarr & McCartney, 1983; Tucker-Drob, Briley, & Harden, 2013). Whereas transmission models view parents as broadcasters and children as receivers, transactional models emphasize the dynamic roles found in the socialization process. Bell (1968) was one of the earliest researchers to argue that children, even infants, play an active role in influencing the parenting that they receive, and thereby their own development. Transaction implies that simple associations between a parenting behavior and a child outcome are causally ambiguous, because it is unknown whether the parent influenced the child or the child influenced the parent. Causal ambiguity in studies of parenting also occurs because parents pass on to their children both an environment and genetic predispositions. The research methods used in empirical studies must be able to address these types of alternative hypotheses.

Work in developmental behavior genetics offers an empirically tractable solution to this problem by allowing for the possibility that children's genetically influenced behaviors and dispositions influence the types and quality of experiences that they evoke from others (Plomin, DeFries, & Loehlin, 1977). This process is termed *gene–environment correlation* to refer to the correlation that arises between children's genotypes and the environments that they receive.

Gene–environment correlation provides several avenues for the relationship between parental educational expectations and child academic beliefs to occur in addition to unidirectional transmission of values. Child characteristics and behaviors, such as motivations, abilities, and self-concepts, may be subject to genetic influences. Parents may be sensitive to these genetically influenced characteristics and adjust their expectations accordingly. This sensitivity is one potential mechanism whereby the genetic predispositions of the child are able to get "out of the skin" and influence the environment. Thus, evidence that parental educational expectations are "heritable" on the part of children would indicate child-to-parent effects. Three recent meta-analyses revealed that child genetic effects account for roughly 20% of the variance in parenting behaviors depending on the variable (Avinun & Knafo, 2013; Kendler & Baker, 2007; Klahr & Burt, 2013). McAdams, Gregory, and Eley (2013) attempted to explain why parenting variables are "heritable" by examining the correlation between genes influencing variation in child attributes and parenting behavior. They found that adolescent genetic influences on a set of maladaptive traits (e.g., oppositionality and depression) were able to explain the genetic influences on parenting. However, the extent to which this pattern of gene–environment correlation applies to variation in parental educational expectations and their associations with child achievement is unknown.

There are a handful of studies that provide preliminary support for reciprocal parent–child transactions involving educational expectations or academic beliefs. Zhang, Haddad, Torres, and Chen (2011) used cross-lagged path models to simultaneously control for parent and child characteristics. This technique has the desirable effect of modeling the prospective influence of student expectations, parent expectations, and academic achievement on one another over time, above and beyond baseline levels of each outcome. Consistent with a transactional hypothesis, significant bidirectional cross-lagged paths were found between each variable. However, this study tracked the developmental process relatively late in the academic careers of the participants (between eighth and 12th grades), rendering it unclear how early this process begins. Wang (2012) detected similar reciprocal relations between student beliefs, grades, and the classroom environment. Marsh and colleagues (Marsh & Martin, 2011; Marsh & O'Mara, 2008; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005) demonstrated reciprocal effects between academic self-concept, interests, grades, and academic achievement. However, they did not examine parental educational expectations, or any other parent behaviors for that matter.

Proposed Transactional Model Under Investigation

For the current study, we track the transactional relations between three classes of variables: child academic behavior, child academic achievement outcomes, and parental educational expectations. By child academic behavior, we mean behavioral tendencies relevant to academic success or difficulty. These are often labeled as noncognitive or socioemotional skills related to academic readiness (Duncan et al., 2007; Heckman, 2006).[1] For example, a child who diligently completes chores or pays attention may inspire higher expectations. Conversely, a child who creates trouble or has emotional outbursts may lower expectations. By *academic achievement outcomes*, we mean performance on standardized tests of math and reading. Objective test scores are one of the strongest correlates of educational attainment (Strenze, 2007). Similar to child academic behavior, a particularly bright child may enlist increasing parental expectations. Parental educational expectations are predicted to positively influence beneficial academic behaviors and cognitive development and hinder problematic academic behaviors. Additionally, greater academic achievement is likely to reinforce positive academic behaviors and reduce problematic behaviors. Child positive behaviors likely enable success-

[1] We use the more general term *academic behavior* in the current context because we index general patterns of typical behavior across multiple developmental stages. Thus, we use this term to refer to a broad suite of social, emotional, and noncognitive skills that have some stability over time and do not only refer to one developmental period (e.g., kindergarten readiness).

ful learning, and problem behaviors likely interfere with academic achievement. Therefore, we posit a fully interactive transactional model in which child academic behaviors, child achievement, and parental educational expectations each influence the other constructs over development. Furthermore, as nearly all reliably measured psychological variables are subject to genetic influences (Turkheimer, 2000), we expect transactional processes to result in children's environmental circumstances (i.e., parental educational expectations) becoming tied to their genotypes.

A number of processes may mediate or moderate this transactional model. First, parental educational expectations are a distal factor and likely influence the more proximal interactions between parent and child, such as involvement or cognitive stimulation (Wang & Sheikh-Khalil, 2014). For example, parents who have expectations that their children will attend college may be more likely to form relationships with their child's teachers or spend additional time reading to their child. However, parental educational expectations may broadly index the educationally relevant social climate of a family. In this case, it would be unlikely that specific instances of parenting behavior would explain the aggregate effect of the social climate. We examine whether these types of proximal behaviors can mediate a portion of the influence of parental expectations on child outcomes. Second, the role of educational expectations may differ as a function of sociodemographic factors, such as race (Hanson, 1994; Mickelson, 1990), gender (DiPrete & Jennings, 2012; Jacobs & Eccles, 1992; McWhirter, 1997), and socioeconomic status (Davis-Kean, 2005). High-resource environments might facilitate transactional processes between children and their proximal environment (Bronfenbrenner & Ceci, 1994). Children situated in such environments may be able to exert greater control over the type of parenting that they receive, or parents may be more receptive or able to change in high-resource environments. We evaluate whether the transactional processes differ across sociodemographic dimensions.

Goals of the Current Study

Our study had two primary goals. First, we used behavior genetic models of data from twins to evaluate whether parental educational expectations are associated with genetic differences in their children. The current study follows the recommendations of a number of researchers to incorporate genetically informed methods into the study of the social environment (D'Onofrio, Lahey, Turkheimer, & Lichtenstein, 2013; Harden, 2014; Reiss, 2003). As recommended by these authors, we do so to unravel complex family dynamics, rather than to simply establish the heritabilities of the outcomes. Although recent reviews (e.g., Crosnoe & Johnson, 2011; Schneider et al., 2010) of the relevant developmental literature have noted the importance of integrating genetic thinking with socialization models, we are aware of no study that has used a genetically informative sample to evaluate associations between expectations and child academic behaviors or achievement. Second, we use cross-lagged longitudinal models to evaluate specific transactional processes that occur between child academic behavior, child academic achievement outcomes, and parental educational expectations. Importantly, we test whether the transactional processes of interest can be detected even prior to kindergarten entry. The majority of research on educational expectations has focused on children relatively late in their academic careers, but there is evidence of transactional processes that influence cognitive development before children even enter the educational system (Lugo-Gil & Tamis-LeMonda, 2008; Tucker-Drob & Harden, 2012a). It is possible that investigators focusing on the middle-school and high school years may be searching in the wrong place for the origins of social stratification in academic achievement and educational attainment (Barnett, 1995; Downey, von Hippel, & Broh, 2004; Duncan et al., 2007; Heckman, 2006; McLoyd, 1998; Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011). Finally, we track the unfolding of the transactional process across the elementary school years to demonstrate the robust and ubiquitous effect of children on the parenting they receive, as well as test for multiwave mediational pathways of influence.

Method

Sample

Data were drawn from the Early Childhood Longitudinal Study–Birth Cohort (ECLS-B) and Early Childhood Longitudinal Study–Kindergarten Cohort (ECLS-K). These separate data sets are ideal for analyzing the questions posed in that they contain high-quality assessments of children's development and their environments (Snow et al., 2009; Tourangeau, Nord, Lê, Sorongon, & Najarian, 2009). The ECLS-B is nationally representative of United States children born in 2001, and the ECLS-K is nationally representative of the kindergarten cohort of 1998. The data used in the current study were the age 4 (collected in 2005 and 2006) and kindergarten waves (collected in 2006) of the ECLS-B. The data from the ECLS-K included the fall kindergarten (collected in 1998), spring first-grade (collected in 2000), third-grade (collected in 2002), and fifth-grade (collected in 2004) waves. Waves not listed above were omitted due to limited measure or data availability. The initial wave of the ECLS-B recruited 10,650[2] parents to participate, and the ECLS-K recruited 22,666 children. The racial composition of the ECLS-B sample was 41% White, 16% African American, 21% Hispanic, and 11% Asian. The racial composition of the ECLS-K was 51% White, 14% African America, 16% Hispanic, and 6% Asian. The remaining participants were identified as Pacific Islander, Native American, multiracial, or unknown. Males represented 51% of both the ECLS-B and ECLS-K samples. Our behavior genetic models were fit to the twin subsample of the ECLS-B. Data were available for 1,200 twins. The racial composition of the subsample was 61% White, 16% African American, 16% Hispanic, and 3% Asian, with an equal percentage of males and females.

Measures

Zygosity. Twin zygosity was ascertained by trained coders at the second wave of the ECLS-B data collection. Twins were rated on the similarity of their physical appearance (e.g., hair texture, eye color, ear lobe shape). These items ranged from 1 (*no difference*) to 3 (*clear difference*). Using the procedure described in Tucker-Drob et al. (2011), we computed sum scores from the six

[2] ECLS-B confidentiality requirements state that all reported sample sizes must be rounded to the nearest 50.

items, which ranged from 6 to 18. Twin pairs with zygosity scores below 8 were classified as monozygotic. Same-sex twin pairs classified as dizygotic were removed from the sample if the parents reported a medical reason for the twin's dissimilarity. Previous research has revealed that zygosity diagnoses obtained from such physical similarity rating approaches are over 90% accurate when validated with biospecimens (Forget-Dubois et al., 2003). We excluded any twin pair in which either twin had been diagnosed with a developmental delay, mobility disorder, or autism (13% of original pairs). Additionally, we excluded any twin pair discordant for preschool care arrangement as this was a very small proportion of twin pairs ($<$1% of original pairs). The results were very similar when these excluded pairs were included. Our final sample was composed of 29% monozygotic twin pairs, 35% same-sex dizygotic twin pairs, and 36% opposite-sex dizygotic twin pairs.

Parental educational expectations. At each wave, parents were asked what degree they expected their children to achieve. The response options were to receive less than a high school diploma; to graduate from high school; to attend 2 or more years of college; to finish a 4- or 5-year college degree; to earn a master's degree or equivalent; and to get a Ph.D., MD, or other higher degree. The survey items were equivalent across the ECLS-K and ECLS-B.

Academic behavior. Academic behavior, operationalized in terms of approaches toward learning and problem behavior, was collected at each measurement wave. Approaches toward learning items were chosen to represent active, child-centered behaviors that would facilitate transactions with the academic environment, and problem behaviors were chosen as potential sources of interference for transactions. In the ECLS-B, parents reported on the extent to which their children are eager to learn, pay attention, work independently, and work until finished. These items were used to assess approaches toward learning (see Tucker-Drob & Harden, 2012b). Parents additionally reported on the extent to which their children were aggressive, angry, impulsive, overly active, have temper tantrums, annoy other children, and destroy other children's belongings. These items were used to assess problem behaviors (see Tucker-Drob & Harden, 2013). Each item was rated on a scale ranging from 1 (*never*) to 5 (*very often*). Average scores were calculated for each individual.

Because parent report of educational expectations is a primary study variable, we were concerned that method variance would be shared with parent report of academic behavior. To complement parent report of academic behavior, we also included teacher report of the same items. However, teacher report was only obtained for children who attended a formal child-care setting at age 4. This reduces the twin sample size by 33% and represents a serious loss in power. In the ECLS-B data set, children who attend preschool are systematically different from those who do not in terms of their academic growth (Tucker-Drob, 2012). Further, parents and teachers may have access to different information about the focal children. In light of these concerns, we evaluate the convergent validity of these sources of information both phenotypically and at the behavior genetic level. We analyzed both variables independently in order to detect any potential differences in the pattern of association with achievement and parental expectations.

In the ECLS-K, teacher reports of approaches toward learning and externalizing behavior were used to represent similar constructs. Scale scores were computed by the ECLS-K research team that ranged from 1 (*never*) to 4 (*very often*). Upon initial inspection of the data, we determined that the approaches toward learning scales were negatively skewed and the problem behavior scales were positively skewed. Transformations were conducted that minimized skew. For the ECLS-B variables, this approach involved taking the square root of each score. The ECLS-K approaches toward learning scores were also transformed by the square root, but the externalizing scores displayed larger skew and taking the inverse minimized skew. Reliability was acceptable in both data sets and for both measures. Reliability of approaches toward learning ranged from .66 to .68 (parent report) and from .79 to .80 (teacher report) in the ECLS-B and from .89 to .91 in the ECLS-K. Reliability of problem behaviors ranged from .78 to .80 (parent report) and from .79 to .83 (teacher report) in the ECLS-B and from .86 to .90 in the ECLS-K.

Academic outcomes. Both ECLS databases contain extensively developed math and reading achievement scores collected at each data wave. The test materials were modified over the course of the study to account for the dramatic gains in general ability across development. The subject matter and specific skills required for the tests changed with age. Item response theory models were applied to the raw data to calculate comparable scores for each participant regardless of wave of assessment. For a complete description of the test procedures and application of the scoring procedure, see Snow et al. (2009) and Tourangeau et al. (2009). Estimated reliability of the indicators was high in all data sets and waves of data. In the ECLS-B, reliability of math and reading achievement variables ranged from .84 to .92 across waves. In the ECLS-K, reliability of math and reading achievement variables ranged from .89 to .96.

Potential mediators. To assess mediators that may be more proximal behavioral manifestations of educational expectations, we constructed composites in the ECLS-K that indicate parental involvement and parental stimulation of cognitive development. Parental involvement was indicated by whether the parent attended an open house, a PTA meeting, a parent–teacher conference, a school event, acted as a school volunteer, participated in fundraising, and had met the child's teacher. Parental stimulation of cognitive development was indicated by parent report of the frequency that the family told stories, sang songs, did art, played games, taught about nature, built things, played sports, practiced numbers, and read together. These indicators were only available at the first- and third-grade waves. The variables available in the ECLS-B are less extensive, particularly those for school involvement, and we therefore chose to focus the meditation analysis on the ELCS-K. Reliability of parental involvement ranged from .59 to .60, and reliability of parental stimulation ranged from .71 to .73.

Sociodemographic controls and moderators. We included a number of sociodemographic variables including maternal age, type of preschool care (none, relative care, nonrelative care, center, or head start), disability status, child gender, child race, and family socioeconomic status. The socioeconomic status variable was indexed by parental education, occupational prestige, and household income. As described below, these variables acted as both control variables and moderators in the longitudinal analyses.

Analytic Approach

Behavior genetic models. We used behavior genetic models that capitalize on the known differences in genetic similarity of monozygotic and dizygotic twins reared together to make inferences about the effect of additive genetic influences (A), shared environmental influences (C) that operate to make twin pairs more similar to one another, and nonshared environmental influences (E) that operate to make twin pairs more dissimilar to one another. The E estimate also includes measurement error, which (by definition) is not correlated across twins, and thus renders twins dissimilar. Figure 1A illustrates this approach as a structural equation model that is estimated as a multiple-group model for monozygotic and dizygotic twins. An outcome is measured independently for each twin (indicated by the squares labeled Twin1 and Twin2), and the variance in this outcome is fully decomposed into the effects of A, C, and E. The latent factors A1 and A2 represent the specific genotypes of the twins. For monozygotic twins, the correlation between these genotypes is fixed to 1.0, reflecting the assumption that monozygotic twins share nearly identical genotypes. For dizygotic twins, this correlation is fixed to 0.5, reflecting the assumption that dizygotic twins share, on average, 50% of segregating genes. Because the twins share a common rearing environment, the latent variable C is represented by a single factor across both twins. Finally, the E factor, representing unique environmental effects on the outcome, is not correlated across twins. The parameters *a*, *c*, and *e* are constrained to be equal across the twin pair. As the portion of the model representing Twin2 is largely redundant, we only display the model relevant to Twin1 (pathways indicated by solid rather than dashed lines) in subsequent path diagrams.

When the variable under investigation is a measure of the environment, the *a* parameter represents the extent to which individuals select or evoke environmental experiences congruent with their genotype (i.e., active or evocative gene–environment correlation; see Avinun & Knafo, 2013). If this parameter is significant, it would suggest that parents are sensitive to child-to-parent influences. The *c* parameter represents the extent to which environmental influences are experienced equally by both members of the twin pair regardless of zygosity, because of equal parental treatment or common family background. Finally, the *e* parameter represents unequal within-family treatment that is not associated with genotypic differences of the children.

The latent C factor includes all unmeasured influences that operate to make twins living in the same family more similar to one another regardless of zygosity. A number of measured family-level variables are included in the ECLS-B data set. Incorporating these variables in the behavior genetic model has the effect of lowering the estimate of C by a proportion equivalent to the amount of variance accounted for by the measured variable (Turkheimer, D'Onofrio, Maes, & Eaves, 2005). If parental educational expectations, child academic achievement, or child academic behavior have a substantial shared environmental influence, we attempt to explain this influence with known predictors of academically relevant variables, including socioeconomic status, race, preschool type, and maternal age (Bradley & Corwyn, 2002; Tucker-Drob, 2012). Importantly, these variables are *necessarily* shared environmental variables because of the way they are measured; they are the same for both members of a twin pair.

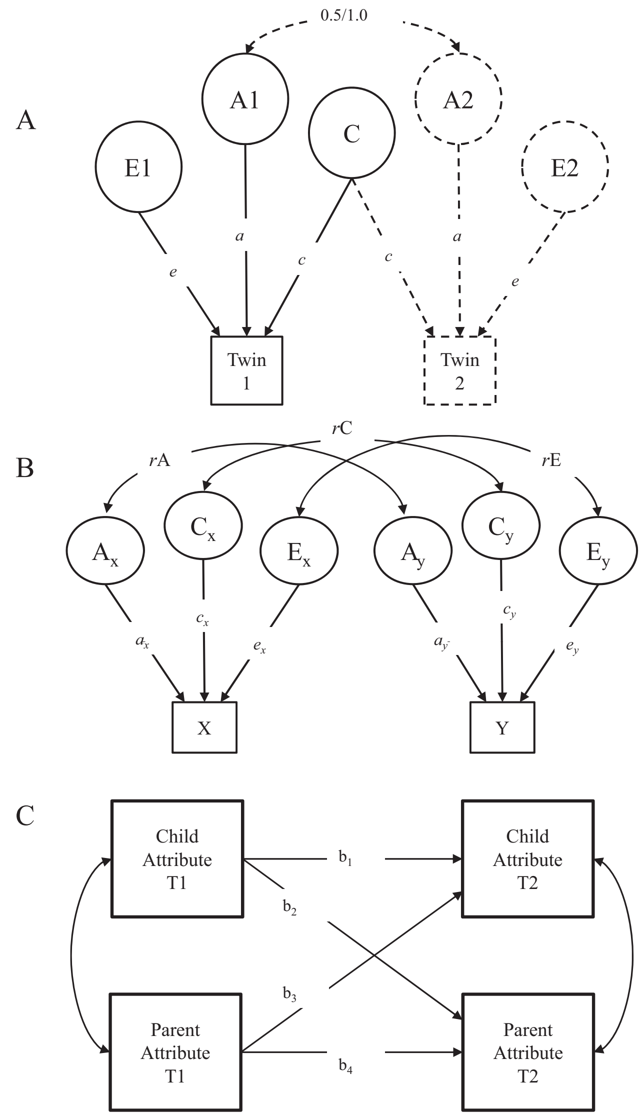

Figure 1. Example model types used in the current study represented as structural equation models with manifest (squares) and latent (circles) variables. A: Univariate behavior genetic model for monozygotic and dizygotic twins reared together. In this model, the variance in a measured outcome is decomposed into that which is due to latent additive genetic (A), shared environmental (C), and nonshared environmental (E) factors. Parameters are constrained to be equal across twins. The model is a multiple-group model with the correlation between Twin1's genetic factor and Twin2's genetic factor set to 1.0 for monozygotic twins and 0.5 for dizygotic twins. Portions of the model represented with dashed lines are largely redundant and not included in later models. B: Correlated factors model. In this model, the correlation between two outcomes is decomposed into genetic (*r*A), shared environmental (*r*C), and nonshared environmental (*r*E) correlations. This assesses the extent to which the same or different genetic or environmental factors influence the outcomes. C: Cross-lagged path model. In this model, the longitudinal stability of the outcomes is indicated by the autoregressive pathways (b_1 and b_4). The cross-paths (b_2 and b_3) establish the directionality of effects between child and parent. T1 = Time 1; T2 = Time 2.

Multivariate behavior genetic models draw information from cross-twin cross-variable correlations to index the extent to which genetic and environmental influences on educational expectations, academic behaviors, and academic outcomes are shared. These are represented as correlations between latent genetic (*r*A), shared environmental (*r*C), and nonshared environmental (*r*E) factors in the *correlated factors* model depicted in Figure 1B. Importantly, this figure illustrates only one member of the twin pair, and the latent variables reflect the genetic and environmental influences on variables X and Y rather than Twin1 and Twin2.

The model presented in Figure 1B. is essentially the behavior genetic extension of a correlation coefficient. That is to say, the entire phenotypic correlation between two variables has been decomposed into genetic and environmental components. To determine the amount that genetic effects mediate the observed correlation between two variables, the product of a_x, *r*A, and a_y would be taken. Similar calculations can be made to determine the extent to which the shared environment and the nonshared environment contribute to the correlation between the variables. Summing the genetic, shared environmental, and nonshared environmental contributions recreates the observed correlation. Thus, these pathways are somewhat akin to a mediational process, as the covariance between the variables is mediated through the latent ACE factors. We make use of this property to calculate the proportion of the observed correlation that can be attributable to genetic, shared environmental, and nonshared environmental factors.

Longitudinal models. In addition to behavior genetic models, we also fit longitudinal *cross-lagged* models, which draw on temporal orderings to make inferences regarding the directionalities of effects. Figure 1C. presents this type of model. Cross-lagged models are composed of a number of distinct paths. Autoregressive paths reflect the stability of the same variable across time (parameters b_1 and b_4). Cross-paths lead from a predictor variable at one point in time to a different outcome variable at a later point in time (parameters b_2 and b_3). Significant cross-paths indicate a time-ordered relation between two variables while controlling for stability in each variable. This can establish the directionality of effects. Additionally, within-wave (residual) correlations between each variable are estimated. Cross-lagged models were conducted with one variable from each domain (academic behaviors, academic achievement, and parental expectations), resulting in eight separate path models for the ECLS-B to incorporate both parent and teacher report and four separate path models for the ECLS-K. All models were fit with controls for maternal age, type of preschool care, disability status, child gender, and child race.

The transactional model predicts that children will influence their own development by way of influencing their parent, and vice versa. To test this hypothesis, we calculate the total indirect effect that originates from the child through the parent and ending in the child. We calculate the similar pathway originating from the parent. Mediation models (Baron & Kenny, 1986) were used to evaluate whether some portion of the influence of educational expectations on child development can be accounted for by the proximal parenting behaviors of involvement and stimulation. To test whether the identified processes differ as a function of sociodemographics, we fit multigroup structural equation models. We compared a model in which the focal parameters are allowed to be free across sociodemographic groups (e.g., socioeconomic status, minority status, and gender) and a model that constrains the parameters to be equal across groups. Because the ECLS-K includes more waves of data, it is more likely that interpretable and consistent patterns will emerge in this data set. Therefore, we focus the moderation analysis on the ECLS-K. We use differences in the comparative fit index (CFI) to compare the fit of the models with the data. If the model with all parameters constrained fits significantly worse than the model with all parameters free, then this result indicates that the transactional process differs on the basis of sociodemograpics.

All analyses were conducted with Mplus statistical software using full-information maximum-likelihood estimation to account for missing data (Muthén & Muthén, 1998–2010). To avoid gender differences distorting parameter estimates in our behavior genetic models, all variables were residualized for the effect of gender and standardized (McGue & Bouchard, 1984). If this is uncontrolled for, it has the effect of inflating estimates of heritability because dizygotic, but not monozygotic, twins can have opposite sexes. For analyses using the full ECLS samples, the complex survey option of Mplus was implemented to weight the results to be representative of the population, and the cluster option was used to account for nonindependence of students sampled from the same sampling frame.

Results

How Are Educational Expectations, Academic Behaviors, and Academic Outcomes Related?

Table 1 presents the correlation matrix for all variables taken from the ECLS-B. Significant correlations are found in the expected direction for all variables. That is, educational expectations correlate positively with achievement (*r*s range from .11 to .17) and parent report of approaches toward learning (*r*s range from .16 to .21) and negatively with problem behavior (*r*s range from −.12 to −.15). Results are similar for teacher report of approaches toward learning (*r*s range from .10 to .13) and problem behavior (*r*s range from −.05 to −.10). Parent report of approaches toward learning correlate positively with achievement (*r*s range from .23 to .31), and problem behavior correlates negatively with achievement (*r*s range from −.15 to −.20). Results are similar for teacher report of approaches toward learning (*r*s range from .25 to .34) and problem behavior (*r*s range from −.15 to −.19). Within domains, approaches toward learning are only moderately related to problem behaviors (*r*s ranging from −.31 to −.40) for parent report, and the results are similar for teacher report (*r*s range from −.33 to −.59). The association between math and reading achievement was much stronger (*r*s ranging from .65 to .81). Despite the fact that many of the associations between expectations, academic behaviors, and achievement are small to moderate, they are impressive in the sense that they exist even prior to kindergarten entry.

Stability coefficients for each variable are generally high (*r*s range from .42 to .72). We evaluate the behavior genetic components of stability in the supplemental material, including in Table S1. Significant genetic stability was found for all outcomes. The shared environment was the primary basis for stability of expectations and achievement, whereas genetic factors were the primary basis for stability of academic behaviors. Convergent validity between parent and teacher report of approaches toward learning and problem behaviors was modest (*r*s range from .24 to .37). We evaluate the behavioral genetic components of convergent validity in the online supplement

Table 1
Phenotypic Correlations for All ECLS-B Variables

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Educational Expectations 4	—													
2. Educational Expectations K	.59	—												
3. Math Achievement 4	.17	.13	—											
4. Math Achievement K	.15	.15	.72	—										
5. Reading Achievement 4	.15	.11	.76	.65	—									
6. Reading Achievement K	.16	.15	.66	.81	.66	—								
7. Parent Approach Toward Learning 4	.21	.16	.28	.25	.28	.23	—							
8. Parent Approach Toward Learning K	.16	.20	.28	.31	.26	.27	.55	—						
9. Parent Problem Behavior 4	−.14	−.12	−.20	−.18	−.20	−.16	−.40	−.31	—					
10. Parent Problem Behavior K	−.12	−.15	−.16	−.16	−.16	−.15	−.31	−.37	.64	—				
11. Teacher Approach Toward Learning 4	.13	.10	.29	.28	.27	.25	.26	.25	−.23	−.22	—			
12. Teacher Approach Toward Learning K	.11	.11	.32	.34	.30	.30	.24	.34	−.25	−.29	.42	—		
13. Teacher Problem Behavior 4	−.08	−.05	−.19	−.15	−.18	−.15	−.19	−.20	.30	.32	−.50	−.33	—	
14. Teacher Problem Behavior K	−.09	−.10	−.18	−.18	−.17	−.19	−.20	−.29	.33	.37	−.35	−.59	.46	—

Note. All $p < .05$. Variables labeled with 4 refer to the age 4 wave, and variables marked with K refer to the kindergarten wave. ECLS-B = Early Childhood Longitudinal Study–Birth Cohort.

and Table S2. Genetic factors were the predominant basis for convergent validity coefficients. We focus the remainder of our analyses on parent reports, as larger sample sizes were available for parent reports than for teacher reports. However, we stress that because our results indicate that parents and teachers respond to overlapping sets of genetic factors, our key results are unlikely to be driven by parent-specific rating biases.

Are Parental Educational Expectations Associated With Children's Genes? Figure 2 presents the results of a univariate behavior genetic decomposition of each outcome variable at the age 4 and kindergarten waves of the ECLS-B. The results are presented graphically in terms of proportion of variance accounted for by genetic or environmental effects. Each estimated proportion of variance is significantly different from zero at $p < .001$, with the exception of the shared environmental parameter for parent and teacher report of approaches toward learning. Nonsignificant variance components were dropped from later models to facilitate convergence. All models fit the data well with no significant chi-square estimates of misfit.

Parental educational expectations display significant child genetic influence at both time points. Approximately 17% of the variance in educational expectations was related to genotypic

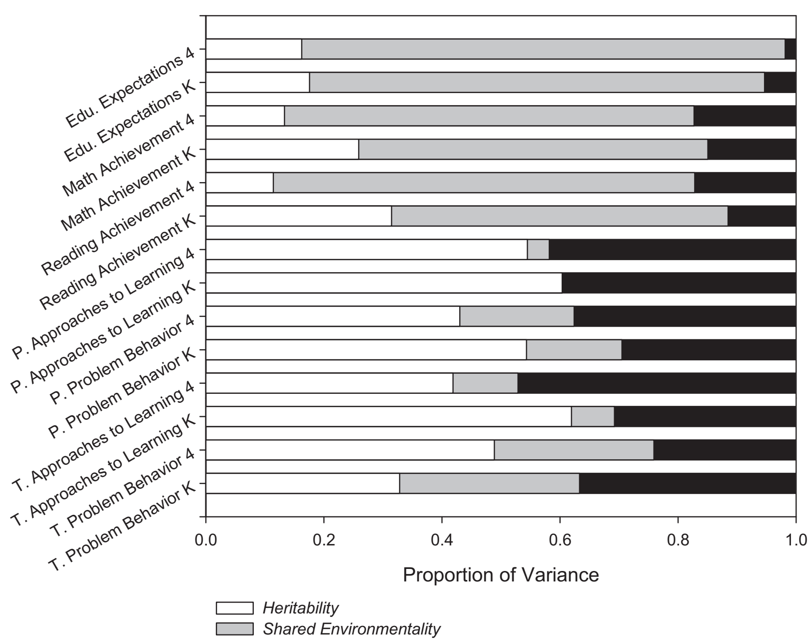

Figure 2. Graphical representation of results from the univariate ACE decomposition for each outcome taken from the Early Childhood Longitudinal Study–Birth Cohort. Bars represent proportion of variance in the outcome attributable to additive genetic effects, shared environmental effects, and nonshared environmental effects. Edu. = Educational; 4 = age 4; K = kindergarten; P. = Parent Report; T. = Teacher Report.

differences between children. This result indicates that parents are responsive to genetically influenced differences in their children or that children even as young as 4 years old are engaged in actively shaping their parent's expectations. However, the variance in educational expectations can primarily be attributed to the shared environment. Roughly three quarters of variation in parental educational expectations can be attributed to between-family variation, pointing to the importance of parents for generating academic beliefs or the influence of structural constraints (e.g., socioeconomic status). The nonshared environment, representing within-family variation and measurement error, accounted for very little variation in expectations, but the estimate was still significant. These results indicate that parental educational expectations are partly influenced by characteristics of the child.

Turning to the child characteristics, each achievement outcome displayed a similar pattern of small, but significant, genetic influence and large shared environmental influence. Approximately 20% of the variance in achievement could be attributed to genotypic differences, 65% to shared environmental differences, and the remaining 15% to unique environmental experiences and measurement error. This distribution of variance components is consistent with previous work examining the developmental behavior genetics of cognition (Briley & Tucker-Drob, 2013). The academic behavior variables, however, display relatively large genetic influences and small or nonexistent shared environmental effects. This distribution of variance components is consistent with previous work examining personality development (Bouchard & Loehlin, 2001; Briley & Tucker-Drob, 2014).

What Explains the Large Shared Environmental Contributions?

To evaluate whether sociodemographics could account for the large estimates of the shared environment for expectations and achievement, we incorporated these variables into our behavior genetic model. Because these variables are somewhat correlated, we entered socioeconomic status into the model to determine its specific effect, and then sequentially added race/ethnicity, preschool type, and maternal age. Figure 3 presents the proportion of total variance in expectations and achievement attributable to latent shared environmental effects and measured family-level variables. Race and socioeconomic status accounted for 22% of the variance in expectations and achievement on average and thereby reduced the influence of the shared environment by the same amount. Preschool type and maternal age accounted for very little remaining variance, approximately 3% on average. About twice as much variance in achievement was explained by measured aspects of the shared environment compared with expectations. In each case, the reduced estimate of the shared environmental influence remained substantial and significant at $p < .001$. This result indicates that some family-level influence is operating beyond the well-documented influence of sociodemographics.

What Mechanisms Link Parental Educational Expectations and Child Factors?

Table 2 presents the genetic and environmental correlations between educational expectations and the child factors within and across

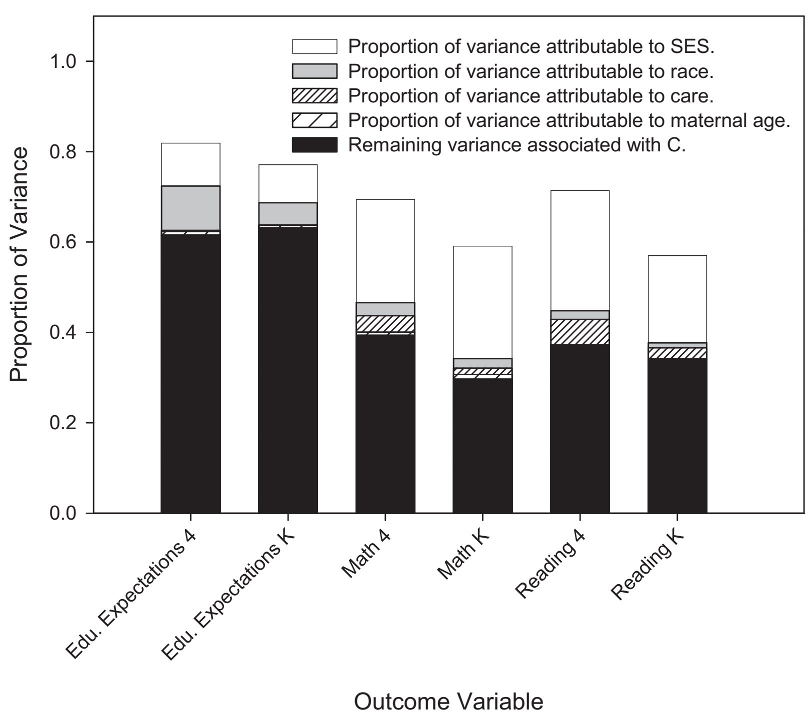

Figure 3. Graphical representation of results from attempts to explain latent C influences with measured family-level environmental variables from the Early Childhood Longitudinal Study–Birth Cohort. SES = socioeconomic status; Edu. = Educational; 4 = age 4; K = kindergarten.

Table 2
Genetic and Environmental Correlates of Educational Expectations

Panel 1: Within wave	Age 4 expectations *r*A	Age 4 expectations *r*C	Age 4 expectations *r*E	K expectations *r*A	K expectations *r*C	K expectations *r*E
Child factors						
1. Math Achievement	.22 (.12)	.22 (.05)***	.12 (.08)	.34 (.12)**	.17 (.07)**	.12 (.08)
2. Reading Achievement	.33 (.15)*	.20 (.05)***	−.04 (.08)	.14 (.11)	.21 (.07)**	.15 (.08)
3. Parent ATL	.42 (.08)***	—	−.09 (.08)	.39 (.09)***	—	.14 (.08)
4. Parent Problem Behavior	−.14 (.10)	−.22 (.11)*	.07 (.08)	−.26 (.12)*	−.19 (.14)	.11 (.08)
5. Teacher ATL	.19 (.12)	—	.09 (.12)	.21 (.11)	—	−.06 (.12)
6. Teacher Problem Behavior	−.24 (.13)	.04 (.12)	−.10 (.12)	−.38 (.23)	.09 (.13)	.08 (.13)

Panel 2: Across wave	Age 4 expectations with K child factors *r*A	Age 4 expectations with K child factors *r*C	Age 4 expectations with K child factors *r*E	K expectations with age 4 child factors *r*A	K expectations with age 4 child factors *r*C	K expectations with age 4 child factors *r*E
Child factors						
1. Math Achievement	.27 (.10)**	.24 (.06)***	−.02 (.09)	.03 (.17)	.31 (.06)***	.09 (.08)
2. Reading Achievement	.19 (.09)*	.23 (.06)***	−.04 (.09)	.05 (.18)	.21 (.06)***	.14 (.08)
3. Parent ATL	.50 (.10)***	—	−.21 (.09)*	.45 (.12)***	—	−.24 (.08)**
4. Parent Problem Behavior	.07 (.10)	−.32 (.14)*	−.02 (.09)	−.24 (.14)	−.19 (.13)	.14 (.08)
5. Teacher ATL	.27 (.10)**	—	−.08 (.09)	.43 (.15)**	—	.11 (.13)
6. Teacher Problem Behavior	−.30 (.16)	−.02 (.11)	.02 (.09)	−.32 (.17)	−.02 (.14)	.09 (.13)

Note. Standardized parameter estimates are presented first, followed by standard errors in parentheses. Data are from the Early Childhood Longitudinal Study–Birth Cohort. K = kindergarten; ATL = approaches toward learning; *r*A = genetic correlation; *r*C = shared environmental correlation; *r*E = nonshared environmental correlation. Dashes indicate that this parameter was not estimated due to no shared environmental influences on ATL.
* $p < .05$. ** $p < .01$. *** $p < .001$.

waves. Each model fit the data well (χ^2 estimates $p > .05$) or adequately (two models: χ^2 estimates $p > .01$, with CFI values of .98 and .99). It is likely that the chi-square test is overpowered for these two exceptions as other indicators of fit are excellent. Table 3 presents the proportion of the observed phenotypic correlation that is due to genetic or environmental factors. Note that the proportion of the observed phenotypic correlation due to a specific factor can exceed 1.0 or take a negative value if the genetic and environmental correlations are in contrasting directions (e.g., positive *r*A and negative *r*C). In all cases, the sum of the proportions equals 1.0.

Table 3
Proportion of the Observed Correlation Between Educational Expectations and Child Factors Due to ACE

Panel 1: Within wave	Age 4 expectations prop. A	Age 4 expectations prop. C	Age 4 expectations prop. E	K expectations prop. A	K expectations prop. C	K expectations prop. E
Child factors						
1. Math Achievement	.16	.81	.03	.36	.58	.06
2. Reading Achievement	.23	.78	−.01	.18	.76	.06
3. Parent ATL	1.07	—	−.07	.87	—	.13
4. Parent Problem Behavior	.31	.74	−.05	.60	.51	−.11
5. Teacher ATL	.88	—	.12	1.11	—	−.11
6. Teacher Problem Behavior	1.19	−.31	.12	2.44	−1.16	−.28

Panel 2: Across wave	Age 4 expectations with K child factors prop. A	Age 4 expectations with K child factors prop. C	Age 4 expectations with K child factors prop. E	K expectations with Age 4 child factors prop. A	K expectations with Age 4 child factors prop. C	K expectations with Age 4 child factors prop. E
Child factors						
1. Math Achievement	.25	.75	.00	.02	.94	.04
2. Reading Achievement	.21	.80	−.01	.04	.88	.08
3. Parent ATL	1.14	—	−.14	1.35	—	−.35
4. Parent Problem Behavior	.14	.85	.01	.56	.60	−.16
5. Teacher ATL	1.07	—	−.07	.88	—	.12
6. Teacher Problem Behavior	.92	.11	−.03	.99	.12	−.11

Note. The proportion due to a variance component can be greater than 1 if the direction of correlation differs across variance components (e.g., positive *r*A but negative *r*C). Data are from the Early Childhood Longitudinal Study–Birth Cohort. K = kindergarten; ATL = approaches toward learning; prop. A = proportion of the observed phenotypic correlations due to the genetic variance component; prop. C = proportion of the observed phenotypic correlations due to the shared environmental variance component; prop. E = proportion of the observed phenotypic correlations due to the nonshared environmental variance component. Dashes indicate that this proportion was not calculated due to no shared environmental influences on ATL.

As shown in Table 2, there were significant shared environmental correlations between parental expectations and child achievement in reading and math. This result indicates that parents who had higher expectations for both their children, on average, had higher achieving children. Put differently, between-family differences in educational expectations were correlated with between-family differences in achievement. This result was true at both age 4 and at kindergarten, both within waves and across waves. In addition, there were shared environmental correlations between educational expectations and problem behavior, but only for age 4 expectations: Parents who perceived their children to have less problem behavior had higher expectations, on average, for their children.

There were also genetic correlations between child characteristics and parental expectations. With regards to achievement (math and reading), four of the eight possible genetic correlations between achievement and educational expectations were statistically significant. The largest genetic correlations were between reading at age 4 and expectations at age 4 (.33) and between math at kindergarten and expectations at kindergarten (.34). In addition, there was a consistent genetic correlation between approaches toward learning and expectations; this correlation was evident at age 4 and at kindergarten, both within and across waves. These genetic correlations indicate that within-family variation in educational expectations is associated with genetic differences in measured child characteristics, particularly approaches toward learning.

Do Transactional Processes Occur at This Very Early Stage of Development?

We performed a series of longitudinal cross-lagged path models using data from the entire ECLS-B sample to clarify the longitudinal processes that link child characteristics and parental expectations. Because we used four indicators each of child academic behaviors and two indicators of child academic achievement, we fit eight trivariate models based on combinations of key study variables. As the two-wave cross-lagged path model is fully saturated, it has perfect fit to the data. Figure 4 presents the standardized parameter estimates from this model for combinations of parental educational expectation, parent-reported academic behavior, and academic achievement. All models controlled for variation in family socioeconomic status, race/ethnicity, child gender, maternal age, preschool care arrangement, and disability status.

Several pathways are of note. First, there was substantial stability for each outcome. High stability places an upper limit on the amount of transactional effects that can be observed over the interval of a year. Second, higher levels of approaches toward learning at the initial time point predict higher levels of achievement and expectations at the second time point. Higher levels of early problem behavior predicted lower expectations at the second time point, but not achievement. Third, earlier achievement predicts higher approaches toward learning at the later time point, but not expectations or problem behavior. Fourth, early expectations had significant positive relations with later achievement (although this effect is only marginally significant in one model; $p < .10$). Fifth, early expectations did not significantly predict later approaches toward learning or problem behavior. The full parameter estimates, standard errors, (residual) correlations, and significance levels for all models (including teacher report of academic behavior) can be found in Tables S3–S4.

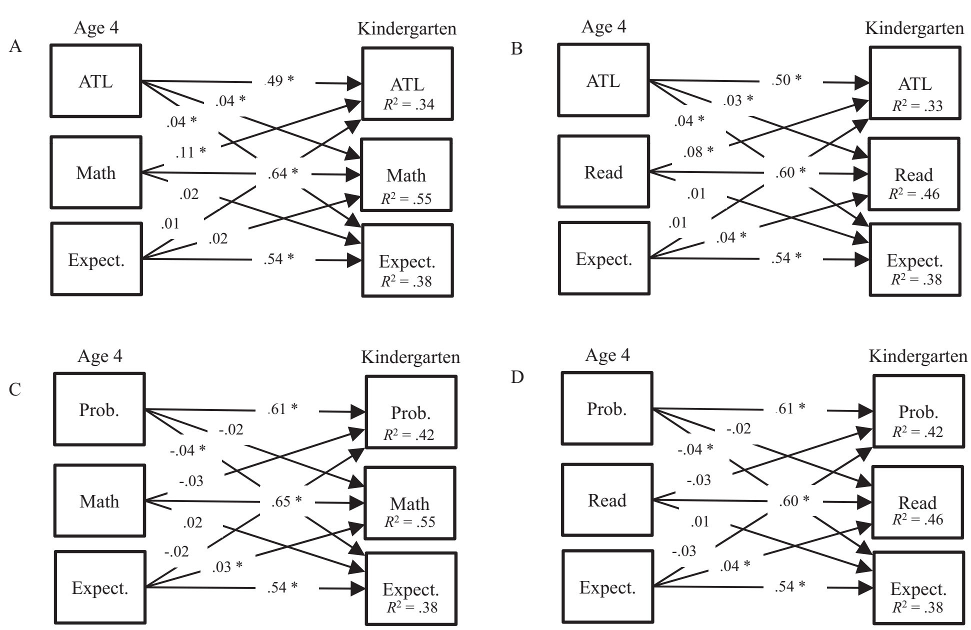

Figure 4. Cross-lagged path model using from the Early Childhood Longitudinal Study–Birth Cohort data and the variables of approaches toward learning, problem behavior, math and reading achievement, and educational expectations. ATL = approaches toward learning; Prob. = problem behavior; Expect. = parental educational expectations. Standardized parameters with significance levels are reported (* $p < .05$). To reduce clutter, standard errors and complete significance levels are not reported, but these may be found in the online supplemental material.

Overall, there was consilience between the results from the longitudinal approach and the behavior genetic approach. For both methodologies, there was the strongest evidence for transactions between child academic behavior—particularly approaches toward learning—and parental expectations. Approaches toward learning showed the strongest genetic correlations both between and across waves, and the strongest cross-lagged paths with subsequent expectations.

How Do Transactional Processes Develop as Children Progress Academically?

The ECLS-K data can act as an extension of the previous results and allow an examination of how these reciprocal effects develop as children grow and gain more independence over their environment. Importantly, this analysis is based on a separate data set containing different individuals, and therefore represents a conceptual extension rather than direct longitudinal follow-up of the same children. Figure 5 presents a similar, trivariate cross-lagged path model beginning in kindergarten and ending in fifth grade for teacher report of approaches toward learning, math and reading achievement, and parental educational expectations. Figure 6 presents similar results for teacher report of problem behavior, math and reading achievement, and parental educational expectations. The full parameter estimates, standard errors, (residual) correlations, and significance levels can be found in Tables S5–S6. Each model recaptured the data well as indicated by excellent model fit statistics (CFI = .95–.97). Again, we controlled for variation in family socioeconomic status, race/ethnicity, child gender, maternal age, preschool care arrangement, and disability status.

The results are generally consistent with those found from the ECLS-B, except the effect sizes are somewhat larger. Initial levels of parental educational expectations tend to predict increases in achievement and approaches toward learning and decreases in problem behaviors. Similarly, approaches toward learning predict increases in achievement and expectations. Problem behavior, however, predicts decreases in achievement and expectations. Achievement predicts increases in expectations and approaches toward learning and decreases in problem behavior. The consistency of these longitudinal associations is particularly impressive given the massive developmental changes that children undergo in this age range, the changing school environment, the highly controlled model, and the number of parameters tested. The transactional mechanisms that undergird this type of academic development appear to be highly generalizable across outcomes (math and reading achievement), child characteristics (approaches toward learning and problem behaviors), and time (preschool to fifth grade).

Table S7 reports indirect effects of child characteristics filtered through parental expectations on child outcomes at the final wave. Additionally, we calculated a similar pathway originating from the parent, filtered through child characteristics, and ending with ultimate expectations. We found small (average absolute value of $\beta = .002$, range $= 0$–$.006$), but statistically significant, indirect effects for several pathways. The strongest effects were for early achievement to predict later achievement through parental expectations, and for parental expectations to predict later expectations through child academic achievement. These results indicate that children influence the parenting that they receive, and this process in turn influences their psychological development. Similarly, parental expectations influence children's psychological development, and this in turn influences parental beliefs. Although the effects are small, they are impressive in that they are detectable

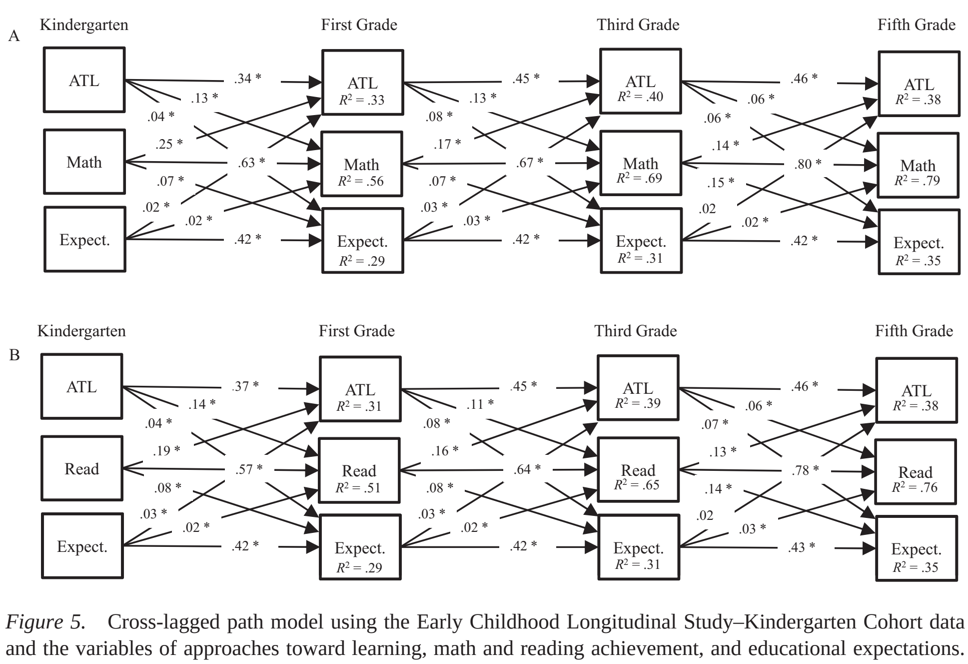

Figure 5. Cross-lagged path model using the Early Childhood Longitudinal Study–Kindergarten Cohort data and the variables of approaches toward learning, math and reading achievement, and educational expectations. ATL = approaches toward learning; Expect. = parental educational expectations. Standardized parameters with significance levels are reported ($^* p < .05$). To reduce clutter, standard errors and complete significance levels are not reported, but these may be found in the online supplemental material.

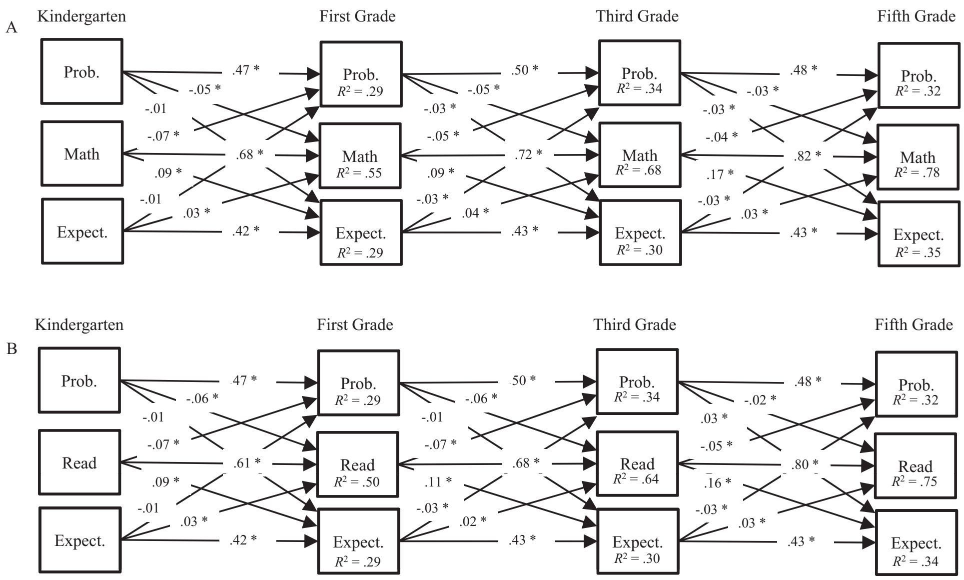

Figure 6. Cross-lagged path model using the Early Childhood Longitudinal Study–Kindergarten Cohort data and the variables of problem behavior, math and reading achievement, and educational expectations. Prob. = problem behavior; Expect. = parental educational expectations. Standardized parameters with significance levels are reported (* $p < .05$). To reduce clutter, standard errors and complete significance levels are not reported, but these may be found in the online supplemental material.

even at kindergarten entry in a highly controlled model and that the indirect effects are forced to be mediated by a psychological characteristic of a separate individual.

Does the Transactional Model Differ Across Sociodemographic Groups?

We fit a series of multiple-group structural equation models to test whether parameters differed by gender, socioeconomic status quintile, and minority status. We initially fit models without cross-group constraints and then constrained autoregressive and cross-paths to equality. Because the chi-square difference test is sensitive to sample size, we primarily rely on differences in CFI across models. Following the recommendations of Cheung and Rensvold (2002), we considered a decrease in CFI of greater than .01 to be indicative of a significant worsening of model fit by imposing cross-group constraints. Table S8 presents model fit statistics for this analysis. We found no evidence of moderation, as the largest change in CFI was only .006. This result is evidence that the transactional processes do not differ by sociodemographics and are generalizable across most common demographic groups.

What Proximal Processes Allow Expectations to Influence Child Academic Success?

Due to the limited longitudinal data availability (measures were changed, dropped, or otherwise unavailable at other waves), we chose to examine whether parent involvement and stimulation of cognitive development statistically mediated the within-wave association between expectations and academic achievement and behavior at the first- and third-grade waves. We fit a dual-mediation model in which the outcome was predicted by the two mediators and parental expectations. Additionally, expectations acted as a predictor of the mediators, and the mediators were allowed to correlate. This is a just identified model, and therefore fits the data exactly.

To ensure comparable interpretation across outcomes, we report the mediation results as a percentage of the total effect of educational expectations on an outcome. For example, the total effect of educational expectations on math achievement in first grade was .123, and .012 of this effect was mediated by parental involvement (9.8%). For the remaining variables at the first-grade wave, parental involvement mediated a small percentage of the total effect of expectations for reading (7.7%), approaches toward learning (10.2%), and problem behavior (16.7%). At the third-grade wave, parental involvement again mediated a small percentage of the total effect of expectations for math (5.5%), reading (5.6%), approaches toward learning (7.1%), and problem behavior (6.0%). Parental stimulation of cognitive development did not mediate any additional variance at either wave. Importantly, these values are percentages of the total effect (e.g., total R^2), not variance accounted for by the mediators.

Discussion

We hypothesized that parental educational expectations, child academic achievement, and child academic behaviors transact over development. Using behavior genetic methods, we find that parental educational expectations are associated with genetically influenced characteristics of their children, including approaches toward learning and math achievement. Using longitudinal methods, we find time-ordered, bidirectional associations between child characteristics and parental educational expectations. Parents are responsive to individual differences of their children, and children actively shape the educationally relevant parenting they receive. Both of these processes begin before children even enter the educational system. The parent–child relationship and the psychological characteristics of parent and child are dynamic. This finding means that children are transmitters of academic beliefs and can evoke changes in parental expectations. Our results establish a complex, reciprocal pattern between child academic behaviors, child cognitive development, and parental educational expectations. Our results indicate that even before entry into formal schooling, child abilities, general tendencies of academic behavior, and environmental support are mutually dependent. This dependency indicates that efforts to improve the academic readiness of very young children (e.g., Duncan et al., 2007; Heckman, 2006; Shonkoff & Phillips, 2000) must take into account the dynamic relationship between children with unique characteristics and family-level supports for child development, such as parental educational expectations.

The causal ambiguity of simple correlations between parenting practices and child outcomes has been known for over 40 years. Bell (1968), for example, concluded that "the effect of children on parents can no longer be dismissed as only a logical but implausible alternative explanation of a correlation" (p. 81). Similarly, more than 30 years ago, Plomin et al. (1977) and Scarr and McCartney (1983) provided a motivating developmental theory that incorporates processes that link a child's genotype with the types of environments that they passively receive from their parents, evoke from their surroundings, and actively seek out in accord with their genetic predispositions. Indeed, even major elaborations of the E-V model have specified that "parents' and children's beliefs are likely to influence each other reciprocally" (Jacobs & Eccles, 2000, p. 416). Nevertheless, rigorous empirical research to test such hypotheses remains rare in the domain of parental educational expectations. Perhaps implicitly guided by unidirectional transmissive thinking, much of the empirical work on parental educational expectations takes the approach of measuring parental expectations before child variables (an approach incapable of testing for child-to-parent effects) or only assesses parenting at a single time point (an approach incapable of testing for dynamic transaction). Further, previous research in this area typically does not incorporate general patterns of child behavior and has failed to use genetically informative approaches. Why transactional frameworks have not been better integrated into empirical studies of educational expectations is unclear. J. Richard Udry (2003), in a characteristic to-the-point style, provided his opinion. He argued:

> Most social science theories assume parent-to-child effects as the basic causal sequence because they do not believe that children have inherent attributes. If children do not have inherent attributes, then there is no starting point in the child. It is tabula rasa all over again . . .. If you believe that individuals differ from one another from birth because of inherent attributes, then no assumption of parent-to-child as the starting point makes any sense. Longitudinal designs will not solve the problem. Nor will starting your investigations at younger and younger ages. (p. 49)

Our aim for the current project was to provide an empirical counterpoint to the tendency to focus on parent-to-child models of parental educational expectations and child academic development. Importantly, the current results are consistent with established theoretical perspectives, but for the first time, we provide evidence of reciprocal, bidirectional influences between parent educational expectations and early child academic development.

"Heritable" Environments and Gene–Environment Correlation

We found that a significant portion of variance in parental beliefs about the educational future of their children was associated with child-genotypic differences. Because parental beliefs are traditionally conceptualized as environmental contexts, this result is indicative of active or evocative gene–environment correlation, whereby parents form their expectations on the basis of genetically influenced characteristics of their children. In line with previous research indicating that cognitive ability influences the type and quality of parental interaction that children receive (Lugo-Gil & Tamis-LeMonda, 2008; Tucker-Drob & Harden, 2012a), our results indicate that parents are sensitive to their children's math and reading achievement and adjust their expectations over time accordingly. We also found evidence that parental beliefs are formed, in part, based on a child's general tendency for behaviors that facilitate or hinder task-focused academic learning. These genetically influenced child characteristics predicted later parental educational expectations, allowing the genetically influenced behaviors to get "out of the skin" to influence environmental experience, even before children entered formal schooling. Interestingly, although our behavior genetic models indicated shared environmental mediation of the associations between achievement and educational expectations, approaches toward learning and educational expectations consistently reflected shared genetic, rather than environmental, influences. Thus, our results suggest that general patterns of behavior, as opposed to achievement test scores, may be more robust mechanisms of gene–environment correlation with respect to parental expectations in early childhood.

Despite the significant amount of variance in parental educational expectations associated with child genotype, shared environmental effects accounted for the majority of the variance in expectations. Conceptually, these influences represent child-invariant, family-level influences on parenting. The mechanisms leading to these large shared environmental influences on educational expectations, however, are not entirely known. We found that only about one quarter of the shared environmental effect on expectations could be attributed to sociodemographics, such as socioeconomic status (including parental education) and race/ethnicity. The remaining variance could be due to parenting values, other family-level cultural or environmental influences, or genetically influenced traits of the parent (e.g., Avinun, Ebstein, & Knafo, 2012; Bakermans-Kranenburg & Van IJzendoorn, 2008). If parents possess genetically influenced traits that affect their parenting and these traits are passed on to their children, this represents a type of passive gene–environment correlation. As it operates to make children living in the same household more similar to one another, passive gene–environment correlation would act as a shared environmental influence even though the developmental process is partially genetic. A more complex design would be necessary to evaluate this possibility, for instance, a children-of-twins design. Meta-analyzing such studies, Klahr and Burt (2014) found that 37%, 0%, and 28% of the variance in parental warmth, control, and negativity can be explained by parental genetic effects, respectively. It is likely that the shared environmental factor for educational expectations represents several of these possibilities. The nonshared environment, representing differential within-family treatment, was very small. This result indicates that, apart from variation associated with genotypic differences between children, parents form very similar expectations for their children.

Incorporating gene–environment correlation into academic socialization models has important implications for developmental theory. One of the most widely replicated findings in all of behavior genetics is that the heritability of cognitively relevant outcomes increases with age (Briley & Tucker-Drob, 2013; Haworth et al., 2010). Explanations for this finding rely primarily on an understanding of active gene–environment correlation whereby children increasingly select environments that are congruent with their genetic predispositions as they age (Dickens & Flynn, 2001; Scarr & McCartney, 1983; Tucker-Drob & Briley, 2014). Applied to the current results, preliminary evidence for this process can be found in the longitudinal models. In general, the effect sizes are larger in the ECLS-K data set (of elementary and middle-school development) compared with the ECLS-B (of preschool and kindergarten development), which is consistent with the hypothesis that as children age, they exert an increasing influence on their own achievement and the type of received parental support. As this feedback process depends, in some small part, on genetically influenced characteristics, it is likely that the heritability of expectations would increase along with other cognitive variables. Crucially, this hypothesis implies that the heritability coefficient is not a deterministic value that limits environmental effects, but rather, heritability depends on environmental inputs and opportunities (see Bronfenbrenner & Ceci, 1994; Tucker-Drob et al., 2013).

Both Children and Parents as Drivers of Academic Development

The current results indicate that children are important drivers of the climate of their academic development. We have focused on child-driven effects for the majority of the article because this pathway is often overlooked in empirical studies. It is also important to emphasize that the current results implicate parents as strong drivers of academic development. We found a significant shared environmental correlation between parental educational expectations and child math and reading achievement both within waves and across waves of the ECLS-B. Transmitted beliefs, values, and perceptions of competence are likely mechanisms for this shared environmental correlation. Therefore, we would argue that our results are largely consistent with previous empirical work on educational expectations. An open empirical question, however, is to what extent the shared environmental effects detected reflect patterns of passive gene–environment correlation (described above).

The longitudinal cross-lagged path models identified bidirectional interactions between parents and children, but it is somewhat unclear whether genetic or environmental mechanisms mediate these associations. For example, parent educational expectations may be associated with later approaches toward learning because of an underlying genetic pathway, consistent with the idea that parents are responding to enduring patterns of behavior in their children. Several models of cognitive development (e.g., Bouchard, 1997; Dickens & Flynn, 2001; Hayes, 1962; Scarr, 1997) speculate that only environments that are experienced as a result of this type of gene–environment correlation are likely to have an appreciable influence on development, as these environments will be recurrently experienced with age. Unfortunately, we were unable to decompose the cross-lagged pathways into variance components due to genetic, shared environmental, and nonshared environmental factors. A much larger sample size of twins would be required to detect these effects at this age.

Locating Causal Effects in Development

Our results indicate that the dynamic processes between the student and his or her environment begin to shape academic trajectories even before the entry into schooling. It is therefore possible that correlations found in older students may largely reflect the accumulated effects of processes that are initiated very early in childhood. Our cross-lagged path models provide support for the concept of a "developmental cascade" (e.g., Bornstein, Hahn, & Wolke, 2013). Another recent example of such a process comes from Bornstein, Hahn, and Suwalsky (2013), who found that exploratory ability of 5-month-old infants was associated with academic achievement in adolescence through intermediate associations with intellectual development. One explanation for this result is that children vary in their ability or tendency to explore their world and actively seek out or evoke environmental experiences (Raine, Reynolds, Venables, & Mednick, 2002). If individual differences in motor ability are even slightly genetically influenced, then such a developmental cascade could result in variation in ability becoming increasingly tied to genotypic differences. We found that very early indicators of a child's achievement and behavioral tendencies predict change in their academic trajectory, as do very early parental influences.

In the ECLS-B (ages 4 and 5), we found that the effect of early parental expectations on later child achievement was more than double the effect of early achievement on later parenting. In the ECLS-K (grades K through 5), however, the child-to-parent effect grew to more than 4 times *larger* than the parent-to-child effect for academic achievement. This result likely reflects a response to growing divergence of student academic trajectories. Importantly, the parent-to-child parameter was nearly identical across the separate ECLS-B and ECLS-K data sets, but differences in the child-to-parent effect account for this striking difference. Parents likely generate stable expectations for their children at an early age, but over time, parents dynamically adjust their expectations such that levels of expectations become increasingly child based. Further, the influence of early child academic behaviors on later achievement was more than twice as large in the ECLS-K as in the ECLS-B. Again, growing divergence in academic trajectories emerges from magnified differences in early patterns of behavior. Stratification of achievement may result from the dynamic interaction between child predispositions for learning, child ability, and their educational environment. Focusing attention toward these types of early transactions between children and their environments may prove beneficial for research that aims to foster upward trajectories of academic achievement.

Strengths and Limitations

This study has a number of strengths that support the conclusions being drawn. We applied both behavior genetic models and cross-lagged path models to high-quality, population-representative, longitudinal data of educationally relevant outcomes. The findings of behavior genetic studies of education are rarely integrated within socialization frameworks of child development. We view these models and methods to be highly complementary and provide unique information about child development. Moreover, as all modeling approaches are limited by their unique sets of assumptions, our inferences are strengthened by having been conceptually replicated across behavior genetic and longitudinal approaches.

Several limitations are of note. We were unable to evaluate whether the parent or teacher gender matters for the report of academic behavior. The vast majority of respondents were female (>95%) in the ECLS-B. In the ECLS-K, the respondent gender was suppressed except at the initial wave when the teachers were almost entirely female (98%). Understanding how the socialization process unfolds in relation to male and female parents is an important future direction for research.

Our analyses of child academic behaviors were somewhat limited in the ECLS-B data set because we relied on parent report of behavior. Teacher report of academic behavior was available for some participants, but children in formal preschool differ systematically from the general population (see Tucker-Drob, 2012). The behavior genetic results were largely similar across parent and teacher report, indicating that shared method variance between parent report of behavior and expectations do not fully explain the results. Additionally, the highly consistent results from the ELCS-K were fully based on teacher report of academic behavior.

We were unable to fully explain the child genetic influences on educational expectations. There is much left to be explained both in terms of the gene–environment interplay in the formation of expectations for parents and children as well as the mechanism by which academic behaviors, academic achievement, and expectations are prospectively related. In particular, the cross-lagged path models presented here add clarity to the directionality of effects, but it is unclear whether genetic or environmental mechanisms link the outcomes across time. A much larger twin sample would be necessary to fully integrate the behavior genetic and the longitudinal cross-lagged approach. Similarly, we found that early parent and child characteristics could predict later outcomes, but residual associations remained, suggesting influential unmeasured factors. Unraveling this association across time is an important avenue for future research. Importantly, the finding that child genetic differences influence expectations does not invalidate the "importance" of parents; it displays the developmental process more accurately. Parents still play an active role, for example, by being receptive and open to forming educational beliefs on the basis of their child's preferences.

We were able to evaluate a large span of child development by combining the ECLS-B and ECLS-K data sets. We tracked children across the transition into kindergarten through fifth grade, and nearly every parameter was in the expected direction with the majority statistically significant. The results are somewhat limited due to the fact that the ECLS-B and ECLS-K are separate data sets. Therefore, we cannot draw longitudinal inferences across data sets.

One may wonder whether the effects uncovered in the current study are too small to have a substantial impact on child development. For example, genetic influences only accounted for roughly 20% of the variance in parental educational expectations, and cross-lagged paths were typically small. However, these effects may have more practical importance than might be expected at face. Because the large majority of individuals pass through the education system, even very small benefits are likely to pay large dividends to society. The promise of a transactional model is that reciprocal feedback loops can be constructed to facilitate compounding benefits with development. In this sense, small effects over 1-year intervals may translate to large effects over the entirety of development. Further, expectations represent only one environment that may be selected on the basis of genotype. Evaluating gene–environment interplay for other academically relevant beliefs and values may add to the transactional model presented here.

Finally, the use of a single indicator to assess the child's academic environment has important limitations. Educational expectations are a distal factor that likely influence many more proximal behaviors, beliefs, and values that shape child development. Although this quality may limit mechanistic interpretations, it is clear from the lack of variance mediated by specific proximal behaviors (i.e., involvement and stimulation) that the use of such a broad variable indexes a wide array of parental inputs.

Conclusion

In the current study, we made use of behavior genetic and longitudinal methodology to address whether children actively evoke changes in parental beliefs and influence their developmental environment. We tested these plausible, but previously unexplored, connections between children and parents and found strong evidence that child-to-parent effects do influence educational expectations. Our results are consistent with a fully transactional model between child academic behaviors, child academic achievement, and parental educational expectations that shapes the educational trajectories of children. Even before entry into formal schooling, children influence their educational environments.

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Received June 21, 2013
Revision received April 28, 2014
Accepted August 29, 2014 ■