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Transmission or Transaction? The Role of Child Characteristics in Parental Educational Expectations using Longitudinal and Behavioral Genetic Methods

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Abstract

Parents' educational expectations have been widely hypothesized to play an instrumental role in socializing children's educationally relevant behavior. However, in addition to a process whereby parents socially transmit educationally relevant beliefs to their children, children's behaviors may reciprocally affect parental expectations. We explore evidence for transactional associations using longitudinal and genetically informative twin data from the Early Childhood Longitudinal Study – Birth and Kindergarten cohorts. We find that, although variation in parental expectations is tied closely to family-level influences, expectations are also significantly influenced by variation in child genotypes. We explore mechanisms that might underlie these child-to-parent effects using longitudinal cross-lagged path models of child characteristics (approaches towards learning and problem behaviors), child achievement (math and reading), and parental educational expectations. We find that initial levels of child characteristics predict future expectations above and beyond previous expectations. These results are consistent with transactional frameworks in which parent-to-child and child-to-parent effects co-occur.

Transmission or Transaction? The Role of Child Characteristics in Parental Educational Expectations using both Longitudinal and Behavioral Genetic Methods

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 consistently associated with actual educational attainment and academic achievement, even after controlling for a number of family and individual confounds (Duncan, Featherman, & Duncan, 1972; Sewell & Shah, 1967). Thus, understanding the mechanisms underlying the association behind educational expectations and child development has been implicated as fundamental to the development of policies and interventions to improve academic achievement and educational attainment.

Sociologists and psychologists have examined the relation between educational expectations and educational attainment in separate but parallel literatures. Both of these literatures primarily explore the parent-child relationship under the assumption of a *transmission* model in which parents act as active broadcasters of academic beliefs and children act as passive receivers. However, much work in child development (e.g., Bell, 1968) has highlighted the importance of reciprocal or *transactional* processes between children and their environments. The current project demonstrates that both parent-to-child and child-to-parent effects influence academic development and expectations, that these effects occur even before children enter school and that the transactional process is sensitive to child motivation and problem behavior.

Literature Review

Theories of Expectations and Academic Attainment

Sociology and psychology have used two broad models to study parental expectations and academic achievement: the status attainment model (Sewell & Hauser, 1972; 1980) and the expectancy-value model of motivation (Eccles & Wigfield, 2002; Nagengast, Marsh, Scalas, Xu, Han, Trautwein, 2011; Trautwein, Marsh, Nagengast, Lüdtke, Nagy, & Jonkmann, March, 2012).

The status attainment model notes that society is stratified in terms of background characteristics, such as race or socioeconomic status, which in turn reproduce status inequalities in each successive generation. Building on the work of Blau and Duncan (1967), the major contribution of the status attainment model is in explicating some intervening mechanisms by which socioeconomic background and ability lead to 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 expected simply based on his or her families' socioeconomic background, whereas pessimistic parental educational expectations may influence a child to achieve to a lesser extent than would be expected based on his or her families' socioeconomic background. Under this perspective, child academic trajectories and interactions with the educational system are thought to reflect the influence of internalized parental beliefs.

The expectancy-value model is a complementary framework, focused at the level of the individual (Eccles & Wigfield, 2002). Under this framework, the primary determinants of motivation to complete a task are the expectation that the task is able to be completed and the value of completing the task (Jacobs & Eccles, 2000, see also Bandura, 1986; Zimmerman, Bandura, & Martinez-Ponz, 1992). Applied to academic tasks, perceived competence and belief in the worth of school are crucial for students. For an individual to maintain motivation, a task must seem achievable and worthy of the required effort. Indeed, recent work indicates that expectancies and values may interact such that their joint effects are stronger than the sum of their individual effects (Nagengast et al., 2011). Educational attainment is a clear example of a task that elicits varying degrees of beliefs regarding the value or ability for successful task completion. Parents are thought to instill perceptions of value and ability in their children in part based on expectations to obtain a certain level of credentials.

Does Believing Make a Difference? The Power of Expectations

The status attainment model argues that children whose parents instill in them high educational expectations are able to leverage their social capital to drive achievement through a variety of institutional mechanisms. Children who believe that academic achievement is possible and important for realizing their life goals will be driven to interact with the educational system and invest resources necessary for success. Similarly, the expectancy-value model (Eccles & Wigfield, 2002; Jacobs & Eccles, 2000) argues that educational expectations inform one’s self-concept and beliefs about the importance and value of school, and that these beliefs are prerequisites for motivation, perseverance, and the initiation of academically relevant behaviors. Although these theories may tell elegant stories concerning child motivation, one may remain skeptical that merely expecting to achieve will allow an individual to overcome substantial institutional barriers. Turning to the individual child, does believing that one will complete advanced education actually lead to better academic outcomes?

Analyses using population-level data and longitudinal data have consistently shown that the educational expectations of the individual (rather than the parent) influence academic achievement (Alexander, Entwisle, & Bedinger, 1994). 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). Recently, Jacob and Linkow (2011) have updated this finding using three large, nationally representative datasets: High School & Beyond, National Education Longitudinal Study of 1988, and Educational Longitudinal Study of 2002. Confirming the earlier findings of Sewell and Hauser (1972; 1980), these separate, high quality, longitudinal datasets uncovered significant associations between early expectations and actual educational attainment, even controlling for characteristics of the student, family, school, and county (Jacob & Linkow, 2011). Ou and Reynolds (2008) found similar results with a longitudinal sample of low-income, minority children. This study is particularly impressive in that it was able to track a high-risk sample from birth throughout their academic careers and assess more in-depth social and psychological variables. They found that expectations still predicted achievement even after controlling for sociodemographic characteristics, participation in an intensive preschool program, participation in magnet or other focused academic programs, early and late objective and subjective evaluations of ability, parental involvement, grade retention, days absent per year, percentage students at school above grade level in reading, school mobility, presence of abuse or neglect, and other criminal experiences.

Transmission of Academic Beliefs

A key component of the prevailing work on educational expectations is the assumption of a causal effect of *parental* expectations on children's attainment through the process of transmission of academic beliefs. Under this assumption, parents instill levels of educational expectations in their children, which are then internalized to inform academic self-concepts. A number of researchers have attempted to test this assumption using statistical mediation approaches. Gonzalez-Pienda, Nunez, Gonzalez-Pumariega, Alvarez, Roces, & Garcia (2002) found that parental expectations were significantly associated with child beliefs regarding competence and academic aptitude. These later two variables were significantly associated with achievement and mediated the effect of parental expectations. Neuenschwander, Vida, Garrett, and Eccles (2007) demonstrated the generalizability of this finding by using samples from the United States and Switzerland and found that parental expectations had a significant association with academic self-concept controlling for grades and income. That 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; Simpkins, Fredricks, and Eccles, 2012). Validating the utility of this line of research, Harackiewicz, Rozek, Hulleman, and Hyde (2012) developed a successful intervention based on expectancy-value theory 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 students largely adopt levels of educational expectations based on social background characteristics and adapt to academic feedback (i.e., grades) very modestly. Similarly, Tynkkyen, Tolvanen, and Salmela-Aro (2012) tracked children's trajectories of educational expectations over five years as a function of social background and parental expectations. Parental expectations were significantly associated with child academic expectation trajectories, and importantly, developing along different expectation trajectories resulted in disparities in achievement for the children. In these studies parental expectations are assumed to take both chronological and causal precedence over child variables.

Parent-to-Child Effects as the Theoretical Status Quo

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 common 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, Keesler, & Morlock, 2010, p. 253). Jacobs and Eccles (2000) claim, "The ways in which parents spend their time, the choices they make between available activities, and the sense of self-competence that they project send strong messages to children about activities that are valued and acceptable," and that "the direction of influence for perceptions of competence is from parents to children" (p. 419-420). Following in this tradition, Simpkins et al. (2012) constructed their conceptual model with parenting beliefs and behaviors preceding and independent of child beliefs and behaviors on the basis that past research found that "mothers' beliefs shape child development" (p. 1020). Similar conceptual or path diagrams are found in several expectations studies with similar causal ordering claims (Bleeker & Jacobs, 2004; Frome & Eccles, 1998; Gonzalez-Pienda et al, 2002; Neuenschwander et al., 2007). This type of reasoning implicitly or explicitly regards parental beliefs as exogenous influences on child outcomes. While the extant evidence certainly is consistent with parent-to-child effects, an outstanding and conspicuously neglected question is whether parental educational expectations are subject to dynamic and reciprocal feedback from children.

Transactional Processes Between Parents and Children

Transaction, as opposed to transmission, represents an elaborated framework by which to understand socialization (Sameroff, 2009). While 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. Work in behavior genetics further expands on this idea in allowing for the possibility that children's genetically influenced behaviors, preferences, and dispositions have the potential to influence the types of, and quality of, experiences that they seek out and 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.

An understanding of gene-environment correlation provides several possible avenues for the relationship between parental educational expectations and child academic beliefs to occur besides unidirectional transmission of values. Child characteristics and behaviors, such as motivation, abilities and self-concepts, may be subject to genetic influences. Parents may be sensitive to these characteristics and behaviors and generate and adjust their expectations accordingly. This 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 be indicative of child-to-parent effects. A recent meta-analysis found that child genetic effects account for between 12% and 37% of the variance in parenting behaviors depending on the variable (Kendler & Baker, 2007). 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) published the sole longitudinal study of parental educational expectations motivated by expectancy-value theory to use cross-lagged path models to simultaneously control for parent and child characteristics. This 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 8th 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 & O'Mara, 2008; Marsh & Martin, 2011; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005) have demonstrated reciprocal effects between academic self-concept, interests, grades, and academic achievement. However, they did not examine parental educational expectations, or any other parent beliefs or behaviors for that matter.

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. For example, a child who diligently completes chores or pays attention may be likely to inspire higher expectations. Conversely, a child who consistently creates trouble or has emotional outbursts may lower expectations. By academic achievement outcomes, we mean objective, standardized tests of math and reading. Objective tests scores are consistently one of the strongest correlates of educational attainment (Strenze, 2007). Similar to child academic behavior, a particularly bright child or a child on a faster upward trajectory of cognitive development and academic achievement may enlist increasing parental expectations. Parental educational expectations are expected 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 successful learning, and problem behaviors likely interfere with academic achievement. Therefore, we posit a fully interactive transactional model where child academic behaviors, child cognitive development 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.

Goals of the Present Study

We primarily aim to address three empirical questions. First, we evaluate whether parental educational expectations are influenced by genetic differences in their children. The dynamic interplay between parent and child in the context of education and socialization has a large amount to gain by incorporating samples and studies that are able to evaluate the influence of genes and the environment. While recent reviews (e.g., Crosnoe & Johnson, 2011; Schneider et al., 2010) of the relevant literature have made note of the importance of integrating genetic thinking with socialization models, we are aware of no study that has used a genetically informative sample to evaluate bidirectional effects between expectations and child academic behaviors or achievement. Second, we evaluate the specific transactional processes that occur between child academic behavior, child academic achievement outcomes and parental educational expectations. Constructing longitudinal models that predict future child or parenting constructs from earlier characteristics is particularly valuable for establishing the directionality of child or parent driven effects involved in transactional processes. Finally, we seek to 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 (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. Given existing evidence that educational trajectories begin to differentiate prior to school entry (Heckman, 2006; Tucker-Drob, 2012; Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011), it is prudent to examine transactional processes underlying parental educational expectations during early childhood.

Method

Data

Data were drawn from the Early Childhood Longitudinal Study – Birth Cohort (ECLS-B) and Early Childhood Longitudinal Study – Kindergarten Cohort (ECLS-K). These datasets 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). ECLS-B is nationally representative of United States children born in 2001, and ECLS-K is nationally representative of the kindergarten cohort of 1998. The data used in the current study was the age 4 (collected in 2005 and 2006) and kindergarten waves (collected in 2006) of ECLS-B. The data from 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. We omitted waves from ECLS-B and ECLS-K due to limited measure or data availability. The initial wave of ECLS-B recruited 10,650[1] parents to participate, and 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 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 behavioral genetic models were fit to the twin subsample of 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 items, which ranged from 6 to 18. Twin pairs with zygosity scores below 8 were classified as monozygotic. Same-sex

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

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 found that zygosity diagnoses obtained from such physical similarity rating approaches are over 90% accurate when validated with biospecimens (Forget-Dubois et al., 2003). Our final sample was composed of 28% monozygotic twin pairs, 34% same-sex dizygotic twin pairs and 38% 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 high school diploma, to graduate from high school, to attend two 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 ECLS-K and ECLS-B.

Academic Behavior. Academic behavior, operationalized in terms of approaches towards learning and problem behavior, was collected at each measurement wave. Approaches towards 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 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 towards 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 from 1 (never) to 5 (very often). Average scores were calculated for each individual. In ECLS-K, teacher reports of approaches towards 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 towards 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 involved taking the square root of each score. The ECLS-K approaches towards learning scores were also transformed by the square root, but the externalizing scores displayed larger skew and taking the inverse minimized skew.

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).

Analytic Approach

We made use of behavior genetic models that capitalize on the natural experiment 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 (Neale & Cardon, 1992). The E estimate also includes the influence of measurement error which, by definition, is not correlated across twins, and thus, acts to render twins dissimilar. These models allowed for the evaluation of two questions: (1) what is the genetic contribution of the children to their parents' educational expectations for them?, and (2) is there substantial *common* genetic or environmental variation between parental educational expectations, academic behaviors and academic outcomes? First, substantial variation in parental educational expectations due to child genetic factors would indicate that this variable does not entirely act as an environmental, socialization force. Rather, this would imply that parents to some extent form their expectations based on attributes of their children.

Second, bivariate correlated factors models can determine if genetic or environmental influences on educational expectations, academic behaviors and academic outcomes are shared. This model decomposes an observed correlation between two constructs into correlations between latent genetic, shared environmental and nonshared environmental factors. This decomposition allows for questions concerning whether an observed association between educational expectations and achievement is driven by common genetic or environmental influences.

The third phase of the current analysis involved constructing longitudinal cross-lagged path models. Cross-lagged path models are important for establishing temporal orderings, and hence the directionalities, of effects. Cross-lagged models are composed of a number of distinct paths. Autoregressive paths reflect the stability of the same variable across time. Cross-paths lead from a predictor variable at one point in time to a different outcome variable at a later point in time. Significant cross-paths indicate a time-ordered relation between two variables while controlling for stability in each variable. Additionally, within-wave residual correlations between each variable are estimated. Cross-lagged panel models were conducted with one variable from each domain (academic behaviors, academic outcomes, and parental expectations) resulting in four separate path models for each dataset.

All analyses were conducted with M*plus* 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, we residualized of the influence of gender and standardized all variables (McGue & Bouchard, 1984). For analyses using the full ECLS samples, the complex survey option of M*plus* 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 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 .107 to .165) and approaches towards learning (*r*'s range from .155 to .207) and negatively with problem behavior (*r*'s range from -.120 to -.153). Approaches towards learning correlate positively with achievement (*r*'s range from .224 to .306), and problem behavior correlates negatively (*r*'s range from -.154 to -.203). Within domains, approaches towards learning are only moderately related to problem behaviors (*r*'s ranging from -.307 to -.395) indicating that analyzing these influences on development separately may yield unique insights. The association between math and reading achievement was much stronger (*r*'s ranging from .644 to .808). Stability coefficients for each variable are generally high (*r*'s range from .548 to .722). 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. Thus, understanding these small associations and the underlying causal processes may shed light on the further differentiation of academic trajectories across development.

Are parental educational expectations associated with children's genes?

Figure 1 presents the results of a univariate behavior genetic decomposition of each outcome variable at the age 4 and kindergarten waves of 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 three exceptions. The estimate of shared environmental influences on problem behavior at the kindergarten wave was only significant at $p < .05$. The shared environmental estimate for approaches towards learning at the age 4 and kindergarten waves was nonsignificant. Nonsignificant variance components were dropped from later models to facilitate convergence.

Parental educational expectations display significant child genetic influence at both time points. Approximately 10% of variance in educational expectations was related to genotypic differences of the children. This 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 provide strong evidence that parental educational expectations are, in part, influenced by characteristics of the child.

Turning to the specific measured characteristics of the child, 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 highly congruent with previous work examining the developmental behavior genetics of cognition (Haworth et al., 2010; Briley & Tucker-Drob, *in press*). The academic behavior variables, on the other hand, display relatively large genetic influences and small or nonexistent shared environmental effects. Approximately 50% of the variance in academic behaviors could be attributed to genotypic differences, only 10% to shared environmental influences and 40% to nonshared environmental influences and measurement error. This distribution of variance components is highly congruent with previous work examining personality trait development (Bouchard & Loehlin, 2001).

What explains the large shared environmental contributions?

Behavior genetic models can take into account measured variables to determine if this can explain a portion of the latent shared environmental influence (Turkheimer, D'Onofrio, Maes, & Eaves, 2005). Socioeconomic status and race are examples of measured family-level variables that are also associated with educational outcomes (Tucker-Drob, 2012). To evaluate whether socioeconomic status or race could account for the large estimates of the shared environment for expectations and achievement, we incorporated these variables into our behavior genetic model. The ECLS-B dataset includes a socioeconomic composite that includes information concerning parental education, occupation and income. This variable was standardized in reference to the full sample to have a mean of 0 and a standard deviation of 1. Child race was operationalized as a set of dummy-coded variables indicating whether the child was Black, Hispanic, Asian, Pacific Islander or Native American with White serving as the reference category. Figure 2 presents the proportion of total variance in expectations and achievement attributable to latent shared environmental effects and measured socioeconomic and racial differences. 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. Socioeconomic status shows particularly strong associations with the achievement measures. Racial differences, on the other hand, were not strongly associated with the outcomes. In each case, the reduced estimate of the shared environmental influence remained significant at $p < .001$. Variance in educational expectations was still primarily due to the shared environment (roughly 60%). This indicates that some family-level influence is operating beyond the well-documented influence of social class or race.

Do genetic or environmental factors underlie the observed within-time correlations?

Table 2 presents the genetic, shared environmental and nonshared environmental correlation matrix for each variable in the age 4 wave. Correlated genetic or environmental factors point towards shared or overlapping developmental influences. For example, the genetic influences on educational expectations and reading achievement overlap substantially ($r = .7$). Although both constructs reflect relatively small genetic effects, the genetic influences on achievement are largely the same as those on expectations. Similarly, expectations shares a moderate level of genetic overlap with approaches towards learning ($r = .4$). Approaches towards learning were substantially influenced by genetic variation, and some portion of this variation also informs a parent’s level of expectations. Thus, one possible child-driven effect that influences parental educational expectations is the observation of a child’s ability to function in academic situations. Turning to the other variables, the genetic influences on approaches towards learning and achievement are largely shared, and common genetic effects that increase levels of approaches towards learning also decrease problem behaviors. Near perfect genetic overlap was found for math and reading achievement. Similarly, the shared environmental influences on math and reading achievement are nearly perfectly correlated. Significant shared environmental correlations are found between educational expectations and achievement. Again, this significant correlation indicates that there are shared family-level influences that act to increase (or decrease) both expectations and achievement. Problem behavior, which does not share genetic influences with achievement, does display overlapping shared environmental variance with achievement. Nonshared environmental correlations are particularly interesting in that they represent within identical-twin pair differences. For example, the significant nonshared environmental correlation between math and reading indicates that the member of a twin pair who tends to do better on math also tends to do better on reading holding genetic and shared environmental influences constant. Somewhat intuitively, the member of a twin pair who possesses a higher level of approaches towards learning tends to also have less problem behavior and parents who believe they will go farther in school. Counter-intuitively, the member of an identical twin pair that exhibits more problem behavior also tends to elicit higher levels of educational expectations.

Table 3 presents the results for a similar analysis conducted at the kindergarten wave. Interestingly, the significant nonshared environmental correlation between educational expectations and problem behavior is replicated a year later, as well as the correlation with approaches towards learning. Similarly, the influences on math and reading achievement overlapped substantially at the genetic, shared environmental, and to a lesser extent, the nonshared environmental levels. Significant genetic correlations were replicated between approaches towards learning and every other variable. The shared environmental correlations between expectations and achievement were replicated. There were a few points of departure from the previous results, particularly in reference to problem behaviors. Before children entered formal schooling, variance in problem behavior was primarily associated with other variables at the shared environmental level. However, the kindergarten results indicate sizeable genetic overlap between problem behaviors and each outcome, and the environmental correlations have been attenuated to non-significance. This reflects the possibility that the implications of problem behavior change once children transition to the structured kindergarten setting. Potentially, achievement and expectations of educational attainment become tied to this disruptive behavior as it interferes with learning novel material at school. Finally, approach towards learning displays a significant nonshared environmental correlation with math achievement that was not found at age 4. Again, children’s active engagement in learning may come to facilitate achievement in kindergarten in a manner that was not available in unstructured learning environments.

Do genetic or environmental factors underlie across-time correlations?

Table 4 presents the genetic, shared environmental, and nonshared environmental correlation matrices between the age 4 wave and the kindergarten wave. The on-diagonal coefficients indicate the extent to which genetic or environmental influences contribute to stability in the construct. Put differently, these coefficients indicate whether the same genetic or environmental influences are present across time. For example, a family's socioeconomic status does not change a great deal over a period of a year, and thus this environmental circumstance may cause levels of achievement or expectations to be stable across time. On the other hand, it may seem obvious that genetic polymorphisms do not change across time, and thus genetic effects should be stable across time. However, the same variable may be affected by different genes during different periods of development. In the current context, genetic influences were largely stable across time. Educational expectations are the exception to this, and the stability of parental educational expectations is entirely environmental. Shared environmental factors also contribute to the stability of the other variables. Again, nonshared environmental stability coefficients are particularly interesting to interpret as they indicate the degree to which individuals remain high or low on a given outcome controlling for genetic and shared environmental confounds. This type of stability was especially high for educational expectations and was present to a lesser extent for the remaining variables.

The pattern of association between variables across waves is largely consistent with that found within waves. Common genetic influences on educational expectation, child academic behavior, and child cognitive development are found for each association across time. On the other hand, common shared and nonshared environmental influences were somewhat rarer across time. Math and reading achievement possessed significant shared and nonshared environmental correlations. Similarly, educational expectations were associated with achievement due to common shared environmental influences. Finally, the counter-intuitive finding that problem behavior and educational expectations are linked through a nonshared environmental mechanism was replicated across time.

Do transactional processes occur at this very early stage of development?

Our behavioral genetic analyses indicated that an environmental variable, parental educational expectations, was significantly correlated with the genotype of the children, and indicated that parental responses to children's academic behaviors and academic achievement may be the basis for these gene-environment correlations. To further clarify the longitudinal process by which child characteristics become linked with educational expectations, we performed a series of longitudinal cross-lagged path models using data from the entire ECLS-B sample. Because we made use of two indicators each of child academic behaviors and child academic achievement, we fit a total of four trivariate models. Due to space considerations, Figure 3 presents the average results of these models. As math and reading achievement are highly correlated, we averaged across these outcomes in the models. Approaches towards learning and problem behaviors are not highly correlated, and therefore we include average parameters for these separately.[2] In order to reduce clutter in Figure 3, standard errors and significance levels are omitted, but most parameters were significant at $p < .05$ in each model. The pathway from educational expectations to later child academic behaviors is an exception to this, as it was only significant in one model. Similarly, the pathway from achievement to later expectations was not significant in any model. Additionally, early problem behaviors did not predict later math or reading achievement. The remaining pathways were statistically significant. The full parameter estimates including standard errors can be found in the supplemental materials (Table S1). We focus our interpretation on the specific models, of which the average values are very good approximations.

Across each model, there are substantial estimates of stability in the outcomes and residual correlations. The cross-paths are the primary statistic of interest. In every case, academic behaviors predicted later parental educational expectations independent of previous levels of expectations. A child with more positive approaches towards learning before entering school is more likely to have a parent that increases their level of expectations as children transition into school. Conversely, children who display academic problem behaviors before the entry into school are more likely to have parents who reduce their

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[2] This strategy proved to be very effective with little loss of information. The average absolute value of parameter deviations from the mean across collapsed models was only .006 (SD = .009).

expectations during the transition into schooling. As mentioned previously, initial ability for math or reading does not predict later expectations in any model. The behavior genetic decomposition demonstrated that academic behaviors are substantially more heritable than math or reading ability. This represents a likely mechanism by which a child's genetically influenced traits alter aspects of parenting.

Other time-lagged pathways are of note. Problem behavior did not uniquely predict later achievement outcomes, whereas approach towards learning uniquely predicted both later math and reading achievement. Students with more positive learning behaviors tend to make larger gains in achievement. Parental educational expectations predicted later achievement outcomes representing the role that parents play as academic motivators. Parents who expect more achievement from their children tend to make larger gains in math and reading over the period of a year. Initial expectations were also associated with increases in approaches towards learning, but this parameter was only significant in one model. Math and reading achievement at the initial time point predict increases in approaches towards learning, but not for problem behaviors. Taken as a whole, these results demonstrate that transactional processes between parental expectations, child ability and child academic behaviors occur even before entry into school. Although the effect sizes are small, they are all theoretically consistent and may signal the start of a developmental process that has cascading effects throughout the academic careers of the children.

How do these 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 life and environment. This dataset contains information from kindergarten (the final time point of the ECLS-B data), first grade, third grade and fifth grade. Figure 4 presents a similar, averaged trivariate cross-lagged path model beginning in kindergarten and ending in fifth grade.[3] The full parameter estimates, standard errors and significance levels can be found in Tables S2-3. Each model recaptured the data well as

[3] Again, this strategy proved very effective. The average absolute value of parameter deviations from the mean across collapsed models was only .006 (SD = .007).

indicated by generally good model fit statistics (RMSEA = .07-.08, CFI = .95-.97, TLI = .89-.92). The results replicate those found before children entered into the educational system with the exception that greater power has allowed every parameter to be significant at the $p < .05$ level.[4] Across each wave, initial levels of parental educational expectations predict increases in achievement and approaches towards learning and decreases in problem behaviors. Similarly, approach towards learning predicts increases in ability and expectations. Problem behavior, on the other hand, predicts decreases in ability and expectations. Achievement predicts increases in expectations and approaches towards 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 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 towards learning and problem behaviors) and time (preschool to fifth grade).

Because the very high power to detect effects renders *p* values somewhat uninformative, we will focus on comparing the magnitudes of the parameter estimates. Importantly, every parameter estimate is highly precise. For the ECLS-B data, the average standard error of the estimate for all regression parameters was .015 (SD = .002; range = .010 - .018). For the ECLS-K data, the average standard error of the estimate was .010 (SD = .003; range = .004 - .016). Thus, the 95% confidence interval around the average parameter from ECLS-B only spans ± .029 standardized units around a point estimate, and the 95% confidence interval around the average parameter from ECLS-K only spans ± .020 standardized units around a point estimate. The very small standard deviation and range of the standard errors attests to the fact that this average is an excellent estimate for every parameter. Due to the extreme precision of

[4] In fact, nearly every parameter (92.59%) was significant at $p < .001$. Two parameters associated with problem behavior and educational expectations each were significant at $p < .05$. Two parameters associated with expectations were significant at $p < .01$. One parameter each for approaches towards learning and problem behaviors were significant at $p < .01$.

these estimates, we will forgo confidence intervals or error bars and instead evaluate the magnitudes of parameters from the different datasets as exact estimates.

The major trend across time is that the parameter estimates are slightly stronger at later ages and particularly so when comparing with the results of ECLS-B. To quantify this, we can compare the parameter estimates found before children entered formal schooling from the ECLS-B dataset with the average parameter estimate found across each wave in the ECLS-K dataset. Figure 5 displays the result of this analysis for each longitudinal association averaged across wave or model as necessary. With one exception, the magnitude of the effect size was larger in the ECLS-K dataset than the ECLS-B dataset. The exception concerned the pathway from expectations to reading achievement which was slightly larger in ECLS-B ($\beta = .059$) than in ECLS-K ($\beta = .037$). It may be the case that parent's expectations for their children influence the degree to which they read to or teach reading skills to a larger extent before formal schooling than after. However, the absolute difference is rather small. Examining the other trends, it appears that some effect sizes are substantially larger. For example, each pathway from approaches towards learning to ability and expectations nearly doubled. Similarly, paths between child achievement and each other class of variables are substantially greater in ECLS-K. Interestingly, pathways from parental expectations to other outcomes are relatively unchanged. Although parents are still an academic influence, their contribution to the process remains constant as children move through schooling. Children's characteristics tend to become much more of a driver as children age and influence not only their own levels of ability, but also the expectations that their parents have for their future.

Discussion

In line with unidirectional theories of parent-to-child socialization, our results indicate a substantial role for parents as active transmitters of educational beliefs. Parents who believe their children will go farther in school tend to have children who perform better academically both in terms of objective achievement and educationally relevant behaviors such as approaches towards learning and externalizing behaviors. However, we also find that parental educational expectations are themselves influenced by children's genetically influenced characteristics and behaviors. This means that children are also active transmitters of academic beliefs and can evoke changes in parental expectations. Our results established a complex, reciprocal pattern between child academic behaviors, child cognitive development and parental educational expectations. Before entry into formal schooling, child abilities, general tendencies of academic behavior and environmental support are mutually dependent and shape the trajectory of development. These complex developmental mechanisms have been largely neglected in previous research and in the primary theoretical frameworks of child educational achievement. In the sections that follow we discuss the implications of these findings for developmental theory, ongoing scientific inquiry, and applied policy and intervention.

"Heritable" Environments and Gene-Environment Correlation

Influences on child development that have been traditionally labeled as environments appear to be substantially tied to genetic differences between children. In other words, parents are not purely exogenous influences on child development, but in fact alter their child-rearing beliefs and behaviors in response to their children. We found that a significant portion of variance in parental beliefs about the educational future of their children was associated with genotypic differences in their children. Previous research has indicated that cognitive ability influences the type and quality of parental interaction that is received (Lugo-Gil & Tamis-LeMonda, 2008; Tucker-Drob & Harden, 2012). Similarly, we found that parents are sensitive to their children's math and reading achievement and adjust their expectations over time in accordance with this feedback. Examining correlated genetic and environmental influences on expectations, however, our results indicated that achievement outcomes tended to be associated with expectations through environmental mechanisms. The current project identified additional mechanisms beyond cognitive ability by which a child's genetic predispositions may become coupled with parenting. Parental beliefs are formed, in part, based on a child's general tendency for behaviors that facilitate task-focused academic learning and general tendencies for behaviors that may interfere with the academic environment. These genetically influenced child characteristics predicted later parental educational expectations, allowing the genetic predispositions of the child to get "out of the skin." Contrary to the results for achievement, approaches towards learning and educational expectations consistently reflected shared genetic, rather than environmental, influences within and across waves. In fact, our results indicate that general patterns of behavior such as approaches towards learning or problem behavior may be more robust mechanisms of gene-environment correlation with respect to parental expectations in early childhood, as these variables were marked by substantially larger genetic influences than child ability outcomes.

Children and Parents as Drivers of Academic Development

The present 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 and adds substantial theoretical complexity to a number of prominent conceptual models of academic development. It is also important to emphasize that the current results strongly implicate parents as 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 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 work on educational expectations with the developmental mechanisms driving the achievement-expectations association more clearly delineated. An open empirical question, however, is to what extent the shared environmental effects detected reflect patterns of passive gene-environment correlation, in which parents socially transmit an environmental climate to their children that they have also reproductively transmitted their genetic material to their children. Gauging the extent to which parenting practices are heritability on the part of parental genotypes requires a more complex behavioral genetic design than was available from the ECLS-B data, such as a children-of-twins design.

Locating Causal Effects in Development

Identifying truly causal effects on child development is a key issue for education researchers. This type of research is conducted with an eye towards improving the life outcomes of children, and policy levers to enable this change are very costly. Therefore, substantial confidence in the research methodology and theoretical explanation of a potential mechanism are important for informing more applied policy and intervention research. Our results indicate that the dynamic processes between the student and their 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 strong support for the conceptual notion of a "developmental cascade" (e.g., Masten et al., 2005). Very early indicators of a child's achievement and tendencies of behavior influence change in their academic trajectory. Similarly, very early parental influences predict change in the overall academic trajectory. The dynamic, transactional process continues throughout development and actually strengths in magnitude as children age. This may reflect the greater degree of freedom and autonomy that children possess with maturation. Focusing attention towards 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. First, we applied both behavior genetic models and cross-lagged path models to high quality, population representative, longitudinal data of educationally relevant outcomes. The important findings of behavioral 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 behavioral genetic and longitudinal approaches. Second, this study is the first to examine parental educational expectations using a genetically informative sample. Although between-parent differences are certainly reflected in the variance of expectations, parents base their expectations on the characteristics of their children even before entry into formal schooling. Finally, we were able to evaluate a large span of child development by combining the ECLS-B and ECLS-K datasets. We tracked children across the transition into kindergarten through fifth grade. In our longitudinal models, we tested a total of 96 potential transactional pathways and every pathway was in the hypothesized direction (although some were not statistically significant in ECLS-B). Cross-lagged path models provide several important features that strengthen the claims that can be drawn. Due to the fact that we control for previous levels of the constructs of interest, we are able to say that initial levels of child behavior, child achievement and parental expectations predict later outcomes holding constant initial levels of the outcome. One possibility that we are inclined to believe is that these small effects are largely causal in nature. Another possibility that we are unable to entirely rule out is that each of these associations is driven by some other variable that was not included in our model. Taking that caveat into consideration, the mechanism displayed in the current results appears to be highly generalizable across constructs and developmental periods and was entirely consistent with theoretical predictions.

One may wonder whether the effects uncovered in the present study are too small to have a substantial impact on child development. For example, genes only accounted for roughly 10% of the variance in parental educational expectations, and cross lagged paths had standardized coefficients that averaged .032. However, these effects may have more practical importance than might be expected at face. For example, Rosenthal and Rubin (1982) demonstrated that a correlation of .32, often looked down upon as accounting for only 10% of the variance, would reduce illness rates from 66% to 34% when applied to psychotherapy. Similarly, Schmidt and Hunter (1998) have demonstrated that relatively small increases in the incremental validity of hiring practices can have dramatic impacts on a company’s bottom-line when many personnel are hired. Returning to the findings at hand, the large majority of individuals pass through the education system, and thus, even very small benefits are likely to pay large dividends. Further, our transactional model implies that multiple causes function to determine levels of ability, academic behaviors and parental expectations. Ahadi and Diener (1989) demonstrated that under such a circumstance the upper bound of a correlation between separate constructs may be as low as .30. When multiple influences constrain variation in a given outcome, the possibility of any one influence appearing as a large predictor is non-existent. Education is certainly a multi-determined outcome. With these statistical considerations in mind, the effect sizes found in this study do not appear to be particularly small. Even if they were small, the promise of a transactional model is that reciprocal feedback loops can be constructed to facilitate compounding benefits with development. In this sense, the identified pattern has real implications for the health and well-being of children.

Some final methodological limitations and an unexpected finding are of note. Our assessment of child academic behavior in ECLS-B was based on parent report, but in ECLS-K, teachers rated the students. It is possible that the difference in informants of child academic behaviors could account for the larger in magnitude parameter estimates in ECLS-K compared to ECLS-B rather than maturation or greater autonomy in the learning environment. Even if this is the case, our primary finding of a fully interactive transactional model stands. As mentioned previously, our behavioral genetic decomposition of variance in parental educational expectations was unable to account for genotypic differences among parents that might influence expectations. Therefore, our attribution of the large amount of latent shared environmental variance not due to socioeconomic status or race to parenting processes may need to be modified if it is determined that parental genetic influences shape expectations. Finally, we replicated a positive nonshared environmental correlation between educational expectations and problem behaviors within and across two time points. Theoretically, one would anticipate that these outcomes would be negatively correlated (as they are at the observed level). It may be the case that this type of behavior is interpreted by parents as indicative of more drive or determination. Alternatively, the effect may be driven by those at the low end of the problem behavior distribution. Parents might perceive these children as lacking motivation to engage at school. As the correlation is rather small in magnitude, it is difficult to put much confidence in any interpretation even though the effect appears to be robust across time.

Conclusion

The present study 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. Unquestionably, our results indicate that parental expectations are important for the academic development of their children, but parents cannot be viewed as purely exogenous actors. We have introduced a fully transactional model between child academic behaviors, child academic development and parental educational expectations that shapes the educational trajectories of children. Even before entry into formal schooling, children are active participants in their educational environment. With development, these effects become even stronger as children gain increasing autonomy over their learning environment.

References

Ahadi, S., & Diener, E. (1989). Multiple determinants and effect size. *Journal of Personality and Social Psychology, 56,* 398-406.

Alexander, K. L., Entwisle, D. R., & Bedinger, S. D. (1994). When expectations work: Race and socioeconomic differences in school performance. *Social Psychology Quarterly, 57,* 283-299.

Andrew, M. & Hauser, R. M. (2011). Adoption? Adaptation? Evaluating the formation of educational expectations. *Social Forces, 90,* 497-520.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Beal, S. J. & Crockett, L. J. (2010). Adolescents' occupational and educational aspirations and expectations: Links to high school activities and adult educational attainment. *Developmental Psychology, 46,* 258-265.

Bell, R. Q. (1968). A reinterpretation of the direction of effects in studies of socialization. *Psychological Review, 75,* 81-95.

Blau, P. M., & Duncan, O. D. (1967). *The American occupational structure*. New York: John Wiley and Sons.

Bleeker, M. M. & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later? *Journal of Educational Psychology, 96*, 97-109.

Bouchard, T. J., Jr., & Loehlin, J. C. (2001). Genes, evolution, and personality. *Behavior Genetics, 31,* 243-273.

Briley, D. A., & Tucker-Drob, E. M. (*in press*). Explaining the increasing heritability of cognition over development: A meta-analysis of longitudinal twin and adoption studies. *Psychological Science.*

Crosnoe, R. & Johnson, M. K. (2011). Research on adolescence in the twenty-first century. *Annual Review of Sociology, 37,* 439-460.

Day, J. C. & Newburger, E. C. (2002). *The big payoff: Educational attainment and synthetic estimates of work-life earnings* (Current Population Report P23-210). Washington, D.C.: U.S. Census Bureau.

Duncan, O. D., Featherman, D. L., & Duncan, B. (1972). *Socioeconomic background and achievement.* New York: Seminar Press.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53,* 109-132.

Forget-Dubois, N., Pérusse, D., Turecki, G., Girard, A., Billette, J., Rouleau, G., …Tremblay, R. E. (2003). Diagnosing zygosity in infant twins: Physical similarity, genotyping, and chorionicity. *Twin Research, 6,* 479-485.

Fredricks, J. A. & Eccles, J. S. (2002). Children’s competence and value beliefs from childhood through adolescence: Growth trajectories in two male-sex-typed domains. *Developmental Psychology, 38,* 519-533.

Frome, P. M. & Eccles, J. S. (1998). Parents’ influence on children’s achievement-related perceptions. *Journal of Personality and Social Psychology, 74,* 435-452.

Gonzalez-Pienda, J. A., Nunez, J. C., Gonzalez-Pumariega, S., Alvarez, L., Roces, C., & Garcia, M. (2002). A structural equation model of parental involvement, motivational and aptitudinal characteristics, and academic achievement. *The Journal of Experimental Education, 70,* 257-287.

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science, 23,* 899-906.

Haworth, C. M. A., Wright, M. J., Luciano, M., Martin, N. G., de Geus, E. J. C., van Beijsterveldt, C. E. M. … & Plomin, R. (2010). The heritability of general cognitive ability increases linearly from childhood to young adulthood. *Molecular Psychiatry, 15,* 1112-1120.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312,* 1900-1902.

Jacob, B. A. & Linkow, T. W. (2011). Educational expectations and attainment. In G. J. Duncan, & R. J. Murnane (Eds.), *Wither opportunity?* (pp. 133-162). New York: Russell Sage Foundation.

Jacobs, J. E., & Eccles, J. S. (1992). The impact of mothers' gender-role stereotypic beliefs on mothers' and children's ability perceptions. *Journal of Personality and Social Psychology, 63,* 932-944.

Jacobs, J. E. & Eccles, J. S. (2000). Parents, task values, and real-life achievement-related choices. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic motivation* (pp. 405-439). San Diego, CA: Academic Press.

Kendler, K. S., & Baker, J. S. (2007). Genetic influences on the environment: A systematic review. *Psychological Medicine, 37,* 615-626.

Marsh, H. W. & O'Mara, A. (2008). Reciprocal effects between academic self-concept, self-esteem, achievement, and attainment over seven adolescent years: Unidimensional and multidimensional perspectives of self-concept. *Personality and Social Psychology Bulletin, 34,* 542-552.

Marsh, H. W. & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *British Journal of Educational Psychology, 81,* 59-77.

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interests, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76,* 397-416.

Masten, A. S., Roisman, G. I., Long, J. D., Burt, K. B., Obradovic, J., Riley, J. R., Boelcke-Stennes, K., & Tellegen, A. (2005). Developmental cascades: Linking achievement and externalizing and internalizing symptoms over 20 years. *Developmental Psychology, 41,* 733-746.

McGue, M., & Bouchard, T. J., Jr. (1984). Adjustment of twin data for the effects of age and sex. *Behavior Genetics, 14,* 325-343.

Montez, J. K., Hummer, R. A., Hayward, M. D., Woo, H., & Rogers, R. G. (2011). Trends in the educational gradient of U.S. adult mortality from 1986 through 2006 by race, gender, and age group. *Research on Aging, 33,* 145-171.

Muthén, L. K., & Muthén, B. O. (1998-2010). *Mplus user's guide* (6th ed.). Los Angeles, CA: Muthén and Muthén.

Nagengast, G., Marsh, H. W., Scalas, L. F., Xu, M. K., Hau, K., & Trautwein, U. (2011). Who took the "×" out of expectancy-value theory? A psychological mystery, a substantive-methodological synergy, and a cross-national generalization. *Psychological Science*, *22,* 1058-1066.

Neale, R. C., & Cardon, L. R. (1992). *Methodology for genetic studies of twins and families*. Dordrecht, The Netherlands: Kluwer.

Neuenschwander, M. P., Vida, M., Garrett, J. L., & Eccles, J. S. (2007). Parents' expectations and students' achievement in two western nations. *International Journal of Behavioral Development, 31,* 594-602.

Ou, S. & Reynolds, A. J. (2008). Predictors of educational attainment in the Chicago Longitudinal Study. *School Psychology Quarterly*, *23,* 199-229.

Plomin, R., DeFries, J. C., & Loehlin, J. C. (1977). Genotype – environment interaction and correlation in the analysis of human behavior. *Psychological Bulletin*, *88,* 245-258.

Rosenthal, R., & Rubin, D. B. (1982). A simple, general purpose display of magnitude of experimental effect. *Journal of Educational Psychology*, *74*, 166-169.

Sameroff, A. (2009). *The transactional model of development: How children and contexts shape each other.* Washington, DC: American Psychological Association.

Schmidt, F. L., & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin, 124,* 262-274.

Schneider, B., Keesler, V., & Morlock, L. (2010). The effects of family on children's learning and socialization. In H. Dumont, D. Istance, & F. Benavides (Eds.), *The nature of learning: Using research to inspire practice* (pp. 251-284). Paris: OECD.

Schneider, B., & Stevenson, D. (1999). *The ambitious generation: America's teenagers, motivated but directionless.* New Haven, CT: Yale University Press.

Sewell, W. H. & Hauser, R. M. (1972). Causes and consequences of higher education: Models of the status attainment process. *American Journal of Agricultural Economics*, *54,* 851-861.

Sewell, W. H. & Hauser, R. M. (1980). The Wisconsin Longitudinal Study of social and psychological factors in aspirations and achievements. *Research in Sociology of Education and Socialization, 1,* 59-99.

Sewell, W. H. & Shah, V. P. (1967). Socioeconomic status, intelligence, and the attainment of higher education. *Sociology of Education, 40,* 1-23.

Simpkins, S. D., Fredricks, J. A., & Eccles, J. S. (2012). Charting the Eccles' expectancy-value model from mothers' beliefs in childhood to youths' activities in adolescence. *Developmental Psychology*, *48,* 1019-1032.

Snow, K., Derecho, A., Wheeless, S., Lennon, J., Rosen, J., Rogers, J., . . . Einaudi, P. (2009). *Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), kindergarten 2006 and 2007 data file user's manual (2010-010)*. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences.

Strenze, T. (2007). Intelligence and socioeconomic success: A meta-analytic review of longitudinal research. *Intelligence*, *35,* 401-426.

Tourangeau, K., Nord, C., Lê, T., Sorongon, A. G., and Najarian, M. (2009). *Early Childhood Longitudinal Study, Kindergarten Class of 1998–99 (ECLS-K), Combined User's Manual for the ECLS-K Eighth-Grade and K–8 Full Sample Data Files and Electronic Codebooks (NCES 2009–004)*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Trautwein, U., Marsh, H. W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy – value theory: A latent interaction modeling study. *Journal of Educational Psychology*, *104*, 463-777.

Tucker-Drob, E. M. (2012). Presechools reduce early academic-achievement gaps: A longitudinal twin approach. *Psychological Science, 23,* 310-319.

Tucker-Drob, E. M. & Harden, K. P. (2012a). Early cognitive development and parental cognitive stimulation: Evidence for reciprocal gene – environment transactions. *Developmental Science, 15*, 250-259.

Tucker-Drob, E. M., & Harden, K. P. (2012b). Learning motivation mediates gene-by-socioeconomic status interaction on early mathematics achievement. *Learning and Individual Differences, 22,* 250-259.

Tucker-Drob, E. M., & Harden, K. P. (2013). Gene-by-preschool interaction on the development of early externalizing problems. *Journal of Child Psychology and Psychiatry, 54,* 77-85.

Tucker-Drob, E. M., Rhemtulla, M., Harden, K. P., Turkheimer, E., & Fask, D. (2011). Emergence of a gene × socioeconomic status interaction on infant mental ability between 10 months and 2 years. *Psychological Science, 22,* 125-133.

Turkheimer, E. (2000). Three laws of behavior genetics and what they mean. *Current Directions in Psychological Science, 9,* 160-164.

Turkheimer, E., D'Onofrio, B. M., Maes, H. H., & Eaves, L. J. (2005). Analysis and interpretation of twin studies including measures of the shared environment. *Child Development, 76,* 1217-1233.

Tynkkynen, L., Tolvanen, A., & Salmela-Aro, K. (2012). Trajectories of educational expectations from adolescence to young adulthood in Finland. *Developmental Psychology, 48,* 1674-1685.

Wang, M.-T. (2012). Educational and career interests in math: A longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Developmental Psychology, 48*, 1643-1657.

Zhang, Y., Haddad, E., Torres, B., & Chen, C. (2011). The reciprocal relationships among parents' expectations, adolescents' expectations, and adolescents' achievement: A two-wave longitudinal analysis of the NELS data. *Journal of Youth and Adolescence, 40,* 479-489.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*, 663-676.

Figure Captions

Figure 1. Graphical representation of results from the univariate ACE decomposition for each outcome taken from ECLS-B. Bars represent proportion of variance in the outcome attributable to additive genetic effects, shared environmental effects and nonshared environmental effects.

Figure 2. Graphical representation of results from attempts to explain latent C influences with measured family-level environmental variables.

Figure 3. Averaged **c**ross-lagged path model using ECLS-B data and the variables of approaches towards learning, problem behaviors, math ability, reading ability and educational expectations. Academic behavior represents approaches towards learning and problem behaviors. Academic achievement represents math and reading ability. Pathways leading to or from academic behaviors are broken down between approaches towards learning (parameter listed first) and problem behaviors (parameter listed second). All pathways are significant in at least one model except the pathway from academic achievement to educational expectations.

Figure 4. Averaged cross-lagged path model using ECLS-K data and the variables of approaches towards learning, problem behaviors, math ability, reading ability and educational expectations. Academic behavior represents approaches towards learning and problem behaviors. Academic achievement represents math and reading ability. Pathways leading to or from academic behaviors are broken down between approaches towards learning (parameter listed first) and problem behaviors (parameter listed second). All pathways are significant at $p < .05$.

Figure 5. Average parameter estimates from ECLS-B and ECLS-K averaged across wave or model as necessary. Note that the absolute value of pathways from problem behavior to other outcomes has been taken for ease of presentation. In every case, the association between problem behaviors and ability and expectations was negative.

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Table 1. Correlation matrix of all study variables from ECLS-B

Variable and Wave	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Educational Expectations 4	1									
2. Educational Expectations K	.591	1								
3. Learning 4	.207	.164	1							
4. Learning K	.155	.200	.548	1						
5. Problem Behavior 4	-.137	-.122	-.395	-.310	1					
6. Problem Behavior K	-.120	-.153	-.307	-.371	.638	1				
7. Math Achievement 4	.165	.128	.276	.278	-.203	-.163	1			
8. Math Achievement K	.150	.153	.246	.306	-.175	-.159	.722	1		
9. Reading Achievement 4	.150	.107	.276	.259	-.199	-.157	.761	.644	1	
10. Reading Achievement K	.163	.153	.224	.269	-.163	-.154	.660	.808	.662	1

Note. All correlations significant at $p < .05$. Variables labeled with 4 refer to the age 4 wave, and variables marked with K refer to the kindergarten wave.

Table 2. Within age 4 wave genetic, shared environmental, and nonshared environmental correlation matrices

Genetic	Educational Exp. 4	Learning 4	Problem 4	Math 4	Reading 4
Educational Exp. 4	1				
Learning 4	.426 (.089) ***	1			
Problem 4	-.259 (.143)	-.412 (.077) ***	1		
Math 4	.085 (.185)	.829 (.144) ***	-.046 (.204)	1	
Reading 4	.703 (.337) *	1.223 (.311) ***	.081 (.292)	.870 (.230) ***	1

Shared	Educational Exp. 4	Learning 4	Problem 4	Math 4	Reading 4
Educational Exp. 4	1				
Learning 4	-	1			
Problem 4	-.183 (.112)	-	1		
Math 4	.252 (.058) ***	-	-.391 (.144) **	1	
Reading 4	.150 (.057) **	-	-.390 (.139) **	.905 (.038) ***	1

Nonshared	Educational Exp. 4	Learning 4	Problem 4	Math 4	Reading 4
Educational Exp. 4	1				
Learning 4	.164 (.069) *	1			
Problem 4	.185 (.071) **	-.359 (.054) ***	1		
Math 4	.208 (.111)	.044 (.072)	-.153 (.079)	1	
Reading 4	-.113 (.116)	-.049 (.070)	-.138 (.079)	.151 (.075) *	1

Note. Standard error of the estimate is placed inside parentheses. Variables marked with 4 refer to the age 4 wave.
* $p < .05$; ** $p < .01$; $p < .001$

Table 3. Within kindergarten wave genetic, shared environmental, and nonshared environmental correlation matrices

Genetic	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp. K	1				
Learning K	.412 (.145) **	1			
Problem K	-1.002 (.369) **	-.599 (.082) ***	1		
Math K	.488 (.273)	.638 (.094) ***	-.418 (.150) **	1	
Reading K	.245 (.227)	.746 (.096) ***	-.530 (.136) ***	.934 (.090) ***	1

Shared	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp. K	1				
Learning K	-	1			
Problem K	.071 (.161)	-	1		
Math K	.193 (.063) **	-	-.302 (.207)	1	
Reading K	.220 (.063) ***	-	-.124 (.194)	.933 (.031) ***	1

Nonshared	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp. K	1				
Learning K	.251 (.073) **	1			
Problem K	.296 (.074) ***	-.120 (.071)	1		
Math K	.092 (.117)	.271 (.074) ***	.041 (.089)	1	
Reading K	.107 (.116)	.012 (079)	.132 (.087)	.216 (.077) **	1

Note. Standard error of the estimate is placed inside parentheses. Variables marked with K refer to kindergarten wave. * $p < .05$; ** $p < .01$; $p < .001$

Table 4. Cross-wave genetic, shared environmental, and nonshared environmental correlation matrices

Genetic	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp. 4	-.343 (.285)				
Learning 4	.452 (.108) ***	.794 (.049) ***			
Problem 4	-.371 (.148) *	-.391 (.079) ***	.746 (.109) ***		
Math 4	.450 (.179) *	.778 (.110) ***	-.397 (.180) *	.604 (.124) ***	
Reading 4	.399 (.157) *	.730 (.100) ***	-.356 (.148) *	.610 (.122) ***	.542 (.177) **

Shared	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp.4	.723 (.032) ***				
Learning 4	-	-			
Problem 4	-.246 (.178)	-	.664 (.280) *		
Math 4	.202 (.066) **	-	-.170 (.149)	.891 (.037) ***	
Reading 4	.193 (.066) **	-	-.098 (.149)	.829 (.048) ***	.862 (.044) ***

Nonshared	Educational Exp. K	Learning K	Problem K	Math K	Reading K
Educational Exp. 4	.668 (.045) ***				
Learning 4	.086 (.083)	.302 (.063) ***			
Problem 4	.322 (.078) ***	-.125 (.075)	.423 (.064) ***		
Math 4	-.158 (.137)	.084 (.079)	.001 (.085)	.397 (.069) ***	
Reading 4	-.240 (.133)	-.085 (.080)	-.060 (.084)	.205 (.077) ***	.232 (.078) **

Note. Standard error of the estimate is placed inside parentheses. Variables marked with 4 refer to age 4 wave, and variables marked with K refer to kindergarten wave. * $p < .05$; ** $p < .01$; $p < .001$

Figure 1

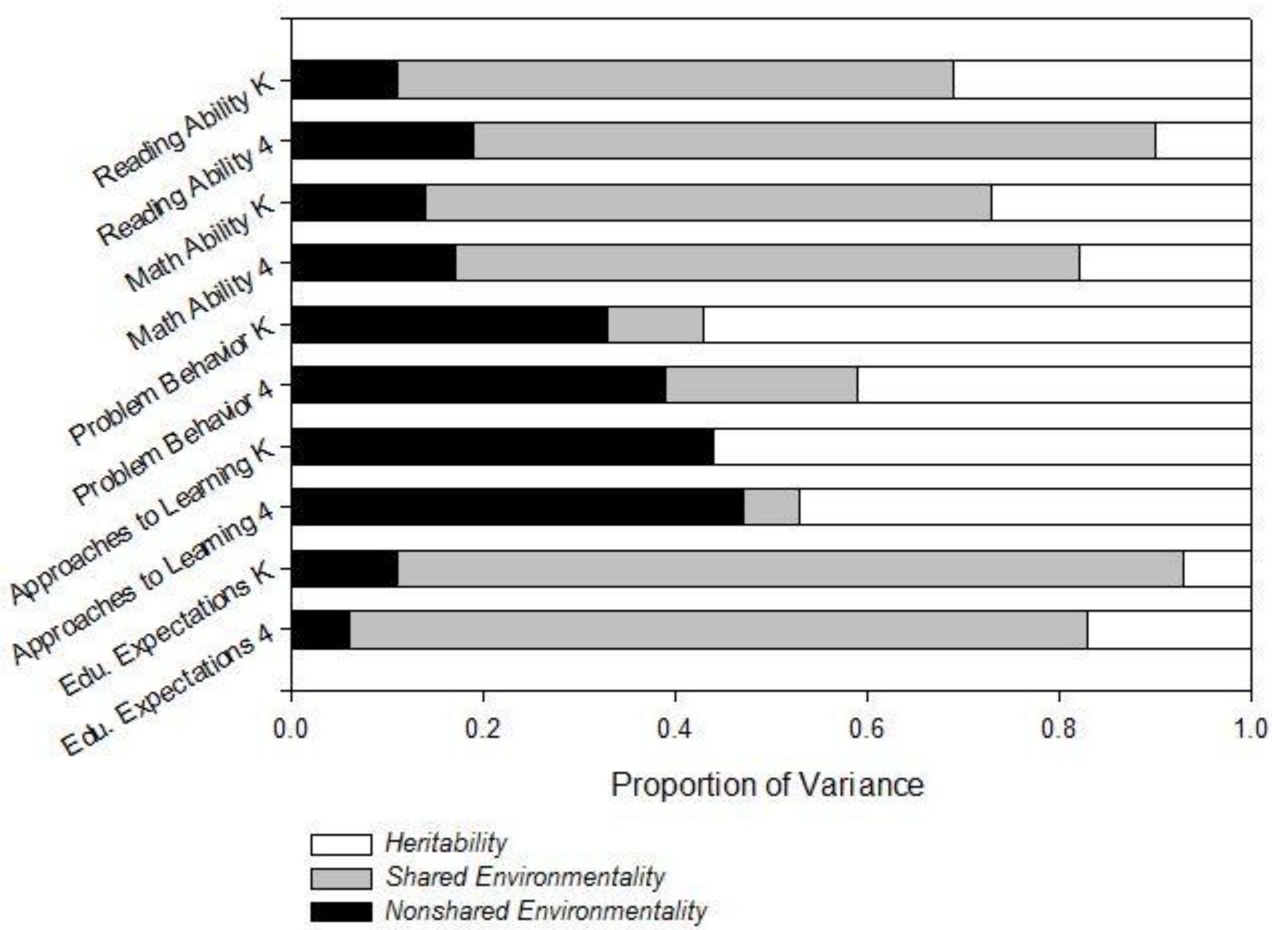

Reading Ability K
Reading Ability 4
Math Ability K
Math Ability 4
Problem Behavior K
Problem Behavior 4
Approaches to Learning K
Approaches to Learning 4
Edu. Expectations K
Edu. Expectations 4
0.0
0.2
0.4
0.6
0.8
1.0
Proportion of Variance
Heritability
Shared Environmentality
Nonshared Environmentality

Figure 2

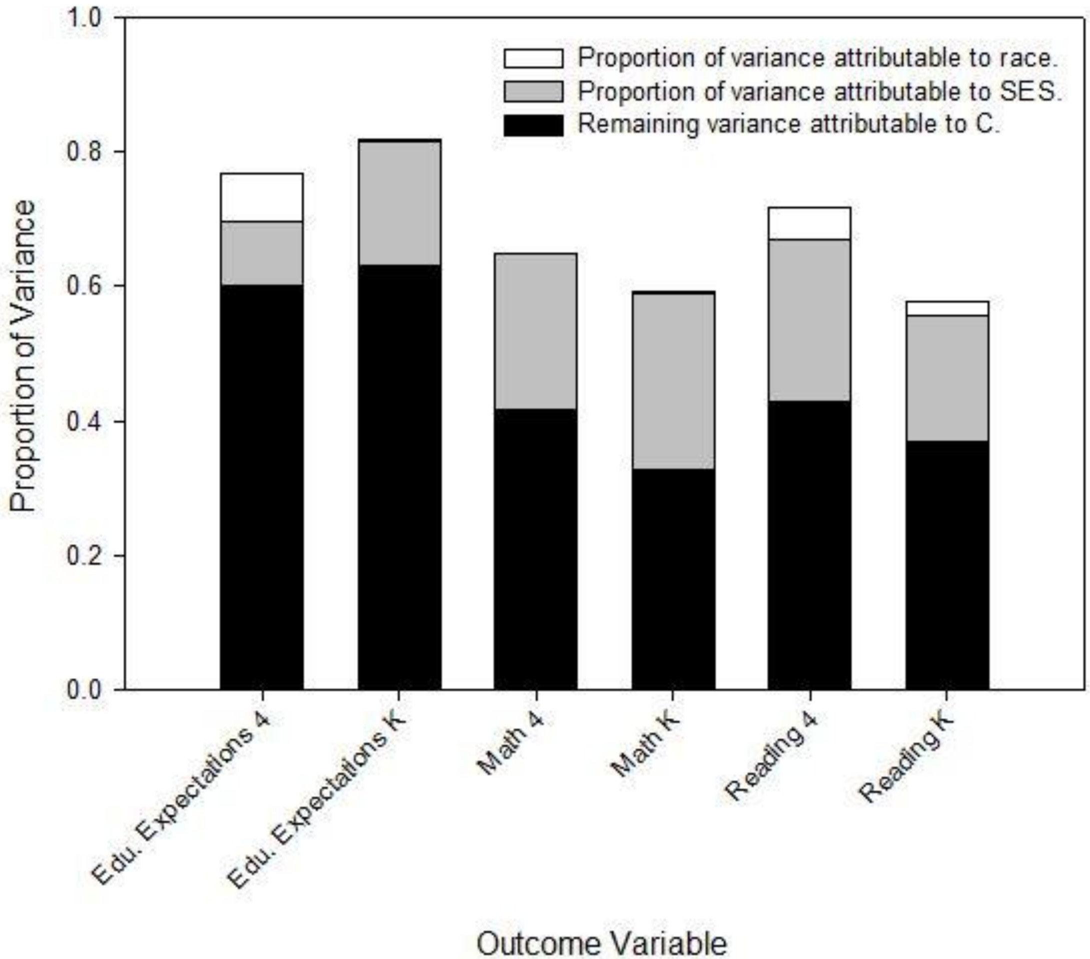

Proportion of variance attributable to race.
Proportion of variance attributable to SES.
Remaining variance attributable to C.
1.0
0.8
0.6
0.4
0.2
0.0
Proportion of Variance
Edu. Expectations 4
Edu. Expectations K
Math 4
Math K
Reading 4
Reading K
Outcome Variable

Figure 3

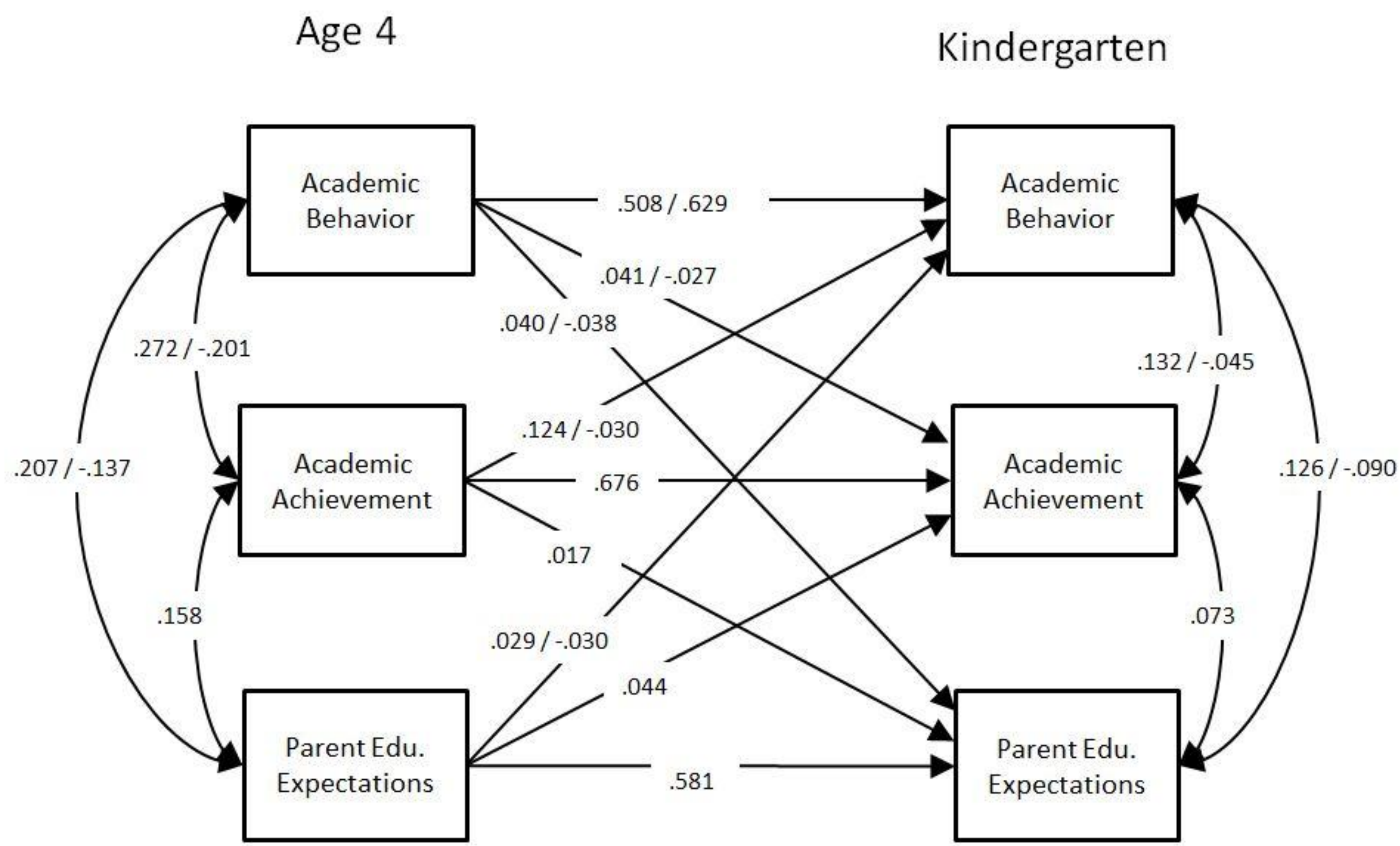

Age 4
Kindergarten
Academic Behavior
Academic Achievement
Parent Edu. Expectations
Academic Behavior
Academic Achievement
Parent Edu. Expectations
.508 / .629
.041 / -.027
.040 / -.038
.272 / -.201
.124 / -.030
.207 / -.137
.676
.017
.158
.029 / -.030
.044
.581
.132 / -.045
.126 / -.090
.073

Figure 4

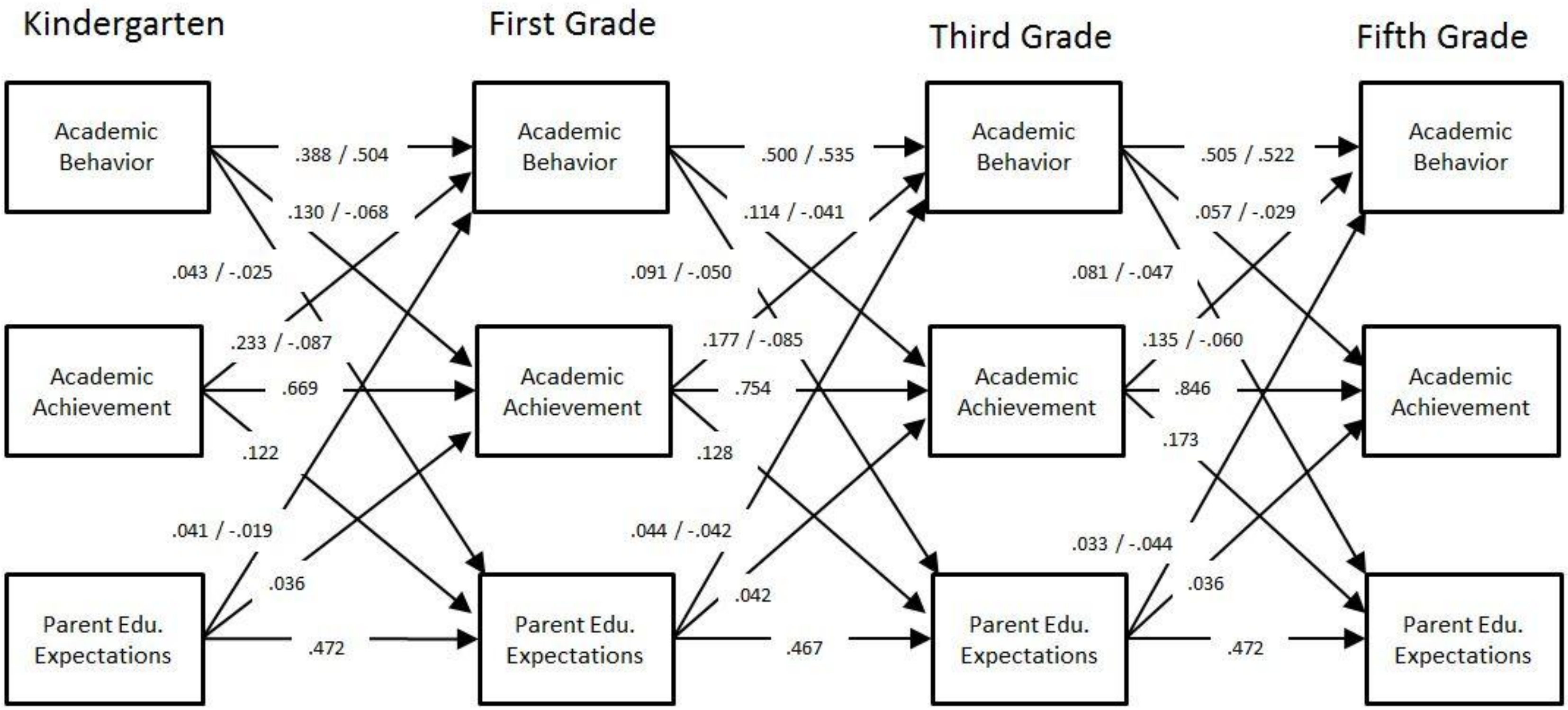
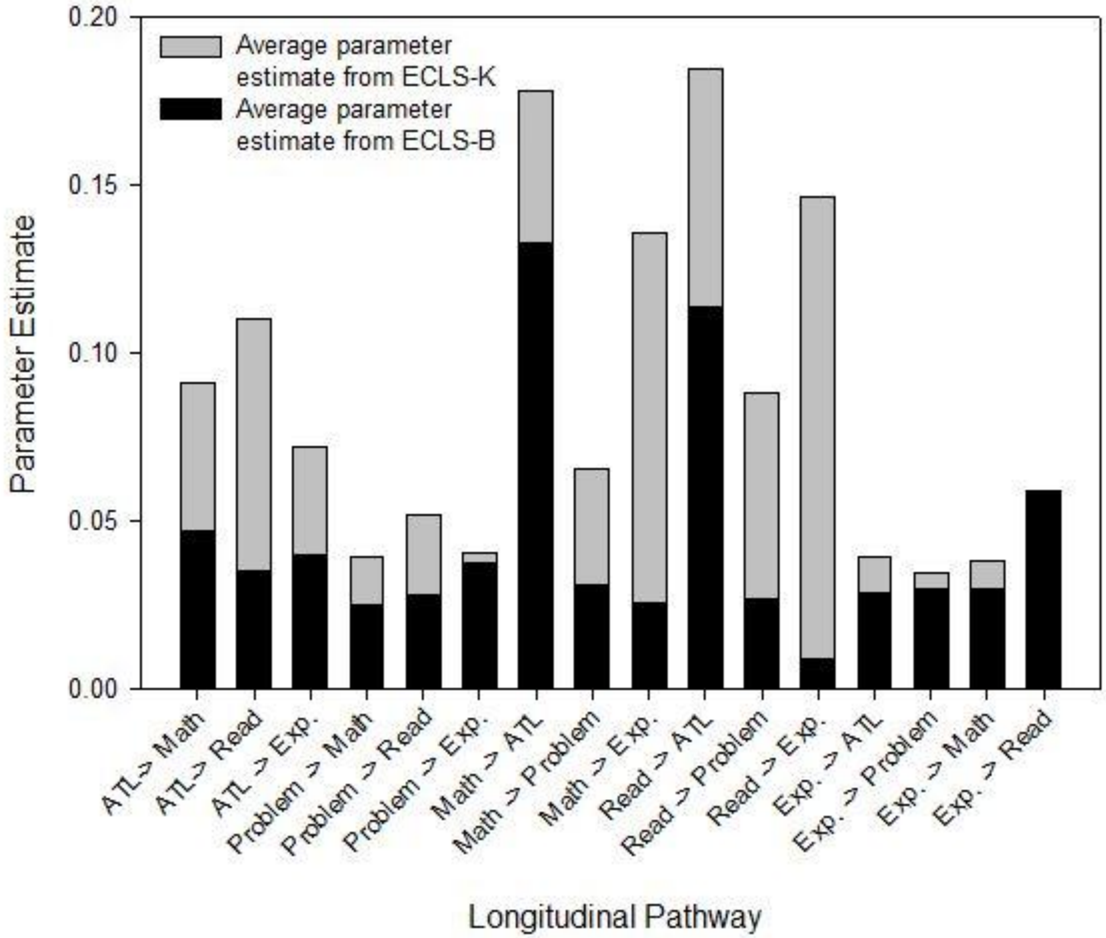

Kindergarten
First Grade
Third Grade
Fifth Grade
Academic Behavior
Academic Achievement
Parent Edu. Expectations
Academic Behavior
Academic Achievement
Parent Edu. Expectations
Academic Behavior
Academic Achievement
Parent Edu. Expectations
Academic Behavior
Academic Achievement
Parent Edu. Expectations
.388 / .504
.130 / -.068
.043 / -.025
.233 / -.087
.669
.122
.041 / -.019
.036
.472
.500 / .535
.114 / -.041
.091 / -.050
.177 / -.085
.754
.128
.044 / -.042
.042
.467
.505 / .522
.057 / -.029
.081 / -.047
.135 / -.060
.846
.173
.033 / -.044
.036
.472

Figure 5


0.20
0.15
0.10
0.05
0.00
Parameter Estimate
Average parameter estimate from ECLS-K
Average parameter estimate from ECLS-B
ATL-> Math
ATL-> Read
ATL -> Exp.
Problem -> Math
Problem -> Read
Problem -> Exp.
Math -> ATL
Math -> Problem
Math -> Exp.
Read -> ATL
Read -> Problem
Read -> Exp.
Exp. -> ATL
Exp. -> Problem
Exp. -> Math
Exp. -> Read
Longitudinal Pathway

Supplemental Material

Table S1. Full standardized parameter estimates of four separate cross-lagged path models from ECLS-B

Model 1 – Approaches Towards Learning, Math Achievement and Expectations			
	Kindergarten Variable		
Age 4 Variable	Math	ATL	Expectations
Auto-Regressive	.706 (.012) ***	.505 (.012) ***	.579 (.018) ***
Cross-Paths			
Math →		.133 (.017) ***	.024 (.016)
ATL →	.047 (.014) **		.038 (.016) *
Expectations →	.025 (.013)	.029 (.014) *	
(Residual) Correlations			
Math		.275 (.019) ***	.165 (.022) ***
ATL	.144 (.017) ***		.207 (.022) ***
Expectations	.073 (.021) **	.125 (.020) ***	
Model 2 – Problem Behavior, Math Achievement and Expectations			
	Kindergarten Variable		
Age 4 Variable	Math	Problem	Expectations
Auto-Regressive	.713 (.011) ***	.628 (.011) ***	.581 (.018) ***
Cross-Paths			
Math →		-.031 (.016)	.027 (.016)
Problem →	-.025 (.013)		-.036 (.018) *
Expectations →	.030 (.013) *	-.029 (.016)	
(Residual) Correlations			
Math		-.204 (.017) ***	.165 (.022) ***
Problem	-.040 (.016) *		-.137 (.023) ***
Expectations	.073 (.021) ***	-.089 (.020) ***	
Model 3 – Approaches Towards Learning, Reading Achievement and Expectations			
	Kindergarten Variable		
Age 4 Variable	Reading	ATL	Expectations
Auto-Regressive	.641 (.012) ***	.510 (.013) ***	.581 (.018) ***
Cross-Paths			
Reading →		.114 (.015) ***	.007 (.017)
ATL →	.035 (.015) *		.042 (.017) *
Expectations →	.058 (.018) **	.032 (.014) *	
(Residual Correlations)			

Reading		.276 (.019) ***	.153 (.022) ***
ATL	.120 (.017) ***		.207 (.022) ***
Expectations	.073 (.024) **	.127 (.020) ***	

Model 4 – Problem Behavior, Reading Achievement and Expectations			
		Kindergarten Variable	
Age 4 Variable	Reading	Problem	Expectations
Auto-Regressive	.645 (.012) ***	.629 (.010) ***	.584 (.018) ***
Cross-Paths			
Reading →		-.027 (.015)	.011 (.016)
Problem →	-.028 (.015)		-.039 (.015) **
Expectations →	.060 (.018) **	-.030 (.016)	
(Residual) Correlations			
Reading		-.196 (.018) ***	.154 (.022) ***
Problem	-.049 (.019) *		-.137 (.023) ***
Expectations	.072 (.024) **	-.090 (.020) ***	

Note. All parameter estimates are standardized with standard errors in parentheses. Correlations listed above the diagonal represent associations at the initial time point, and correlations below the diagonal represent residual correlations at the second time point. ATL refers to approaches towards learning.
* $p < .05$; ** $p < .01$; *** $p < .001$

Table S2. Full standardized parameter estimates of four separate cross-lagged path models from ECLS-K

Model 1 – Approaches Towards Learning, Math Achievement and Expectations			
		Next Wave	
Previous Wave	Math	ATL	Expectations
Autoregressive			
Kindergarten	.678 (.007) ***	.379 (.009) ***	.475 (.013) ***
First Grade	.751 (.007) ***	.506 (.011) ***	.466 (.014) ***
Third Grade	.849 (.004) ***	.513 (.011) ***	.471 (.016) ***
Cross-lagged Paths			
Kindergarten			
Math →		.245 (.011) ***	.102 (.014) ***
ATL →	.110 (.008) ***		.046 (.013) ***
Expectations →	.032 (.008) ***	.044 (.010) ***	
First Grade			
Math →		.168 (.011) ***	.112 (.014) ***
ATL →	.109 (.009) ***		.094 (.011) ***
Expectations →	.043 (.007) ***	.047 (.009) ***	
Third Grade			
Math →		.121 (.012) ***	.158 (.013) ***
ATL →	.053 (.006) ***		.084 (.012) ***
Expectations →	.033 (.007) ***	.036 (.011) **	

Model 2 – Problem Behavior, Math Achievement and Expectations			
		Next Wave	
Previous Wave	Math	Problem	Expectations
Autoregressive			
Kindergarten	.719 (.006) ***	.504 (.008) ***	.476 (.013) ***
First Grade	.791 (.005) ***	.538 (.008) ***	.472 (.013) ***
Wave 5	.864 (.004) ***	.526 (.009) ***	.476 (.016) ***
Cross-lagged Paths			
Kindergarten			
Math →		-.082 (.009) ***	.119 (.012) ***
Problem →	-.056 (.007) ***		-.026 (.012) *
Expectations →	.035 (.008) ***	-.021 (.008) *	
First Grade			
Math →		-.071 (.011) ***	.142 (.013) ***
Problem →	-.030 (.008) ***		-.051 (.012) ***
Expectations →	.051 (.007) ***	-.045 (.010) ***	
Third Grade			
Math →		-.044 (.012) ***	.182 (.012) ***
Problem →	-.032 (.006) ***		-.050 (.013) ***

Expectations →	.036 (.006) ***	-.048 (.011) ***	

Model 3 – Approaches Towards Learning, Reading Achievement and Expectations

	Next Wave		
Previous Wave	Reading	ATL	Expectations
Autoregressive			
Kindergarten	.614 (.008) ***	.396 (.010) ***	.467 (.013) ***
First Grade	.714 (.008) ***	.493 (.010) ***	.462 (.013) ***
Third Grade	.825 (.007) ***	.497 (.011) ***	.468 (.016) ***
Cross-lagged Paths			
Kindergarten			
Reading →		.220 (.012) ***	.127 (.014) ***
ATL →	.149 (.010) ***		.040 (.013) **
Expectations →	.037 (.008) ***	.038 (.010) ***	
First Grade			
Reading →		.185 (.010) ***	.118 (.016) ***
ATL →	.119 (.008) ***		.088 (.011) ***
Expectations →	.033 (.009) ***	.040 (.009) ***	
Third Grade			
Reading →		.149 (.013) ***	.165 (.015) ***
ATL →	.061 (.007) ***		.077 (.013) ***
Expectations →	.035 (.008) ***	.030 (.011) **	

Model 4 – Problem Behavior, Reading Achievement and Expectations

	Next Wave		
Previous Wave	Reading	Problem	Expectations
Autoregressive			
Kindergarten	.665 (.007) ***	.503 (.008) ***	.468 (.013) ***
First Grade	.759 (.006) ***	.532 (.009) ***	.466 (.013) ***
Third Grade	.846 (.006) ***	.518 (.009) ***	.472 (.016) ***
Cross-lagged Paths			
Kindergarten			
Reading →		-.091 (.009) ***	.140 (.012) ***
Problem →	-.079 (.008) ***		-.024 (.011) *
Expectations →	.040 (.008) ***	-.017 (.008) *	
First Grade			
Reading →		-.098 (.011) ***	.149 (.015) ***
Problem →	-.051 (.008) ***		-.048 (.012) ***
Expectations →	.039 (.008) ***	-.038 (.010) ***	
Third Grade			
Reading →		-.076 (.011) ***	.188 (.015) ***
Problem →	-.025 (.007) ***		-.044 (.014) ***
Expectations →	.039 (.009) ***	-.039 (.009) ***	

Note. All parameter estimates are standardized with standard errors in parentheses. ATL refers to approaches towards learning.
* $p < .05$; ** $p < .01$; *** $p < .001$

Table S3. Full standardized (residual) correlations from four separate cross-lagged path models from ECLS-K

Model 1 – Approaches Towards Learning, Math Achievement and Expectations			
Kindergarten	Math	ATL	Expectations
Math	1		
ATL	.445 (.010) ***	1	
Expectations	.136 (.019) ***	.100 (.011) ***	1
First Grade			
Math	1		
ATL	.168 (.011) ***	1	
Expectations	.068 (.011) ***	.065 (.011) ***	1
Third Grade			
Math	1		
ATL	.125 (.013) ***	1	
Expectations	.073 (.013) ***	.061 (.012) ***	1
Fifth Grade			
Math	1		
ATL	.106 (.011) ***	1	
Expectations	.061 (.012) ***	.078 (.013) ***	1
Model 2 – Problem Behavior, Math Achievement and Expectations			
Kindergarten	Math	Problem	Expectations
Math	1		
Problem	-.144 (.014) ***	1	
Expectations	.136 (.019) ***	-.049 (.010) ***	1
First Grade			
Math	1		
Problem	-.065 (.010) ***	1	
Expectations	.071 (.011) ***	-.026 (.012) *	1
Third Grade			
Math	1		
Problem	-.082 (.012) ***	1	
Expectations	.085 (.013) ***	-.041 (.012) **	1
Fifth Grade			
Math	1		
Problem	-.066 (.013) ***	1	
Expectations	.065 (.012) ***	-.029 (.011) *	1
Model 3 – Approaches Towards Learning, Reading Achievement and Expectations			

Kindergarten	Reading	ATL	Expectations
Reading	1		
ATL	.416 (.009) ***	1	
Expectations	.167 (.019) ***	.100 (.011) ***	1
First Grade			
Reading	1		
ATL	.249 (.014) ***	1	
Expectations	.088 (.012) ***	.061 (.011) ***	1
Third Grade			
Reading	1		
ATL	.156 (.011) ***	1	
Expectations	.090 (.015) ***	.058 (.012) ***	1
Fifth Grade			
Reading	1		
ATL	.106 (.011) ***	1	
Expectations	.049 (.011) ***	.073 (.013) ***	1

Model 4 – Problem Behavior, Reading Achievement and Expectations

Kindergarten	Reading	Problem	Expectations
Reading	1		
Problem	-.137 (.015) ***	1	
Expectations	.167 (.019) ***	-.048 (.010) ***	1
First Grade			
Reading	1		
Problem	-.077 (.012) ***	1	
Expectations	.091 (.013) ***	-.023 (.012) *	1
Third Grade			
Reading	1		
Problem	-.069 (.012) ***	1	
Expectations	.099 (.015) ***	-.036 (.012) **	1
Fifth Grade			
Reading	1		
Problem	-.070 (.011) ***	1	
Expectations	.055 (.011) ***	-.022 (.011) *	1

Note. Standard errors in parentheses. ATL refers to approaches towards learning.
* $p < .05$; ** $p < .01$; *** $p < .001$