



The role of the shared environment in college attainment: An adoption study

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Abstract

Objective: College attainment is one of the few phenotypes to have substantial variance accounted for by environmental factors shared by reared-together relatives. The shared environment is implicated by the consistently strong parent-to-offspring transmission of college attainment. The mechanisms underlying this relationship remain unclear. We use genetically informative methods with a longitudinal, adoption sample to identify possible environmental mechanisms underlying parent-offspring college transmission.

Method: Data were drawn from the Sibling Interaction and Behavior Study (SIBS), which includes 409 adoptive and 208 nonadoptive families, consisting of two offspring followed from adolescence into young adulthood and their rearing parents. Four domains of environmental mechanisms were examined: (a) skill enhancement; (b) academic support; (c) material advantage; and (d) supportive family environment.

Results: Both shared environmental and genetic factors contributed to the parent-offspring transmission of college attainment. However, highly educated parents did not appear to be increasing their *adopted* offspring's attainment through skill development. The environmental factors that were associated with increased odds of offspring college attainment were mother's academic expectations and family income.

Conclusion: While complete mediation of the parent-offspring transmission of college attainment was not identified, the results shed light on some of the mechanisms associated with the common environment variance in the college attainment phenotype.

KEYWORDS

adoption, college attainment, intergeneration transmission, shared environment

1 | INTRODUCTION

A college degree is widely considered a gateway to the middle class, occupational success, and financial security (McGue et al., 2017) and so has been encouraged through government programs (Hout, 2012). Nonetheless, the U.S. is far short of achieving the goal, advanced by the Obama administration, that by 2020 the U.S. would have the highest

proportion of college graduates in the world (United States & Obama, 2009). To help individuals and society reach their educational goals, we need to understand the factors that contribute to individual differences in college attainment.

Behavioral genetics offers a powerful set of methodologies for characterizing the factors underlying individual differences in complex behavioral phenotypes such as college attainment. The consistent observation that college attainment

is transmitted from parent to offspring (Hertz et al., 2008) makes behavioral genetic methodology especially relevant, as such methods can be used to pinpoint the contributing genetic and environmental factors. Nonetheless, college attainment is not like most other phenotypes studied using behavioral genetic methods. Turkheimer (2000) argued that a wealth of behavioral genetic research can be summarized in terms of three general laws: (a) genetic factors matter; (b) the shared family environment is largely inconsequential; and (c) the nonshared environment is the major nongenetic contributor. Consistent with the first law, a meta-analysis of relevant twin studies found that an estimated 40% of the variance in educational attainment was attributable to additive genetic effects (Branigan et al., 2013). Yet the same meta-analysis provided evidence counter to the second law that an estimated 36% of the variance in educational attainment was attributed to the shared environment (i.e., environmental effects that contribute to the similarity of reared-together offspring). The exceptional nature of educational attainment led Freese and Jao (2017) to argue that characterizing the nature of its substantial shared environmental effect is a puzzle in search of a solution.

An adoption study is particularly well suited for exploring environmental contributions to the similarity among relatives. In nonadoptive families offspring are biologically related to each other and their parents and it is difficult to tease apart whether their similarity is due to genetics, the shared environment, or an interaction between the two (Cheesman et al., 2020). Alternatively, in the absence of selective placement, any resemblance among adoptive relatives must owe to their shared environment, as there would be no genetic relationship between these individuals. Consistent with the finding of shared environmental effects in twin studies, adoption studies have reported significant parent-offspring resemblance for college attainment in adoptive families (McGue et al., 2017; Sacerdote, 2007). The aim of the current study is to use the adoption study design to try to identify environmental mechanisms underlying this parent-offspring transmission.

We consider four, not necessarily independent, environmentally mediated mechanisms by which college-educated parents might facilitate the college attainment of their children. First, highly educated parents may provide a rearing environment that fosters the development of the cognitive or noncognitive skills needed for academic success. Second, parents might provide direct support of their children's academic efforts (e.g., helping with homework, which could facilitate academic success without building underlying abilities). Third, highly educated parents are likely to have greater economic resources than parents who are less well educated, and the resulting material advantages might allow them to create opportunities that promote the academic success of their children. Finally, highly educated parents might be more

likely to provide a stable and supportive family environment than parents who are less well educated.

1.1 | Parent skill enhancement

General cognitive ability (GCA) is one of the strongest predictors of college attainment (Marioni et al., 2014; McGue et al., 2017). Research has also consistently found heritable effects on GCA (e.g., using twin samples; van Leeuwen et al., 2008; as well as adoptive and nonadoptive parent-offspring correlations; Petrill & Deater-Deckard, 2004), suggesting that the association between GCA and college attainment may be genetically mediated. Nonetheless, in an investigation of the intergenerational transmission of educational attainment, Kendler et al. (2015) reported that both biological and adopted offspring of parents with high levels of education had higher GCA than their peers whose parents had low educational attainment. Providing a rearing environment that promotes the development of GCA might be one mechanism by which parents influence the college attainment of their children.

GCA is not the only skill related to academic success. Noncognitive abilities (sometimes referred to as “soft skills”) encompass individual differences in a range of phenotypes such as personality traits, goals, motivations, and preferences (Heckman & Kautz, 2012) that have been related to college attainment (e.g., Borghans et al., 2008; Kuncel et al., 2010). For instance, the personality trait Conscientiousness has a consistent association with academic performance (Poropat, 2009). Other noncognitive factors related to educational achievement include academic study skills, habits, and attitudes (Credé & Kuncel, 2008). The extent to which parents provide a rearing environment that fosters the development of academic soft skills has seldom been investigated, with only weak evidence of a parental effect (Willoughby et al., 2019).

1.2 | Parent academic support

Direct parent support of their children's academic efforts has generally been shown to be positively associated with offspring academic achievement (Wilder, 2014). However, parental academic support can take various forms, which are associated with different effect sizes on offspring academic achievement. For instance, while parental expectations of offspring academic achievement suggest a moderately positive relationship, the benefits (or lack thereof) of homework assistance are mixed (Castro, et al., 2015; Wilder, 2014). Jacob and Linkow (2011) found that parents appear to be more effective at shaping their offspring's academic expectations than schools are and that these expectations for achieving

educational attainment are a positive correlate of later educational attainment. Stable academic expectations through high school also appear to be more predictive of four-year degree attainment than expectations during senior year alone (Johnson & Reynolds, 2013).

1.3 | Family material advantage

Family income frequently appears in the literature as a possible mechanism affecting college attainment. Doren and Grodsky (2016) argued that parents with economic resources not only contribute financially to their children's academic efforts but also likely have skills that support their children's academic development. Similarly, Willoughby et al. (2019) used aggregate genetic scores predictive of educational attainment to demonstrate that parents make more than a genetic contribution to their offspring's educational outcomes and that socioeconomic status may be one of the relevant environmental factors.

Looking at how finances might influence academic outcomes, Kaushal et al. (2011) noted that more highly educated parents spend more on enrichment experiences (such as recreation, noncollege tuition, and child care) than less-educated parents. However, the authors were careful to note causality was far from established, and that the actual impact of these investments on the offspring is unclear. Taking advantage of a natural experiment due to the opening of a casino, Akee et al. (2018) found that Native American children from families that had received an unconditional cash transfer had improved well-being, increased Conscientiousness, and decreased behavioral problems, outcomes that may contribute to later educational success. Cessarini et al. (2016), in contrast, found that the children of Swedish lottery winners did not show improvements relative to nonwinners on the rate of drug consumption, scholastic performance, or cognitive skills. Black and Devereux (2011) concluded that findings from research on the benefits of family income for child education are mixed and it is difficult to draw general conclusions.

Family income may also affect educational outcomes indirectly through the families of the neighborhood they live in and the schools their children attend (Freese & Jao, 2017). Certainly, regional and urban/rural differences in educational attainment have been identified (e.g., Byun et al., 2012; Ryan & Siebens, 2012). A large-scale U.S. study supported the impact of neighborhood influences on offspring education by examining the outcomes of families who moved to better neighborhoods (Chetty & Hendren, 2018). Although the impact of school differences on academic achievement has been debated for more than 50 years—sparked in part by the controversial results of the Coleman report that suggested school quality did not play a substantial role in the academic

achievement differences between students—on balance, the evidence is consistent with a modest school effect.

1.4 | Supportive family environment

Longitudinal data suggest that both family stability (measured by both parents' presence in the home through the offspring's adolescent years) and family cohesion (described as the love and care directed toward the offspring) are conducive to offspring educational attainment (Emonds & van Tubergen, 2015). Martin et al. (2015) found that a variety of family-related factors (e.g., effective child management, family conflict) were associated with educational attainment. Johnson et al. (2006) developed a family risk composite by summing a variety of individual-level risk factors (e.g., low offspring birth weight and parent substance abuse) and family-level risk factors (e.g., single-parent household), and found higher family risk composite scores were negatively associated with offspring secondary and high school grades.

1.5 | Summary of the current study

We used an adoption study to identify factors that mediate parent-offspring environmental transmission of college attainment. Four types of candidate mediating factors were considered: (a) skill enhancement; (b) academic support; (c) material advantage; and (d) supportive family environment. Although each of these factors has been implicated in earlier research, this research has typically not controlled for genetic mediation such that causal mechanisms remain unclear. By using a sample of adoptive and nonadoptive families, we controlled for genetic factors that confound parent-offspring similarity to determine whether these mediating processes were due to nongenetic transmission.

2 | METHODS

2.1 | Participants

The current sample consisted of participants in the Sibling Interaction and Behavior Study (SIBS), a longitudinal study of 409 adoptive and 208 nonadoptive families. Adoptive families consisted of two genetically unrelated offspring and their rearing parents. Nonadoptive families consisted of two full biological siblings and their parents. For 124 of the 409 adoptive families, one of the offspring was the biological offspring of the parents but not genetically related to the family's other participating offspring; in the remaining 285 families, both offspring were adopted. Families had been systematically ascertained either from adoption records from

	Nonadoptive family	Adoptive family	Mixed family	
	Nonadoptive offspring	Adoptive offspring	Adopted offspring	Nonadoptive offspring
Sample ^a				
Offspring	375	529	109	112
Parents	394	549	232	
Demographics				
Offspring female %	52.3	58.8	46.8	62.5
Offspring college %	62.4	55.8	58.7	72.3
Parent college %	44.4	63.6	59.5	
Age intake <i>M</i> (<i>SD</i>)	15.1 (1.8)	14.9 (2.1)	15.5 (1.1)	14.2 (2.2)
Age FU1 <i>M</i> (<i>SD</i>)	18.4 (1.9)	18.2 (2.3)	19.0 (1.4)	17.7 (2.3)
Age FU2 <i>M</i> (<i>SD</i>)	22.5 (1.7)	22.3 (2.0)	23.0 (1.2)	21.5 (2.1)
Skill enhancement				
GCA <i>M</i> (<i>SD</i>)	.04 (.87)	-.03 (.99)	-.02 (1.13)	.23 (1.11)
Noncognitive <i>M</i> (<i>SD</i>)	.06 (.98)	-.02 (1.03)	-.20 (.89)	.23 (.98)
Academic support				
Expectations <i>M</i> (<i>SD</i>)	.06 (1.02)	-.05 (.99)	-.01 (.98)	.10 (.99)
Help <i>M</i> (<i>SD</i>)	-.08 (1.07)	.05 (.97)	-.04 (1.02)	.00 (.95)
Material advantage				
Family income <i>M</i> (<i>SD</i>)	-.06 (1.01)	.05 (.98)	-.01 (1.01)	-.01 (1.00)
School <i>M</i> (<i>SD</i>)	.03 (.98)	-.02 (1.00)	-.07 (.98)	.22 (.93)
Neighborhood <i>M</i> (<i>SD</i>)	-.14 (1.08)	.07 (.91)	.05 (1.05)	.07 (1.04)
Supportive family environment				
Parent involvement <i>M</i> (<i>SD</i>)	.06 (.98)	-.04 (1.03)	-.11 (.88)	.22 (.94)
Parent disinhibition <i>M</i> (<i>SD</i>)	.23 (1.21)	-.18 (.79)	-.02 (.99)	-.05 (.98)
Structure <i>M</i> (<i>SD</i>)	.01 (.87)	-.01 (1.15)	-.07 (.92)	.00 (.83)

Note: Offspring college attainment = Completed a four-year degree or in college at follow-up 2. All potential mediators have been standardized to a mean of zero and a standard deviation of one to facilitate ease of comparison between mediators.

Abbreviations: GCA, general cognitive ability; FU1, follow-up 1; FU2, follow-up 2.

^aSample size does not account for missing data. Lower bound *N* is 437, 245, 86, 88 by offspring type respectively—see Table S1 for missing data by each variable.

three large adoption agencies in Minnesota or, for nonadoptive families, from Minnesota state birth records. Adoptions were closed (i.e., birth-parent identity was not revealed to the adoptive family). Additional details concerning the recruitment of the SIBS sample can be found in McGue et al. (2007). Inclusion criteria at the intake assessment included living within driving distance of our labs at the University of Minnesota and having no physical, intellectual or behavioral disabilities that would preclude the completion of in-person assessments.

SIBS participants completed up to three assessments. At the intake assessment, a total of 613 (99% of the target sample of 617) mothers and 551 (89%) fathers were assessed. Among 1,234 assessed offspring in the 617 families, two (in two different adoptive families) were judged to be ineligible after they had completed their intake assessment (one because the participant was found to be biologically related to the participating sibling and the other because the participant's IQ test performance suggested a mild intellectual disability, a study exclusion criterion). SIBS offspring

TABLE 1 Descriptive statistics for demographics and standardized predictor variables by family type and adoption status

were recruited for two follow-up assessments, on average approximately 3.5 and 7 years after their intake assessment. A total of 1,158 (94%) and 1,129 (92%; of the original and eligible sample) offspring completed the first and second follow-up assessments, respectively. Note that only 1,125 individuals were included in the current study because of an additional inclusion criterion regarding college attainment, specified below.

Offspring data used in the present study come from their intake and follow-up assessments. Our sample consisted of the 638 adopted and 487 nonadopted individuals in 590 families (393 adoptive and 197 nonadoptive) who provided valid college outcome data at the third assessment. These individuals had a mean age of 14.9 years ($SD = 1.9$, range = 11–21) at intake and 22.4 years ($SD = 1.9$, range = 19–28) at the third assessment. See Table 1 for demographics of offspring by family type.

Only those rearing parents for whom we had college outcome data, either through self-report or spouse-report, were included in the sample ($N = 1,175$); five fathers from adoptive families did not have a college outcome reported. At intake, the 549 parents from 277 adoptive families in this study had a mean age of 48.9 years ($SD = 3.7$), the 394 parents from 197 nonadoptive families had a mean age of 45.0 years ($SD = 4.7$), and the 232 parents from 116 mixed adopted/nonadopted families had a mean age of 47.6 ($SD = 3.7$). Parent college attainment varied by family type, with 63.6% of the adoptive family parents, 44.4% of nonadoptive family parents, and 59.9% of mixed family parents having completed a 4-year college degree.

2.2 | Measures

2.2.1 | College status

While offspring had a mean age of approximately 22 years, the youngest was 19 years at the time of the third assessment, and thus many were not old enough to have completed a four-year college degree. Offspring college attainment was defined in the following way: Offspring were considered to have achieved college if they had completed a four-year degree *or* they were in college at their last assessment. Offspring were designated as not having achieved college if they were not attending college and without a degree. Parent college status was coded as the number of parents in each family having completed a college degree.

Ten potential mediators of parent college effects were clustered in four domains: **skill enhancement** (parents fostered the development of the skills offspring needed to succeed academically), **academic support** (parents set high academic standards and provided help in completing academic assignments), **material advantages** (parents had resources they could use to pay for experiences that increased

the likelihood their children would succeed academically), **supportive family environment** (parents provided a stable, nonchaotic, and supportive rearing environment).

2.2.2 | Mediators of parent college effects

2.2.1 | Skill enhancement

Skill enhancement, which involves parents fostering the development of skills offspring need to succeed academically, was assessed through offspring attributes previously shown to be related to academic success and included a measure of general cognitive ability (GCA) and noncognitive skills composite (McGue et al., 2017).

GCA was assessed via an abbreviated form of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) for offspring aged 16 years and older and the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974) for those 15 years and younger at intake. For both the WAIS-R and the WISC-R, the abbreviated form consisted of two performance (block design and picture arrangement) and two verbal (vocabulary and information) subtests. Previous research has shown a composite of these four subtests correlates at .90 with full-scale IQ when based on all Wechsler subtests (Kaufman, 1990).

Noncognitive skills of offspring were assessed with the composite of six personality and behavioral scales shown previously to be predictive of college attainment (McGue et al., 2017). The three personality scales used were the Alienation, Aggression, and Control scales from the Multidimensional Personality Questionnaire (MPQ; Tellegen & Waller, 2008). The three behavioral scales included an 8-item mother-rated Academic Effort scale (e.g., “Turns in homework on time”), a three-item mother-rated Academic Problems scale (e.g., “Easily distracted in class”) and an Externalizing Symptoms scale. The latter consisted of the number of symptoms of attention deficit/hyperactivity disorder, conduct disorder, and oppositional defiant disorder as assessed by the clinical interview of the mothers and their offspring. A noncognitive composite was formed by summing the six individual tests (with Alienation, Aggression, Academic Problems, and Externalizing Symptoms being reverse-coded) after each had been standardized. We have previously shown that each of the noncognitive scales was associated with college attainment in three separate samples (standardized OR from 1.3 to 3; McGue et al., 2017). Correlations among the individual scales for this sample are provided in the supplement.

2.2.2 | Academic support

Academic support, in which parents hold high academic standards and provide help in completing academic assignments, included two variables.

Mother Academic Expectation was assessed at intake by the single item “How far do you expect your child to go in school?”, which mothers rated on a 6-point scale ranging from “1 = Not completing high school” to “6 = College plus a professional degree.” The Mother Academic Expectation variable was adjusted by regressing out offspring academic skills (i.e., GCA and the noncognitive composite—see supplement) and results reported here are all based on the regression residuals.

Academic Help was a 4-item scale completed by the mother at the second assessment and included items covering parental involvement (e.g., “I keep close track of how this child is doing in school”). Scale and descriptives are provided in the supplement.

2.2.3 | Material advantage

Material advantages included mother reports of family income and neighborhood and offspring report of school environment obtained at the second assessment.

Family Income was measured as household gross annual income reported at the intake assessment on a scale that ranged from 1 = “Less than \$10,000” to 15 = “More than \$100,000.” The neighborhood and school assessments were adapted from the scales developed by Ennett and colleagues (Ennett, 2002; Ennett et al., 1997).

Neighborhood was the sum of the four individual neighborhood scales after each had been standardized. The four neighborhood scales were a 7-item Cohesion scale (e.g., “Most of the people there know each other”); a 6-item Intervention scale (e.g., “How likely are your neighbors to step in when they see teens damaging property”), a 6-item Crime scale (e.g., “People are afraid to come into my neighborhood”), and a 3-item Involvement scale (e.g., “How often have you socialized with your neighbors at your home or theirs?”).

School was a composite formed by summing the two offspring-rated school scales after each had been standardized. The two school scales were School Support, which consisted of nine items (e.g., “Students treat each other with respect,” and “Teachers are really interested in the students”), and School Substance Use, which consisted of eight items (e.g., “It is easy to get some marijuana from some kids at school”; reversed).

2.2.4 | Supportive family environment

The supportive family environment cluster included measures of parental involvement, degree of household structure, and parent disinhibitory psychopathology.

Household Structure was reported by the father at intake using the 5-item Structure scale (e.g., “I make it clear what I want my child to do or not to do”) from the Parent Environment Questionnaire (PEQ; Elkins et al., 1997).

Parent Involvement was assessed using the 12-item Involvement scale from the PEQ (e.g., “My child talks about

their concerns and experiences with me”) as reported separately by mothers and fathers. A composite parental involvement score was computed by taking the mid-parent average after eliminating the mother-father mean difference. In cases where only one parent reported involvement, that score was used in place of a mid-parent average.

Parental Disinhibition was a composite of father and mother self-reported symptoms of adult antisocial behavior, alcohol abuse, and substance abuse obtained by clinical interview.

Table 1 provides descriptive statistics of each variable for adopted and nonadopted offspring by family type. Of the variables, only family income and family structure had notable missing data (23.9% and 19.3% missing across all participants, respectively). See supplement for percentage missing across variables by family type and breakdown of the variables by gender.

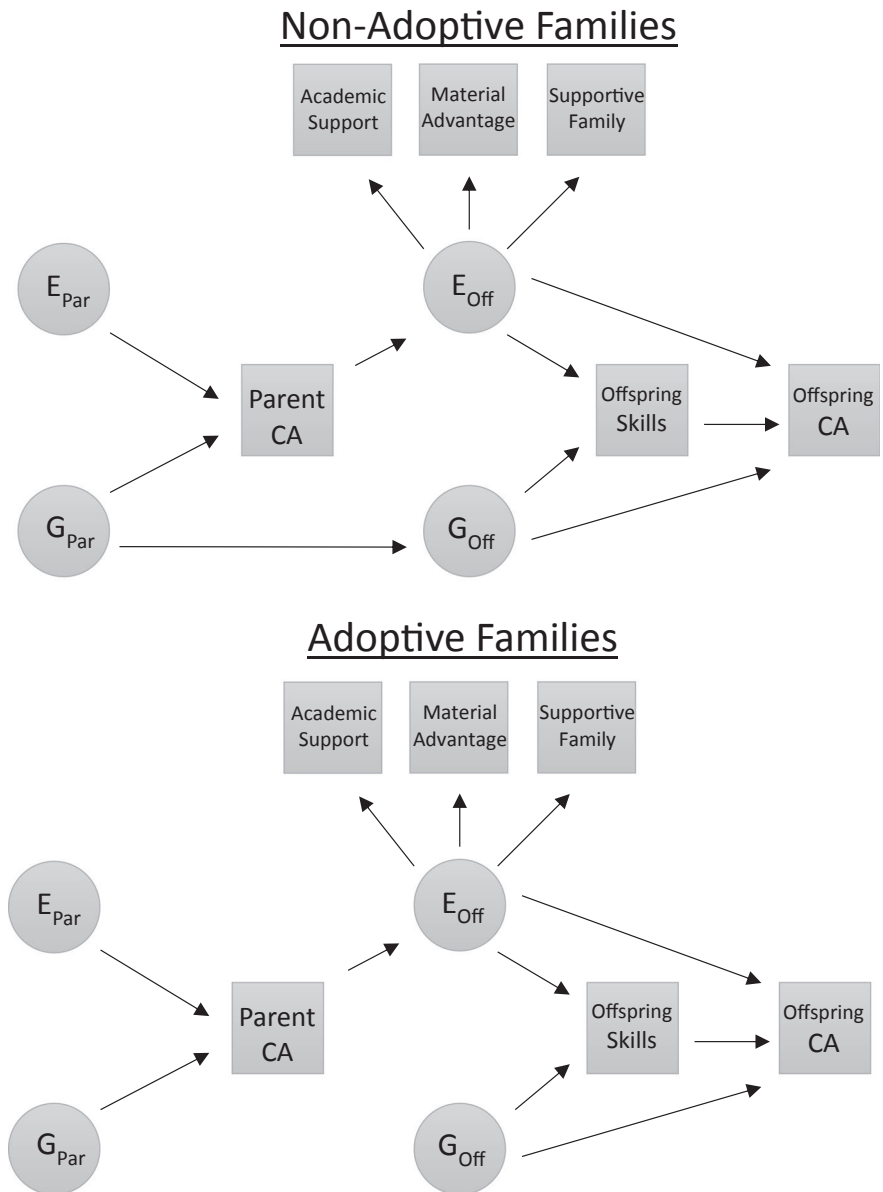
2.3 | Statistical analysis

The conceptual model that guided our analyses is given in Figure 1. Parent-offspring transmission of college attainment is assumed to be mediated both genetically and environmentally in nonadoptive families but only environmentally in adoptive families. Parental environmental contributions to offspring college attainment are modeled in two ways. First, parents can provide an environment that facilitates academic skill development in their offspring. Second, parents can provide academic support, material advantages, and a supportive family environment whose influences on educational outcomes can be both direct, through the creation of academic opportunities, and indirect, through academic skill development.

To establish environmental mediation, three findings are required in our analysis of adoptive and nonadoptive families. First, offspring college attainment must be associated with parent degree attainment. Second, the potential mediator must be associated with offspring college attainment. Third, parental education must be associated with specific potential mediator. Further, when these conditions were met, a main effect within the adoptive families sample was taken as indicating support for environmental mediation, whereas an interaction between family type and parent college education reflecting a stronger parent college effect for nonadoptive than adoptive offspring was taken as evidence of genetic mediation.

To establish the first criterion, offspring college attainment was regressed onto parent degree attainment in R using the *glmer* function, a linear mixed model function for binary outcomes. To establish the second criterion, offspring college attainment was regressed onto each of the potential mediators individually via the *glmer* function. To establish

FIGURE 1 Conceptual model of the parent-offspring transmission of college attainment in adoptive and non-adoptive families. G = genotype, E = Environment, CA = college attainment, Par = Rearing Parents, Off = Offspring



the third criterion, each candidate's environmental mediating factor was regressed onto parent college degree attainment using *lmer*, a general mixed model function for continuous outcomes. We further determined whether the effect existed within the sample of adoptive families (a nonzero effect evidenced environmental mediation), and whether the magnitude of the effect was greater in nonadoptive than adoptive families (evidence for genetic mediation) via an interaction between family type. Percentage of mediation was then assessed with relevant variables in the *lavaan* package. All potential mediators were standardized in the overall sample to facilitate the interpretation of the results. Each regression model included age and sex of offspring as covariates. Familial clustering was accounted for via a random intercept for each family (i.e., a unique intercept for each sibling of a sibling pair).

We also examined the joint effect of candidate mediating factors to test for the full mediation of the parent-offspring transmission of college attainment, and the impact of missing data. We regressed offspring college attainment on parent college degree attainment and the possible candidate mediating factors via *glmer*. Missing data for the independent variables were imputed using a fully conditional specification as implemented in the *mice* function. One hundred imputations were run. Three model types were run: An uncorrected model (offspring college regressed on parent college), identified mediation models (offspring college regressed onto parent college and identified mediating variables), and a full model (offspring college regressed onto parent college and all potential mediators simultaneously). Models were compared using the Bayesian Information Criterion (BIC) and odds ratios (ORs). Elimination of the parent college effect when

the candidate mediators were included in the regression is consistent with complete mediation.

3 | RESULTS

3.1 | Association between offspring and parent college attainment

We first investigated whether college attainment was transmitted in both adoptive and nonadoptive families. The number of college-educated parents was positively associated with offspring college attainment for all four types of offspring (i.e., adopted offspring from adoptive families, adopted offspring from mixed families, nonadoptive offspring from nonadoptive families, and nonadoptive offspring from mixed families). For each offspring type, we computed the OR between the number of college-educated parents and offspring college attainment after taking sex, age at last follow-up, and family clustering into account. The estimated OR [95% CI] was 1.48 [1.13, 1.93] ($p = .004$) in adoptive families, 2.88 [1.89, 4.38] ($p < .001$) in nonadoptive families, 2.03 [1.17, 3.54] ($p = .012$) for adopted offspring in mixed families, and 3.74 [1.40, 9.99] ($p = .009$) for nonadoptive offspring in mixed families. The effect of parent college in adopted offspring implicated an environmental effect. There was a significant interaction between adoption status and parent college on offspring college attainment ($\beta = .53$, 95% CI = .17, .89). The stronger transmission of college attainment in nonadopted offspring compared to adopted offspring implicated genetic factors (Figure S1 depicts the proportion of offspring attaining college by parental degree status and family type). While these results provide evidence of both genetic and environmental contributions, the focus of this paper is on environmental mediation.

The strength of the parent college effect did not vary significantly either between the two adopted offspring groups ($\beta = .21$, 95% CI = $-.10$, .51), or between the two nonadopted offspring groups ($\beta = .31$, 95% CI = $-.44$, 1.05). Consequently, we pooled these groups to form adopted offspring and nonadopted offspring samples to increase power in all subsequent analyses.

3.2 | Potential mechanisms associations with offspring college attainment

The second step in our analysis involved regressing offspring college attainment on each of the potential mediating factors; results are presented in Table 2. Only household structure was not significantly associated with offspring college attainment (i.e., confidence intervals include 1 in both adopted and nonadopted offspring). We did not observe a statistically

significant interaction between any potential environmental mediator and adoption status. However, parent disinhibition was more strongly and negatively associated with college attainment among nonadoptive than adoptive offspring suggesting a genetic pathway. Of the remaining eight variables, help from mother had a negative association for both offspring groups, while all other variables were as expected positively associated with offspring college attainment in both offspring groups.

3.3 | Parent college associations with the potential mechanisms

The results of regressing each candidate mediating factor on parent college, adoption status, and their interaction are given in Table 3. A significant interaction is evidence in favor of at least partial genetic mediation and was present for offspring skills (i.e., offspring general cognitive ability and noncognitive ability), neighborhood, parental disinhibition, parental involvement, and school. A significant main effect of parent college in adoptive families is evidence for at least partial environmental mediation and existed only for family income (main effect for adopted individuals: $\beta = .30$, 95% CI = .20, .39) and adjusted mother expectations ($\beta = .16$, 95% CI = .05, .27). Formal mediation analysis of adopted offspring showed that mother expectations mediated 30% of the parent-offspring college effect, while family income mediated 23% of the effect when run individually. A combined model showed that the mediators together accounted for 45% of the parent-offspring college effect.

Table 4 presents the results of models investigating the combined effect of potential mediators in the adoptive offspring sample with the imputation of missing data (number of imputations = 100). Model 1 is a baseline model in which offspring college attainment was regressed on parent college and covariates, yielding an OR of 1.51 (95% CI = 1.21, 1.89; $p < .001$) for the parent college effect. In Model 2, the two potential mediators consistent with environmental mediation were added and resulted in an OR for the parent college effect of 1.30 (95% CI = 1.01, 1.66; $p = .044$; $\Delta\text{BIC} = -72.33$). Finally, Model 3 included all potential mediators and resulted in a parent college OR of 1.44 (95% CI = 1.05, 1.98; $p = .022$; from Models 2 to 3, $\Delta\text{BIC} = -137.05$). In combination, these variables did not account entirely for the the parent-offspring transmission of college attainment.

4 | DISCUSSION

Our analysis of the parent-offspring transmission of college attainment in adoptive and nonadoptive offspring found that

TABLE 2 Odds ratios (95% CI) for offspring college attainment regressed on possible environmental variables

Predictor	Odds ratio for adopted offspring	Odds ratio for nonadopted offspring	Predictor χ^2 on 1 <i>df</i>	Adoption status χ^2 on 1 <i>df</i>	Adoption status by predictor χ^2 on 1 <i>df</i>
Skill enhancement					
GCA	2.35 [1.85, 2.98]	2.29 [1.71, 3.07]	83.18 <i>p</i> < .001	5.61 <i>p</i> = .018	.14 <i>p</i> = .705
Noncognitive	3.28 [2.45, 4.41]	4.39 [2.80, 6.90]	109.99 <i>p</i> < .001	3.77 <i>p</i> = .052	.25 <i>p</i> = .620
Academic support					
Mother expectations	2.68 [2.00, 3.60]	2.51 [1.79, 3.53]	72.12 <i>p</i> < .001	7.17 <i>p</i> = .007	.64 <i>p</i> = .423
Help from mother	.63 [.49, .80]	.60 [.43, .83]	24.35 <i>p</i> < .001	8.66 <i>p</i> = .003	.15 <i>p</i> = .700
Material advantage					
Family income	1.51 [1.21, 1.89]	1.79 [1.32, 2.43]	26.19 <i>p</i> < .001	7.83 <i>p</i> = .005	.65 <i>p</i> = .419
School	1.43 [1.17, 1.75]	1.51 [1.17, 1.96]	21.60 <i>p</i> < .001	8.79 <i>p</i> = .003	.05 <i>p</i> = .817
Neighborhood	1.36 [1.10, 1.68]	1.37 [1.05, 1.78]	13.30 <i>p</i> < .001	12.22 <i>p</i> < .001	.10 <i>p</i> = .748
Supportive family environment					
Parent involvement	1.75 [1.41, 2.18]	2.24 [1.65, 3.05]	52.27 <i>p</i> < .001	6.70 <i>p</i> = .010	1.15 <i>p</i> = .284
Parent disinhibition	.93 [.74, 1.16]	.71 [.57, .88]	7.95 <i>p</i> = .005	11.11 <i>p</i> = .001	2.25 <i>p</i> = .134
Household structure	.88 [.73, 1.06]	1.08 [.80, 1.45]	.74 <i>p</i> = .388	6.75 <i>p</i> = .009	1.27 <i>p</i> = .260

Note: All analyses controlled for sex of the offspring, age at last follow-up, and family clustering

Abbreviation: GCA, general cognitive ability.

(a) both shared environmental and genetic factors contributed to parent-offspring transmission; (b) while offspring with higher cognitive and noncognitive skills were more likely to achieve college attainment, we did not find evidence that highly educated parents were increasing their *adopted* offspring's college attainment through skill development; and (c) the only environmental factors associated with increased odds of offspring college attainment were mother's academic expectations and family income. Our findings regarding the contributions of both the shared environment and genetics to college attainment are in line with previous meta-analytic findings from twin studies (Branigan et al., 2013) and other adoption studies (e.g., Björklund et al., 2006).

Our findings show that family income partially mediated the parent-offspring transmission of college attainment in adoptive families. Nonetheless, family income was not associated with the cognitive and noncognitive skills of adopted offspring, so its benefit in regards to college attainment must operate through other pathways. One way parent income might increase children's odds of college attainment is through direct financial aid for college expenses, which may be of increasing importance with the rising cost of higher education (CollegeBoard, 2018).

Parent income may also foster college attainment by helping offspring achieve higher scores on college admission

tests (e.g., the SAT, a widely used test in American college admission) via preparation aids (Buchmann et al., 2010) or re-testing opportunities (Vigdor & Clotfelter, 2003). While questions over the size of the effect for the different test preparation methods (e.g., practice tests, private tutors) remain, the available literature indicates that preparation tends to improve scores (Montgomery & Lilly, 2012; Powers & Rock, 1999). Vigdor and Clotfelter (2003) show that students' scores on the SAT generally improve on subsequent testing, and additional test taking is associated with family income. It is worth noting, however, that SAT scores are not merely acting as proxies for family income in the admissions process (Sackett et al., 2012). Sackett and colleagues (2009, 2012) show that including family income in a model alongside SAT score only trivially diminishes the validity of the SAT score in predicting college academic performance.

In addition to potentially aiding offspring's ability to obtain higher admission test scores or paying for college costs, parent income may improve offspring's chances of college attainment indirectly. For instance, high-income parents may fund extracurricular activities or courses that enhance the student's college application. Kaushal et al. (2011) found that as families' overall expenditures increased (a proxy for overall family income), more

TABLE 3 Effect sizes & 95% CI for standardized family background & skill variables regressed on parent college and adoption status

	β for parent college in adopted families	β for parent college in nonadopted families	Parent college effect	Adoption status effect	Adoption status by parent college effect
Skill enhancement					
GCA ^a	.09 [−.02, .19]	.35 [.25, .46]	$\chi^2_{(df=1)} 27.18$ $p < .001$	$\chi^2_{(df=1)} 8.68$ $p = .003$	$\chi^2_{(df=1)} 11.22$ $p = .001$
Noncognitive ^a	−.02 [−.12, .08]	.22 [.12, .33]	$\chi^2_{(df=1)} 6.04$ $p = .014$	$\chi^2_{(df=1)} 9.95$ $p = .002$	$\chi^2_{(df=1)} 10.78$ $p = .001$
Academic support					
Mother expectations ^a	.16 [.05, .27]	.15 [.01, .28]	$\chi^2_{(df=1)} 12.94$ $p < .001$	$\chi^2_{(df=1)} 4.49$ $p = .034$	$\chi^2_{(df=1)} .01$ $p = .931$
Help from mother ^a	−.01 [−.12, .10]	−.06 [−.20, .07]	$\chi^2_{(df=1)} .25$ $p = .615$	$\chi^2_{(df=1)} 2.32$ $p = .128$	$\chi^2_{(df=1)} .11$ $p = .742$
Material advantage					
Family income ^b	.30 [.20, .39]	.34 [.18, .49]	$F_{(1, 852)} 55.22$ $p < .001$	$F_{(1, 852)} .14$ $p = .710$	$F_{(1, 852)} .28$ $p = .598$
School ^a	.03 [−.08, .14]	.21 [.09, .33]	$\chi^2_{(df=1)} 7.04$ $p = .008$	$\chi^2_{(df=1)} 3.99$ $p = .046$	$\chi^2_{(df=1)} 4.66$ $p = .031$
Neighborhood ^b	.05 [−.04, .13]	.22 [.08, .35]	$F_{(1, 1,062)} 7.58$ $p = .006$	$F_{(1, 1,062)} 6.10$ $p = .014$	$F_{(1, 1,062)} 4.70$ $p = .030$
Supportive family environment					
Parent involvement ^a	−.05 [−.16, .06]	.10 [−.02, .22]	$\chi^2_{(df=1)} .19$ $p = .661$	$\chi^2_{(df=1)} 6.14$ $p = .013$	$\chi^2_{(df=1)} 3.56$ $p = .059$
Parent disinhibition ^b	−.07 [−.15, .01]	−.22 [−.37, −.07]	$F_{(1, 1,121)} 11.08$ $p = .001$	$F_{(1, 1,062)} 26.26$ $p < .001$	$F_{(1, 1,062)} 3.94$ $p = .048$
Household structure ^a	.02 [−.12, .16]	.03 [−.09, .14]	$\chi^2_{(df=1)} .13$ $p = .718$	$\chi^2_{(df=1)} .21$ $p = .648$	$\chi^2_{(df=1)} 1.47$ $p = .225$

Note: All potential mediators were standardized.

Abbreviation: GCA, general cognitive ability.

^aMeasured at the individual level controlling for family clustering.

^bMeasured at the family type (adoptive or nonadoptive) as siblings have the same level of the outcome.

TABLE 4 Adopted offspring college attainment regressed on parent degree completion under corrected and uncorrected conditions

	Model 1: Parent college predicting offspring college	Model 2: Mother expectations and family income mediation of parent college effect	Model 3: Full model for predicting offspring college
	OR[95% CI]	OR[95% CI]	OR[95% CI]
Parent college	1.51 [1.21, 1.89] $p < .001$	1.30 [1.01, 1.66] $p = .044$	1.44 [1.05, 1.98] $p = .022$
GCA			2.10 [1.65, 2.68] $p < .001$
Noncognitive			2.99 [2.21, 4.05] $p < .001$
Mother expectations		2.21 [1.78, 2.73] $p < .001$	2.55 [1.95, 3.34] $p < .001$
Help from mother			.81 [.62, 1.04] $p = .101$
Family income		1.34 [1.07, 1.68] $p = .011$	1.34 [1.01, 1.78] $p = .040$
School			.99 [.77, 1.28] $p = .961$
Neighborhood			1.64 [.89, 1.52] $p = .269$
Parent involvement			1.30 [1.00, 1.69] $p = .054$
Parent disinhibition			.82 [.61, 1.10] $p = .187$
Household structure			.90 [.73, 1.11] $p = .334$
BIC	873.20	800.87	663.82

Note: All models corrected for offspring age at last follow-up, sex, and family clustering.

investment was made toward offspring enrichment, such as paying for dance lessons, organized athletics, preschool and private school, trips or electronics. Additionally, in more highly educated families, a greater proportion of resources was devoted to enrichments such as books, lessons, and education (e.g., college, school supplies).

We found that mothers who expected their offspring would attend college (net the offspring's cognitive and non-cognitive skills) tended to have offspring with higher odds of college attainment. Like family income, mother expectations also partially mediated the parent-offspring transmission of education relationship. The nature of this relationship is not completely clear—the mother may be reacting to attributes of the offspring we have not measured or the mother's expectations may influence offspring college attainment directly (e.g., by motivating the offspring to achieve more) or indirectly (e.g., by increasing child's expectations of college attainment). Evidence that high school students' expectations of their own educational attainment are related to college enrollment certainly exists in the literature, though the authors caution against assumptions of causality (Jacob & Linkow, 2011). Rimkute et al. (2012) found that parental educational expectations were related to offspring expectations as well as to the parental educational level and offspring academic achievement. Our current analyses do not tease apart the more complex nature of these relationships, and additional research is needed.

There are several limitations to our research design that should be taken into account when interpreting the results and generalizability of this study. Our sample was drawn from Minnesota, a U.S. state with higher rates of college attendance and lower rates of unemployment than many other U.S. states. Thus, the generalizability of the results to other areas of the country, and certainly to non-U.S. countries, may be limited. Restriction of range in the socioeconomic background of adoptive families is well known, and adoptive families reported higher incomes on average than nonadoptive families in our sample. Such restriction of range can lead to an underestimation of shared environmental influence estimates (Stoolmiller, 1999); however, previous analyses comparing the importance of the shared environmental effects in this adoptive and a twin family sample found limited differences between the two (McGue et al., 2017), thus limiting concerns of range restriction on the current estimates.

Another consideration our study cannot fully address is the potential differences associated with ethnicity. Our biological offspring sample is almost completely white (95%), while our adopted offspring show greater ethnic diversity (21% white, 66% Asian, 13% other). However, the influence of parent college attainment on offspring college attainment in adoptive families only decreases minimally when the ethnicity of the offspring is controlled for in addition to age and sex ($OR = 1.46 [1.17, 1.87]$ vs. $1.54 [1.22, 1.94]$).

While we include a range of variables from parents, we mostly relied on maternal (e.g., mother expectations of offspring academic success) reports. There may be additional value in gathering paternal views on topics such as educational expectations that are not included in this study. Given the increased odds of offspring college attainment when both parents hold a degree, perhaps we would see an increase in college attainment when both parents hold high expectations of their offspring.

An additional limitation of our study is that we did not directly assess the full range of behaviors parents might engage in to support the academic success of their offspring. Our finding that the parent college effect is not mediated by skill development does not mean that parents do not foster the academic skills of their children but rather only that college-educated parents do not appear to be contributing to the likelihood of their children completing college via skill-building.

Given the ages of participants (27% of offspring were between the ages of 19 and 21 at the last follow-up), a number of offspring had not yet had the opportunity to complete a 4-year college degree. Thus, college attainment (completion of a 4-year degree or being enrolled in a degree program) was used in place of college degree attainment. Approximately 60% of participants with college attainment in this sample were still attending college at the point of assessment (see supplement for age differences, as well as GCA and noncognitive mean differences by college status). National statistics suggest that approximately 62% of first-time undergraduate students attending a four-year college will go on to complete their degree (National Center for Education Statistics, 2020).

Finally, this study looks at college attainment without differentiating between colleges in regards to the difficulty of admission (e.g., low admission rate) or price of attendance. Some schools offer high rates of admission with an equally high price (U.S. Department of Education, 2020). This suggests that some parents may be able to pay for their offspring's attendance at a college. However, money may not directly buy admittance to a top tier university.

Analyses of family units consisting of both adoptive and nonadoptive offspring highlight the importance of both genetic and environmental influences on the parent-offspring transmission of college attainment. While cognitive and non-cognitive skills are consistently associated with college attainment across offspring types, we did not find evidence that highly educated parents aided their adoptive offspring's educational chances via skill development. Rather, the mediators identified in the parent-offspring transmission of college attainment were family income and the mother's expectations of her offspring's educational attainment.

A notable finding was that the parent-offspring transmission of educational attainment could not be completely accounted for by the family and neighborhood factors

included in this study. Indeed, the mediating factors we investigated accounted for little of the parent-offspring transmission effect. This may be because no single shared environmental factor has a large effect on the outcome even though in aggregate the shared environment accounts for a large portion of variance. This has been shown to be the case for both the genetic and nonshared environmental contributions to complex behavioral outcomes (Chabris et al., 2015). Thus, the question of what highly educated parents do to increase the odds of offspring educational attainment remains largely open. There are several possibilities we postulate that may be important, though our list should not be taken as exhaustive. First, there may be direct modeling of educational attainment. Offspring who see that their parents have obtained a higher degree may model after this accomplishment. A second possibility is that there are skills parents promote in their offspring that we did not assess. Consistent with this, Kendler and colleagues (2015) report a small effect of parent education on the general cognitive ability of adopted offspring. There may be other important family factors (e.g., father expectations, parent engagement in offspring college applications) related to parent educational attainment that promote offspring educational attainment. It is also possible that there are important school environment factors we did not assess (e.g., academic climate, availability of AP courses). Additionally, the peers of offspring and other neighborhood residents may also serve as models for educational attainment achievement in offspring (e.g., see Chetty & Hendren, 2018).

This study serves as a starting place for piecing together the puzzle described by Freese and Jao (2017). While a complete solution was not identified—mothers' expectations and family income only partially mediated the parent-offspring transmission of educational attainment—we hope this study serves as a springboard for additional research in identifying mechanisms associated with this phenotype.

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CONFLICT OF INTEREST

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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