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# Multivariate Analysis of Genetic and Environmental Influences on Parenting in Adolescence

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Adolescents whose parents are affectionate, maintain consistent rules, and are knowledgeable about their whereabouts tend to exhibit more adaptive levels of psychological functioning across multiple domains. Behavioral genetic research has documented the sensitivity of parenting to genetically influenced child characteristics and behaviors. Yet, the question of whether the correlations between parenting behaviors are driven by overlapping parent effects, overlapping child effects, or some combination of the two remains open. In a sample of $N = 542$ twins, ages 13.6 to 20.1 years, from the Texas Twin Project, we evaluated the extent to which adolescents' genetically influenced traits broadly affect multiple dimensions of parenting (maternal and paternal warmth and control, and parental monitoring). We found that shared environmental factors primarily accounted for the covariation among parental warmth, control, and monitoring. Child-driven genetic effects were primarily detected in parenting variance unique to fathers. These results indicate that adolescents' family-wide environmental contexts are general across multiple domains of parenting, whereas genetically influenced adolescent-driven effects are specific to particular aspects of parenting and to particular relationships.

*Keywords:* behavioral genetics, twin study, parenting, gene–environment correlation, parent–child transactions



Multiple, correlated dimensions of parenting behavior have been empirically associated with positive child outcomes (Amato & Fowler, 2002; Barber, Olsen, & Shagle, 1994; Gray & Steinberg, 1999; Stice, Barrera, & Chassin, 1993). This study focuses on three dimensions of parenting: warmth, control, and monitoring. Parental warmth refers to affectionate, responsive, and supportive behaviors, while behavioral control refers to setting boundaries and maintaining consistent rules. Behavioral control, which focuses on regulating youth behaviors through appropriate limit setting, can be differentiated from psychological control, which might limit the ability of the child to individuate from the parent, and is associated with maladaptive behavior in youth (Barber et al., 1994; Barber, 1996). Parents high in psychological control show domineering behavior, limit the adolescent's autonomy, and exert decision-making authority without input from the adolescent (Barber, 1996). Finally, parental monitoring is an important aspect of parental behavioral control, particularly in adolescence. Parental monitoring refers to parental knowledge of and attention to adolescents' whereabouts, friends, and activities, as well as to parents' specific rules about those activities, such as curfew (Dishion & McMahon, 1998; Stattin & Kerr, 2000). Higher levels of parental monitoring are associated with lower levels of externalizing behaviors (Lac & Crano, 2009; Laird, Pettit, Bates, & Dodge, 2003).

Although distinguishable both statistically and theoretically, warmth, control, and monitoring are, in fact, interrelated. The correlations among them capture the systematic ways in which parenting behaviors share common origins and reinforce each other, such that youth who experience one form of adaptive parenting are more likely to experience another, and less likely to experience other, negative forms of parenting (Gray & Steinberg, 1999). For instance, psychological control is negatively associated with both warmth and monitoring (Barber, Stolz, & Olsen, 2005); parents who attempt to limit expressions of autonomy and dominate decision making are not perceived by their teens as affectionate or as knowledgeable about their activities (Gray & Steinberg, 1999; Barber et al., 2005). In contrast, parental warmth is positively correlated with parental monitoring, consistent with a broader construct of "good" parenting, incorporating both parental responsiveness as well as rule-based structure, providing control while supporting autonomy (Kerr, Stattin, & Özdemir, 2012).

## Behavioral Genetic Designs Are a Tool for Studying Transactional Models of Parenting

The interrelations among parenting behaviors could result from multiple potential mechanisms. Perhaps most intuitively, these

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Preliminary analyses of this study were presented at the Behavior Genetics Association meeting in San Diego, CA, in June 2015. Within the data from the Texas Twin Project, the construct of parental monitoring has previously been analyzed in relation to peer deviance, sensation seeking, and delinquency (Mann, Kretsch, Tackett, Harden, & Tucker-Drob, 2015).

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correlations could emerge as a result of some characteristic of the parent, in alignment with the traditional conceptualization of parenting as a socialization process, in which parents take an active role in shaping their children (Maccoby, 1992). For example, Darling and Steinberg (1993) described parenting style as a "characteristic of the parent (i.e. it is a feature of the child's social environment), independent of the characteristics of the developing person" (p. 487). Correlations between parenting behaviors may also be shaped by some characteristic of the child shaping how they are parented, that is, child effects on parenting behaviors (Bell, 1968). A transactional model of parenting posits a bidirectional interactive process between parent and child, in which parenting practices emerge in response to a child's unique behaviors and characteristics as well as those of their parents (Bell, 1968; Sameroff & MacKenzie, 2003). For example, in longitudinal studies, earlier poor monitoring predicts delinquency, and delinquency, in turn, predicts further poor monitoring, after controlling for previous levels of each outcome (Barber, 1996; Laird et al., 2003).

A behavioral genetic design that examines parenting data collected from twins raised together can provide a powerful test of the extent to which variation in parenting is associated with genetically influenced child characteristics and behaviors. Furthermore, this design can examine the extent to which interrelations among parenting behaviors are influenced by environmental factors (which may include parent characteristics) and child-genetic sources. The classical twin approach typically measures a child outcome (such as IQ or anxiety) in a sample of both identical (monozygotic) and fraternal (dizygotic) twins. If identical twins (who share nearly 100% of their segregating genes)[1] resemble each other more than fraternal twins (who share, on average, 50% of their segregating genes), one infers that variation in that phenotype (at least partially) is associated with genetic differences between people—that is, is heritable. When this same approach is applied to a measure of parenting rather than a child outcome, the key question then becomes whether identical twins experience more similar parenting than fraternal twins. If so, this result indicates that variability in the parenting behavior that children experience is associated with the child's genes (Rowe, 1981).

The concept of "heritable" environments may seem counterintuitive; however, environments are not experienced randomly (Plomin & Bergeman, 1991). Individuals shape their environments by selecting, modifying, and evoking responses from the people and institutions surrounding them. Insofar as the process of shaping one's environment is directed by genetically influenced traits (such as temperament), then this environment becomes matched to one's genotype, known as a *gene–environment correlation* (rGE; Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983). In other words, the parenting environment that is experienced by the child is correlated with genetically influenced individual differences in the child—evidence for a child-driven effect on parenting. When applied to multiple measures of parenting behavior, a behavioral genetic design tests whether the correlations among behaviors are due to child-driven genetic effects operating on multiple parenting behaviors in tandem.

A twin design additionally estimates the extent to which children raised together receive (or perceive) similar parenting beyond what can be explained by their genetic resemblance (the shared environment). In a twin model of parenting, shared environmental variance quantifies the extent children in the same family have similar parenting experiences. Such "family-wide" variance in parenting reflects, of course, the characteristics of the parent (including effects of the parent's genes, which may be shared with the child), as well as any broader family contexts that may influence parenting, such as socioeconomic status, religious affiliation, and cultural norms. The same set of family-wide contexts might operate on multiple parenting behaviors simultaneously, which would be reflected in a twin model as shared environmental effects on correlations between parenting behaviors. For example, parents who are free of psychopathology may be better able to be warm to their adolescents and also to monitor their teens closely.

In contrast, nonshared environmental variance in parenting quantifies the extent to which parents treat their children differently (or the extent to which children perceive their parents to treat them differently) for reasons that are unrelated to the child's genotype. This may result from situational factors individual to each child, such as participating in separate extracurricular activities. The motivations for differential parenting may be varied and idiosyncratic. For example, in a series of qualitative interviews conducted by Caspi and colleagues (2004), many mothers of identical twins reported folk beliefs about twin differences (e.g., one is always submissive and the other dominant; one is always masculine and the other feminine). Others reported that early histories of illness, feeding difficulties, or birth weight differences shaped their perceptions of each twin. Additionally, the nonshared environment quantified by twin studies captures all differences between twins not attributable to genes, and includes measurement error indistinguishable from other sources of unique twin differences.[2]

Twin research has reported child genetic effects on a number of parenting behaviors, including warmth, control, and monitoring (e.g., Kendler & Baker, 2007; McGuire, Segal, & Hershberger, 2012; Klahr, Thomas, Hopwood, Klump, & Burt, 2013). This work has yielded small-to-large estimates of child-genetic influences on parenting. Klahr and Burt (2014) meta-analyzed 44 twin-children studies of parenting that examined three dimensions of parenting behavior: warmth, control, and negativity, and found that additive genetic, shared environmental, and nonshared environmental factors all accounted for a moderate amount of variance in all three parenting behaviors.[3] Child genetic influences accounted for between 23% and 40% of the variance in these parenting behaviors. Other work investigating the role of *r*GE in parental monitoring has evinced smaller and variable estimates of child-genetics influences on monitoring (5%–33%), depending on reporter and design (Reiss, Neiderhiser, & Hetherington, 2000; Neiderhiser et al., 2004). Overall, previous behavioral genetic research on parenting using child-based twin designs has often

[1] Although monozygotic twins inherit identical genetic material from their parents, they may differ due to postzygotic events that may alter their genotypes, resulting in slightly less than 100% concordance (Machin, 1996).

[2] However, when a traditional twin model (i.e., *ACE* model) is fit to a latent variable, like parental warmth and parental control in the current study, estimates of nonshared environmental variance are free of measurement error. In such cases, measurement error is captured by the residual variances of the latent indictors.

[3] It should be noted that both behavioral control, such as monitoring, and psychological control were included within the control factor in this meta-analysis, decreasing generalizability to our measures.

found evidence that genetically influenced child characteristics shape parenting behaviors, although these effects may be small.

## Multivariate Behavioral Genetic Research on Parenting

A multivariate twin study, in which multiple aspects of parenting are measured, can accomplish two goals. First, multivariate research can test, within a single sample, whether certain aspects of parenting are more responsive to genetically influenced child characteristics than other aspects of parenting. Meta-analytic evidence suggests that patterns of genetic and environmental influence might differ across parenting dimensions (Klahr & Burt, 2014). In particular, studies of parental warmth find the largest average estimate of shared environmental variation (39%), and parental control the largest estimate of nonshared environmental variation (44%), with warmth garnering a slightly greater influence from child-genetic sources than control (26% and 23%, respectively). Though this difference may seem negligible, previous work consistently indicates a greater genetic influence on warmth than control, with some previous estimates of heritability for warmth varying from 34% to 37% and control from 12% to 17% (Kendler & Baker, 2007).

Additionally, mothers and fathers may differ in their responsiveness to child-genetic influence. Comparing similar studies conducted with measures of mother behavior and father behavior (Neiderhiser et al., 2004; Neiderhiser, Reiss, Lichtenstein, Spotts, & Ganiban, 2007) indicates variability of estimates across parent and dimension, with mothers showing greater child-genetic influence on control, and fathers on positivity. Klahr and Burt (2014) found that studies of maternal control and negativity had higher average estimates of child genetic influence than studies of paternal control and negativity. These results suggest that mothers and fathers may be responding differently to child-driven genetic factors.

Second, as previously mentioned, results from multivariate genetic studies are informative regarding the processes leading to interrelations among various dimensions of parenting. The interrelations among parenting dimensions, which capture overall quality of parenting in the systematic ways parenting behaviors support and oppose one another, could reflect characteristics of the parent, including those that are genetically driven, as well as those of environments operating on the parent. For example, a mother who is skilled at regulating her own emotions and who enjoys a high level of economic security might be able to practice multiple forms of adaptive parenting (high warmth, active monitoring, low psychological control). In a twin model, such parent-driven, domain-general effects would be reflected as shared environmental variance that is common to multiple measures of parenting.

Alternatively, the interrelations among parenting dimensions may be driven not just by the parent but also by the child being parented. For example, a teenager who is aggressive and oppositional may evoke not just coldness from his parents, but also escalating attempts to control the teen. Although there is a general theoretical consensus that parenting is a two-way street, with both the child and the parent shaping parenting behavior, it is not yet clear whether child-driven effects are highly specific or general across multiple domains of parenting. In other words, the extent to which both parent and child characteristics influence the covariation of family processes remains an open question. The current study fills this gap in the literature by examining child-driven genetic contributions that may shape parental warmth, control, monitoring, and importantly the interrelations of these constructs as they come together to capture broad patterns of parenting.

# Method

## Participants and Procedure

Adolescent twin and triplet pairs and their parents were recruited from the Texas Twin Project (Harden, Tucker-Drob, & Tackett, 2013), a registry of school-age twins identified through public school rosters. Twins who were enrolled in high school (9th to 12th grades) and who were within driving distance of the lab were eligible to participate. During the lab visit, a different research assistant assessed each twin separately in a different room. All survey items were administered on the computer to encourage honest reporting on sensitive items. Study procedures were reviewed and approved by the university institutional review board, and parents and adolescents provided consent/assent prior to the study.

The current sample consisted of 542 individuals from 97 monozygotic (MZ) and 185 dizygotic (DZ) twin pairs (99 same sex, 87 opposite sex). For behavioral genetic analyses, each set of triplets (eight sets) was broken down into three pairwise combinations. Participants' age ranged from 13.6 to 20.1 years ($M$ = 15.8, $SD$ = 1.45), and 51.5% were female. The sample was diverse and representative of the population surrounding Austin, Texas. Just over half (58%) of twins were non-Hispanic White, 17% were Hispanic/Latino, 9% were African American, and 15% were multiple or other race/ethnicity. Thirty-three percent of families reported having received public assistance, such as food stamps, after their twins or multiples were born. Six percent of mothers had not received a high school diploma, 5% had graduated high school, 31% had some college or vocational training, 26% had completed college, and 32% had education beyond college.

## Measures

**Zygosity.** All opposite-sex twin pairs were classified as DZ. Twins, parents, and research assistants rated the physical similarity of twins on 10 items (e.g., "has the same eye color"). These item responses were entered into a latent-class analysis (LCA) to determine zygosity classification for same-sex twin pairs. This method of LCA of questionnaire responses has shown 99% concordance with zygosity testing from genotyping (Heath et al., 2003).

**Parental monitoring.** Parental monitoring was assessed with a 15-item adolescent-report measure completed by both twins (Capaldi & Patterson, 1989). Seven items assessed parents' knowledge of adolescent's friends and activities on a 3-point scale. The remaining eight items inquired about rules and restrictions parents impose on their children (e.g., curfew) and were also rated on a 3-point scale. The mean of item scores was used; higher scores indicate more monitoring ($M$ = 2.6, $SD$ = 0.31, $\alpha$ = .82). Due to negative skew, the mean score was reflected, log-transformed, and reflected back, such that higher scores still indicated more monitoring.

**Parenting warmth and control.** Adolescent reports of parental warmth and control were assessed with the Parental Bonding Instrument (PBI; Parker, Tupling, & Brown, 1979). This measure is divided into two scales, assessing "care" (12 items assessing affection and support; e.g., "appears to understand my problems and worries") and "overprotection or control" (13 items assessing restriction and lack of autonomy; e.g., "tried to make me feel dependent on him/her"), with items rated on a 4-point scale. Each twin completed the inventory separately for mother (or primary female caregiver) and father (or primary male caregiver). Items were scored such that higher values indicate higher ratings of warmth (mother: $M = 2.4$, $SD = 0.51$, $\alpha = .88$; father: $M = 2.2$, $SD = 0.62$, $\alpha = .90$) and control (mother: $M = 1.1$, $SD = 0.54$, $\alpha = .84$; father: $M = 0.89$, $SD = 0.53$, $\alpha = .83$). The paternal and maternal warmth scales were negatively skewed, and so were reflected, log-transformed, and rereflected. Finally, the control scale was also log-transformed.

### Analyses

Twins' age, age$^2$, gender, Age × Gender interaction, and race were partialed out of all variables prior to analyses, with zero-order correlations between all raw variables shown in Table 1. Standardized residuals were used for all subsequent analyses. Structural equation modeling was conducted in *Mplus* (Muthén & Muthén, 1998–2012). The complex survey option was used to account for the nonindependence of data within families (i.e., multiple twins per family in phenotypic analyses; multiple pairs per triplet sets in behavioral genetic analyses).

We conducted three sets of analyses. First, univariate twin modeling was used to estimate environmental and child-driven genetic influences on each parenting measure separately. Observed variance was parsed into three standardized latent factors: additive genetics ($A$), shared (or common) environment ($C$), and nonshared environment ($E$). The correlation between $A$ factors was fixed at 1 for MZ twins and 0.5 for DZ twins. All twins raised in the same household are necessarily concordant for shared environment; thus the correlation for $C$ factors was fixed at 1, and the $E$ factors were uncorrelated between twins and includes measurement error, except where latent variables are used (Neale & Cardon, 1992). Second, we conducted confirmatory factor analyses (CFA) in order to investigate the phenotypic relations among the different dimensions of parenting. Model fit was assessed by Satorra-Bentler Chi-Square Difference Test and root-mean-square error of approximation (RMSEA; Hu & Bentler, 1999). Third, we fit a multivariate twin model that decomposed the covariance among different parenting measures into $A$, $C$, and $E$ components. The specification of this model was informed by results from the univariate twin models and the phenotypic CFA.

## Results

### Univariate Behavioral Genetic Analyses

Univariate *ACE* models were fit separately to parental monitoring, maternal and paternal warmth, and maternal and paternal control. Results are presented in Table 2. The strength of child-driven genetic effects varied considerably across parenting variables. Genetic influences were appreciable and significant for maternal warmth ($h^2 = 33\%$) and paternal control ($h^2 = 37\%$), small and nonsignificant for paternal warmth ($h^2 = 9\%$), and entirely absent for parental monitoring and maternal control. Almost half of the variance in each measure was nonshared environmental ($E$), indicating that even identical twins differed substantially in their reports of the parenting that they experienced. There was also significant shared environmental variance in all measures, particularly maternal control. This finding of significant $C$ variance indicates that twins raised together, regardless of zygosity, experience moderately similar parenting. Put differently, there were consistent nongenetic between-families' differences in all parenting constructs, which is consistent with the conceptualization that parenting reflects characteristics of the parent and family system.

### Confirmatory Factor Analyses

A model with three correlated dimensions (see Figure 1) provided adequate fit to the data, $\chi^2 = 3.22(1)$, $p = .07$, RMSEA = 0.064, Confirmatory Fit Index (CFI) = 0.995, Tucker-Lewis index (TLI) = 0.947. Paternal and maternal warmth loaded onto a warmth factor, and paternal and maternal control loaded onto a control factor. These factors were correlated with each other and with parental monitoring. Warmth was inversely correlated with control ($r = -0.45$, $p < .001$) and positively correlated with monitoring ($r = .47$, $p < .001$). Control and monitoring were independent ($r = -0.06$, $p = .38$). Note that given that warmth and control were measured using the same instrument (PBI) but not monitoring, correlations between these two dimensions may in part reflect method variance. Residual covariances between measures of the same parental target (mother vs. father) were also estimated. Unique variance in maternal warmth (i.e., variance that is independent of that shared with paternal warmth) was negatively correlated with unique variance with maternal control ($r = -0.53$,

Table 1
*Zero-Order Phenotypic Correlations Among Study Variables, Sex, and Age*

| Variable | Sex | Age | Mom warmth | Dad warmth | Mom control | Dad control | Monitoring |
|---|---|---|---|---|---|---|---|
| Sex | 1.000 | | | | | | |
| Age | −.039 | 1.000 | | | | | |
| Mom warmth | −.093 | .043 | 1.000 | | | | |
| Dad warmth | −.037 | −.036 | .497 | 1.000 | | | |
| Mom control | −.024 | −.112 | −.491 | −.227 | 1.000 | | |
| Dad control | −.180 | −.146 | −.164 | −.359 | .390 | 1.000 | |
| Monitoring | −.160 | −.292 | .372 | .269 | −.037 | .092 | 1.000 |

*Note.* Sex coded 0 = female, 1 = male. Age centered at 15 years.

Table 2
*Standardized Estimates and Proportion of Variance Explained in Univariate ACE Models*

| | *A* | | | *C* | | | *E* | | | Model fit indices | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parental factor | Estimate | *SE* | % variance | Estimate | *SE* | % variance | Estimate | *SE* | % variance | $\chi^2$ (*df*, *p*) | RMSEA |
| Monitoring | .001 | .254 | $h^2$ = .0% | .590*** | .055 | $c^2$ = 34.9% | .807*** | .041 | $e^2$ = 65.1% | 7.47 (6, .28) | .042 |
| Mom warmth | .573** | .209 | $h^2$ = 32.9% | .424* | .206 | $c^2$ = 18.0% | .701*** | .073 | $e^2$ = 49.1% | 5.71 (6, .46) | .000 |
| Dad warmth | .300 | .363 | $h^2$ = 9.0% | .575*** | .144 | $c^2$ = 33.1% | .761*** | .056 | $e^2$ = 57.9% | 2.87 (6, .82) | .000 |
| Mom control | .000 | .000 | $h^2$ = .0% | .684*** | .038 | $c^2$ = 46.8% | .729*** | .036 | $e^2$ = 53.2% | 5.23 (6, .51) | .000 |
| Dad control | .611*** | .161 | $h^2$ = 37.3% | .468** | .156 | $c^2$ = 21.9% | .639*** | .062 | $e^2$ = 40.8% | 2.07 (6, .91) | .000 |

*Note.* *A* = additive genetics; *C* = shared environment; *E* = nonshared environment; *SE* = standard error; % variance = proportion variance; RMSEA = root-mean-square error of approximation.
* $p < .05$. ** $p < .01$. *** $p < .001$.



$p < .001$). A similar but attenuated correlation was seen for paternal warmth and paternal control ($r = -0.35$, $p < .001$).

## Multivariate Behavioral Genetic Analyses

**Model trimming.** The full theoretical multivariate twin model is illustrated in Figure 2. Based on univariate models, genetic influences on parental monitoring and genetic influences specific to maternal control were fixed to zero. When estimated freely, the shared environment correlations between maternal warmth and control, and between paternal warmth and control resulted in Heywood cases, and were consequently constrained to −1 (Rindskopf, 1984). This model fit the data well, $\chi^2$ = 105.86(99), $p$ = .30, RMSEA = 0.022, CFI = 0.991, TLI = 0.992. Genetic influences on the factor levels of warmth and control were modest and nonsignificant ($h^2$ = 11.4%, $p$ = .51, for warmth; $h^2$ = 11.2%, $p$ = .48, for control), whereas shared environmental influences were moderate and significant ($c^2$ = 32.9%, $p < .01$, for warmth; $c^2$ = 26.3%, $p < .05$, for control). There was a negligible genetic correlation ($r_A = -0.02$, $p$ = .99) between warmth and control factors, and a moderate (but not significant) shared environmental correlation ($r_C = -0.61$, $p$ = .06). The genetic correlation could be constrained to zero without significant decrement to model fit (Satorro-Bentler scaled $\Delta\chi^2 < 0.001$, $p > .97$). This trimmed model is depicted in Figure 3, and results are summarized in Tables 3 and 4. In the following sections, we consider the results of the trimmed model, beginning with genetic influences, followed by shared environmental influences, and finishing with nonshared environmental influences.

**Shared and unique sources of genetic variance.** A modest contribution of additive genes was estimated for the parental warmth and control factors (representing variance common to both parents; $h^2 \sim 11\%$). When freely estimated, the correlation between these two factors was small and nonsignificant, and was thus constrained to 0 in the final trimmed model. Genetic influences were more concentrated at the level of the individual measures of warmth and control, particularly for paternal variables. For variance unique to fathers (i.e., beyond that shared at the factor level between mother and father), child genotype significantly accounted for paternal warmth ($h^2$ = 49%) and control ($h^2$ = 29%). Residual variance in these paternal measures was also strongly negatively correlated ($r_A = -0.54$), indicating that, despite the lack of common influence at the broader trait level, the same genetically influenced child characteristics are influencing fathers in both warmth and control measures. For variance unique to mothers, child genotype accounted for 21.1% of the variance for maternal warmth, but this estimate was not significantly different from zero ($p$ = .087).

**Shared and unique sources of shared environmental variance.** Shared environmental contributions were significant for parental monitoring ($c^2$ = 35%) and for the warmth and control

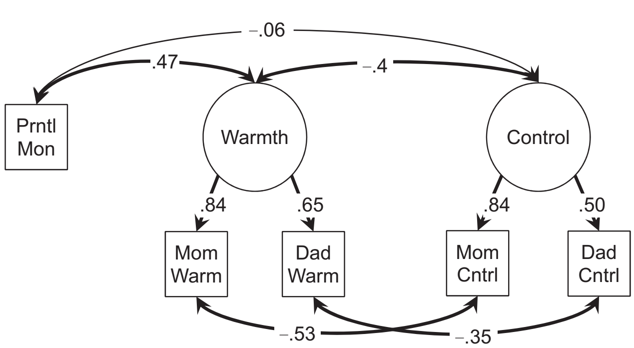


*Figure 1.* Phenotypic confirmatory factor model with standardized estimates. Boldface lines indicate paths significant at the $p < 0.05$ level; warm = warmth; cntrl = control; prntl mon = parental monitoring.

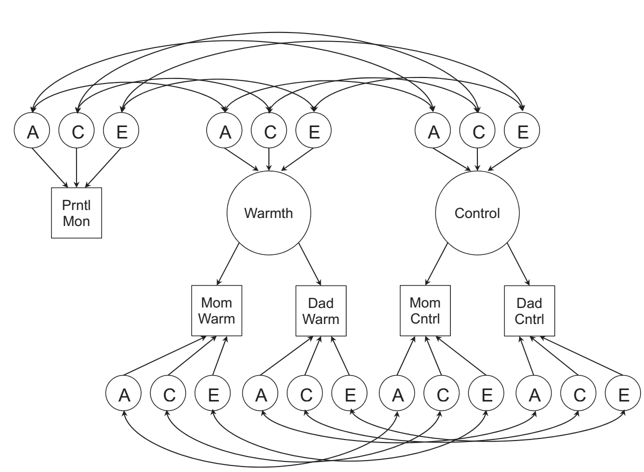


*Figure 2.* Full theoretical multivariate behavioral genetic model. *A* = additive genetics; *C* = shared environment; *E* = nonshared environment; warm = warmth; cntrl = control; prntl mon = parental monitoring.

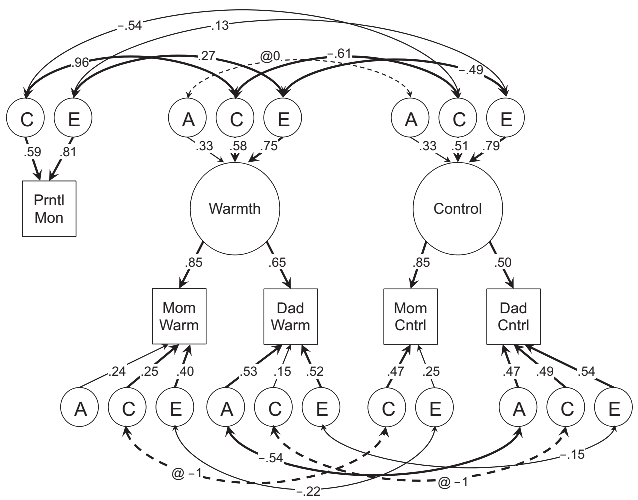


*Figure 3.* Trimmed multivariate behavior genetics model with estimates. $A$ = additive genetics; $C$ = shared environment; $E$ = nonshared environment; boldface lines indicate paths significant at the $p < 0.01$ level; dashed lines are constrained to the indicated value; warm = warmth; cntrl = control; prntl mon = parental monitoring.

factors ($c^2$ = 33.1%, $c^2$ = 26.4%, respectively). Also, the covariance among different parenting dimensions was primarily driven by the shared environment. Families whose children reported more warmth also had children who reported less control ($r_C = -0.614$) and more monitoring ($r_C = 0.956$). Shared environment also significantly contributed to unique variance in maternal warmth ($c^2$ = 22.3%) and control ($c^2$ = 78.2%), as well as unique variance in paternal control ($c^2$ = 32.3%). The correlations between the measures of warmth and control specific to each parent were constrained to −1, indicating that warmth and control for each parent are influenced by synonymous shared environmental aspects. Overall, these results indicate that the shared environment primarily accounts for commonalities between parenting behaviors.

**Shared and unique sources of nonshared environmental variance.** The largest contribution to variance for all parenting dimensions was the nonshared environment (parental monitoring: $e^2$ = 65%; warmth: $e^2$ = 55.8%; control: $e^2$ = 62.6%). Moderate nonshared environmental correlations were detected, with a negative association between warmth and control factors ($r_E = -0.492$) and a positive association between the warmth factor and monitoring ($r_E = 0.273$).[4] For parent-specific warmth and control, the nonshared environment accounted for significant portions of variance in paternal warmth ($e^2$ = 47%) and control ($e^2$ = 39%), as well as maternal warmth ($e^2$ = 57%). Nonshared environmental correlations between parent-specific measures were modest and nonsignificant. This suggests that, at the domain level, there are still substantial differences between how even identical twins within a family are treated. After accounting for these family levels of warmth and control, both parents have further idiosyncrasies (or perceived idiosyncrasies) in their behavior toward their children, with warmth and control having different nonshared environmental influences.

## Discussion

The children-as-twins design provides a unique perspective on child-driven influences on parenting behavior. By applying multivariate children-as-twins models to data collected from a diverse sample of adolescent twins, we evaluated the extent to which child-genetic, shared environmental, and nonshared environmental effects differ in magnitude across parental warmth, control, and monitoring. Moreover, we assessed the extent to which the covariance among parenting domains is driven by environmental factors, such as characteristics of parents themselves leading to adaptive forms of parenting occurring together, and by children's genetically influenced traits, such that the child's traits or behaviors shape multiple aspects of the parenting they receive. We detected modest child-genetic effects for warmth and control factors common across reports on mothers and fathers, and no significant genetic influence on parental monitoring. The covariance among warmth, monitoring, and control was shaped primarily by the shared environment. This indicates that contexts experienced by both twins—such as neighborhood and family environments, parent characteristics, and shared experiences—collectively influence positive parenting behavior, reflected by high levels of warmth and monitoring, as well as low levels of control. That is, parents who are affectionate and supportive toward their children are also more knowledgeable of their whereabouts and less domineering, with family-wide environmental factors driving this constellation of behavior.

### Comparison to Previous Behavioral Genetic Studies of Parenting

Though largely consistent with past literature, the current results differ from previous behavioral genetic studies of parenting in two ways. First, although previous studies have found more consistent support for genetic influences on warmth than on controlling behaviors (Lichtenstein et al., 2003; Plomin, Reiss, Hetherington, & Howe, 1994; Rowe, 1981), significant genetic influences on parental monitoring have been found (Neiderhiser et al., 2004). In contrast, there was no evidence of child genetic effects on monitoring in the current study. However, estimates of heritability on monitoring have been inconsistent, and the lack of genetic influence is not a complete anomaly (Reiss et al., 2000). Furthermore, these estimates appear to depend on reporter, with studies using adolescent reports demonstrating minimal genetic effects, consistent with the current work.

Second, in the current study, genetic influences on fathers were more predominant than mothers. This same pattern has been found in some previous studies (Elkins, McGue, & Iacono, 1997; Plomin et al., 1994); however, meta-analysis of behavioral genetics studies on individual parenting variables found that mothers were more influenced by their children's genetically influenced traits than fathers on average (Klahr & Burt, 2014). These differences in estimates between mothers and fathers in response to child-genetic traits appear to depend on the parenting dimension and reporter (Neiderhiser et al., 2007). Given that previous studies considered mother and father parenting independent of one another, our cur-

[4] Note that this latent correlation between nonshared environmental factors is free of measurement error.

Table 3
*Standardized Estimates and Proportion of Variance Explained for Multivariate Behavioral Genetic Model*

| | Warmth | | | Control | | | Monitoring | | |
|---|---|---|---|---|---|---|---|---|---|
| | Estimate | *SE* | % variance | Estimate | *SE* | % variance | Estimate | *SE* | % variance |
| Maternal factor loadings | .849*** | .064 | | .845*** | .128 | | | | |
| Paternal factor loadings | .646*** | .065 | | .497*** | .103 | | | | |
| Common variance | | | | | | | | | |
| *A* | .334 | .353 | $h^2$ = 11.1% | .331 | .381 | $h^2$ = 11.0% | [0] | | $h^2$ = .0% |
| *C* | .575*** | .160 | $c^2$ = 33.1% | .514** | .193 | $c^2$ = 26.4% | .591*** | .056 | $c^2$ = 35.0% |
| *E* | .747*** | .071 | $e^2$ = 55.8% | .791*** | .080 | $e^2$ = 62.6% | .806*** | .041 | $e^2$ = 65.0% |
| Maternal variance | | | | | | | | | |
| *A* | .243 | .142 | $h^2$ = 21.1% | [0] | | $h^2$ = .0% | | | |
| *C* | .250*** | .077 | $c^2$ = 22.3% | .472*** | .104 | $c^2$ = 78.2% | | | |
| *E* | .398*** | .124 | $e^2$ = 56.6% | .249 | .309 | $e^2$ = 21.8% | | | |
| Paternal variance | | | | | | | | | |
| *A* | .534*** | .047 | $h^2$ = 49% | .467** | .167 | $h^2$ = 28.9% | | | |
| *C* | .152 | .092 | $c^2$ = 3.9% | .493*** | .110 | $c^2$ = 32.3% | | | |
| *E* | .524*** | .064 | $e^2$ = 47.1% | .541*** | .075 | $e^2$ = 38.8% | | | |

*Note.* $\chi^2(df, p)$ = 105.384(100, .337). RMSEA = .020. *A* = additive genetics; *C* = shared environment; *E* = nonshared environment; [0] = path constrained to 0 based on result from preliminary models. Standardized estimates are reported with respect to the total variance. For maternal and paternal variance, percent variance is reported with respect to unique variance.
** $p < .01$. *** $p < .001$.

rent multivariate analysis may have increased sensitivity to dimensional effects after accounting for environments that act on both parents and across dimensions.

## Limitations

A first measurement limitation in this study is the use of the PBI to measure parental warmth and control, as this measure was originally intended to be used as a retrospective report on attachment as opposed to current perceived parenting behaviors (Parker et al., 1979). However, previous work has demonstrated convergent and concurrent validity of the PBI and other measures of parental behavior, particularly for the domain of warmth (Arrindell, Gerlsma, Vandereycken, Hageman, & Daeseleire, 1998; Locke & Prinz, 2002). Moreover, this measure has frequently been used in other behavioral genetic work on parenting (Klahr & Burt, 2014). Furthermore, it should be noted that the correlation between warmth and control may partially reflect common measurement properties, given that these domains were derived from the same instrument, as opposed to parental monitoring.

Additionally, it may be that the negligible associations between control and monitoring further reflects measurement differences. However, a significant correlation was detected between parental

Table 4
*Cross-Dimension ACE Correlations for Multivariate Behavioral Genetics Model*

| Variable | Warmth | Control | Monitoring | Mom warmth | Dad warmth |
|---|---|---|---|---|---|
| $r_A$ | | | | | |
| Warmth | — | | | | |
| Control | [0] | — | | | |
| Monitoring | [0] | [0] | — | | |
| Mom control | | | | [0] | — |
| Dad control | | | | — | −.535** (.193) |
| $r_C$ | | | | | |
| Warmth | — | | | | |
| Control | −.614* (.262) | — | | | |
| Monitoring | .956*** (.275) | −.544 (.280) | — | | |
| Mom control | | | | [−1] | — |
| Dad control | | | | — | [−1] |
| $r_E$ | | | | | |
| Warmth | — | | | | |
| Control | −.492*** (.096) | — | | | |
| Monitoring | .273*** (.063) | .127 (.067) | — | | |
| Mom control | | | | −.220 (.351) | — |
| Dad control | | | | — | −.148 (.146) |

*Note.* *A* = additive genetics; *C* = shared environment; *E* = nonshared environment; [0] = path constrained to 0 based on result from preliminary models; [−1] = path constrained to −1 based on result from preliminary models.
* $p < .05$. ** $p < .01$. *** $p < .001$.

warmth and monitoring, which suggests that measurement properties are not the sole providence of these associations. Although both monitoring and control assess aspects of parenting behavior that is related to restriction, they are conceptually distinct given that they are concerned with different domains (Barber et al., 1994). Phenotypic correlations in previous work demonstrate a modest negative relationship between psychological control and parental monitoring (Pettit, Laird, Dodge, Bates, & Criss, 2001); however, this finding is not consistent across studies, with some indicating little to no correlation between these constructs, concurrently or longitudinally (Smetana & Daddis, 2002). Furthermore, different parenting beliefs contribute to monitoring and control, further underscoring their distinction (Smetana & Daddis, 2002).

Another measurement consideration is the current study's use of adolescent reports on the behavior of their parents. The use of adolescent report may yield higher estimates of nonshared environment due to having multiple reporters (both twins) as opposed to a single informant (the parent). Additionally, concurrent reports of parenting, as compared to retrospective reports, have been associated with higher estimates of the shared environment and lower heritabilities (Klahr & Burt, 2014). This may be a result of children's recollections being influenced by genetically influenced characteristics (Lichtenstein et al., 2003). Moreover, previous univariate behavioral genetic work showed increases in nonshared environment in older-child twin samples (Elkins et al., 1997; Klahr & Burt, 2014). Thus, our use of concurrent adolescent reports on parenting behavior may be reflected in lower heritability estimates and higher estimates of the nonshared environment in the current study compared to previous studies.

With regard to sample composition, twin studies are commonly conducted using racially, ethnically, and socioeconomically homogenous populations. Yet parenting behaviors vary across cultures and across social classes (Deater-Deckard & Dodge, 1997; Weis & Toolis, 2010). For instance, parent's use of control, both behavioral and psychological, appears to differ across Latino and European American families due to differences in cultural and ideological norms (Halgunseth, Ispa, & Rudy, 2006). Additionally, previous twin studies of parenting conducted in different cultural samples have shown child-genetic contributions to parenting to be culturally dependent (Shikishima, Hiraishi, Yamagata, Neiderhiser, & Ando, 2013). As the magnitude of heritability estimates depends on the amount of variation in genetic and environmental factors present in the sample (Maccoby, 2000), the relatively large shared environmental variance (and relatively small heritability estimates) detected in the current study may be the result of using a racially and socioeconomically diverse sample.

Thus, estimates of heritability are bound to the population from which they are derived, and populations of varying compositions from differing contexts may yield different heritability estimates. For instance, a recent meta-analysis on Gene × Socioeconomic Status interactions on the heritability of intelligence detected a significant interaction effect for studies conducted in the United States, but not for studies conducted in other countries (Tucker-Drob & Bates, 2016). This reflects the need to conduct cross-cultural and cross-national research on parenting, in order to examine the contexts in which child-genetic effects are more versus less pronounced.

In order to further refine our understanding of these parent- and child-driven processes, future research may benefit from examining how the pattern of child genetic influence differs across contextual factors, such as socioeconomic status or family structure. For example, one avenue of potential investigation may focus on differing family compositions and structures, which may influence estimates of genetic and environmental variance. Additional work may also consider specific child characteristics—such as personality or psychopathology—that may mediate child-driven influences on parenting.

## Conclusion

The current study helps lays the groundwork for considering parent and child-driven effects on parenting behavior within a multivariate behavioral genetic framework. Although it is readily accepted that bidirectional effects are at play in parenting, the mechanisms and specificity of these effects are relatively unclear. Our results suggest that shared environmental contexts shape a constellation of positive parenting behaviors (high warmth, low control, high monitoring), with child genetic effects more specific to particular parenting behaviors (e.g., warmth) and particular relationships (father vs. mother). These shared environmental effects may include parent characteristics, as well as neighborhood, socioeconomic, or cultural influences that equally affect siblings within the same family. Although behavioral genetic work is often portrayed as focusing exclusively on heritability, results of the current study call for increased attention to both genetic and environmental factors that influence parenting behavior. The current work illuminates the complex, bidirectional influences on parent behaviors within the system of the family, which is key to informing how to understand and shape these systems.

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