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SYNOPSIS

Objective. Caregivers play an important role in child development; in addition to instilling their norms and values in their children through socialization, caregivers modify their parenting practices in response to children's characteristics. Previous studies have documented child genetic effects on parenting behaviors, but multivariate behavioral genetic examinations of parenting are scarce. ***Design***. The current study examined the multivariate structure of child genetic and environmental influences on parenting in a sample of 236 individual twins aged 0–5 years, providing a total of 542 observations. ***Results***. "Shared environments" (between-family environmental differences that are shared by twins reared in the same home, including parental characteristics, family socioeconomic status, and neighborhood characteristics) account for the majority of variation in parenting practices, whereas child genetic effects are more modest and occur more on specific parenting practices. ***Conclusion***. Caregivers generally engage in similar parenting across children reared together and, at the same time, adjust their broad parenting approach and particularly their specific practices in response to genetically driven child characteristics. Future research may benefit from using a multidimensional framework to examine the different components and age-related transformations in these parent-driven and child-driven processes.

INTRODUCTION

Parents play an important socializing role in the development of myriad cognitive, emotional, and behavioral skills during early childhood (Carlson & Corcoran, 2001; Chang, Schwartz, Dodge, & McBride-Chang, 2003; Dubow & Ippolito, 1994; Patterson, Debaryshe, & Ramsey, 1989; Simpkins et al., 2009; Stormshak, Bierman, McMahon, & Lengua, 2000). However, as convincingly argued by Bell (1968), correlations between parenting behaviors and developmental outcomes are not by themselves *prima facie* evidence for socialization effects. Research on parenting skills training provides support for parent-to-child causation (e.g., Eyberg et al., 2001; Taylor & Biglan, 1998; Webster-Stratton, 1994), but child social skills training alone has also been found to improve parenting quality (e.g., Webster-Stratton, Reid, & Hammond, 2004) and provide support for child-to-parent causation. Meta-analyses of univariate studies of parenting practices have also consistently concluded a moderate influence of genetically driven child characteristics on parenting (Avinun & Knafo, 2013; Kendler & Baker, 2007; Klahr & Burt, 2014). In this article, we apply a multivariate, behavioral genetic methodology to address the question: To what extent do broad and narrow dimensions of parenting reflect young children's genetically variable characteristics? We measure multiple correlated parenting behaviors among a twin sample of ages 0–5 years. Specifically, we examine the generality and specificity at which child genetically driven characteristics influence parenting.

"Heritable" Environments

One powerful source of evidence for transactional processes is a behavioral genetic design. The classic twin model uses information from different types of biological relatives (e.g., monozygotic [MZ] twins versus dizygotic [DZ] twins, adoptive siblings versus biological siblings) to decompose variance in a phenotype into three components: variance due to genetic differences (*A*), variance due to environmental differences across kinship pairs (shared environment; [*C*]), and variance due to environmental differences within kinship pairs (non-shared environment; [*E*]). In most cases, this quantitative behavioral genetic approach is used to study child phenotypes, such as cognitive performance or externalizing behaviors. Genetic influences are inferred from the extent to which more genetically related individuals (e.g., MZ twins) are more similar on the phenotype (e.g., aggression) than are less genetically related individuals (e.g., DZ twins). Shared environmental influences are inferred from the extent to which children reared in the same family resemble one another on the phenotype after accounting for their genetic relatedness. Non-shared environmental influences are inferred from the extent to which genetically identical children reared in the same home (i.e., MZ twins reared together) do not perfectly resemble one another on the phenotype. Although less commonly done, this same approach can be applied to *environmental* measures, such as parenting practices. As Plomin (2004, p. 346) quipped, "environments have no DNA." Rather, the "heritable" variation in an environmental measure reflects the extent to which environments have become matched to children's genotypes. For example, when parents alter their parenting practice in response to children's temperament, which is strongly linked to genetic dispositions, this child effect shows up as genetic influences on parenting in a child-based behavioral genetic model.

The influence of children's genes on their environment (e.g., quality of parenting received) is called gene-environment correlation (*r*GE; Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983), in which children select, construct, and evoke environmental experiences on the basis of their genetically influenced dispositions and behaviors. Three forms of *r*GE are frequently discussed (Figure 1). First, genes that children received from their parents also contribute to the environments they are born into; this is called *passive rGE*. For example, hostile or overreacting parents are more likely to pass on genes that put children at risk for difficulties regulating their emotions and, at the same time, create a rearing environment that models emotional dysregulation. Second, persons in a child's environments (e.g., parents or teachers) notice and respond to some genetically driven characteristics unique to the child; this is called *evocative rGE*. For example, parents notice their child's high interest in learning (e.g., genetically disposed to enjoy educational activities, such as reading) and proactively buy more books for him or her. Third, genetic propensities may determine which environment or situation children choose to engage in; this is called *active rGE*. For example, children who have genetically driven proclivities toward engaging with and solving difficult problems may be more likely to pursue educational activities related to natural sciences, thus increasing their likelihood of pursuing careers in science later in life. Evocative and active *r*GE differ in a subtle but important way. In evocative *r*GE, environments change to match the genetically driven characteristics unique to a child without the child's active choice to seek out such

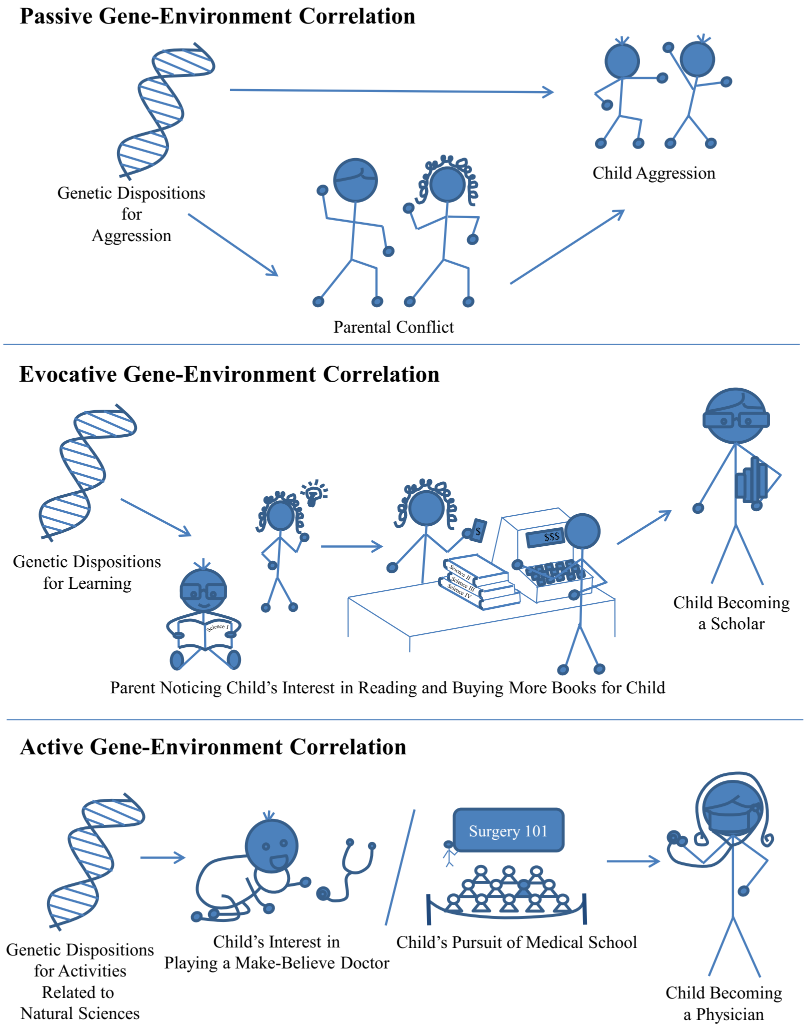

FIGURE 1

Scenarios delineating passive, evocative, and active gene-environment correlations (*r*GE). In the top panel (delineating passive *r*GE), genetic dispositions for aggressive behaviors are expressed both in parents and, after offspring inherited the associated genes, in the children; at the same time, these genetic dispositions for aggressive behaviors contribute to a family environment in which children learn to act aggressively by, for example, observing their parents' aggressive behaviors. In the middle panel (delineating evocative *r*GE), a child's genetic dispositions for learning manifest through his early interest in reading; his mother notices his interest in reading and reinforces it by purchasing more books for him (i.e., his mother responds to his genetically driven behaviors without his active role in asking for such response from her), which facilitates his pursuit of a scholarly career. In the bottom panel (delineating active *r*GE), a child's genetic propensities for engaging with activities related to natural sciences manifest through her early interest in activities such as playing a make-believe doctor as an infant and in pursuing medical school after college, which facilitate her pursuit of a career in medicine (i.e., she proactively seeks experiences that reinforce her genetic dispositions).

accommodations; in active *r*GE, a child proactively selects environments that are congruent with his or her unique, genetically driven characteristics. In a child-based twin design (as opposed to a design looking at parents who are twins), genetic influences on environmental measures capture evocative and active *r*GEs that lead to differentiation of environments by the genotypes of children.

Shared child environmental variation in parenting indicates that both children in a family receive similar parenting, regardless of the children's genetic relatedness. This family-level environmental variation is at least partially driven by the parents' own characteristics (e.g., personality or psychopathology) and by family-level broad contextual factors (i.e., environmental factors in which parents are embedded; e.g., neighborhood characteristics, marital relationships, etc.). Applying child-based behavioral genetic methods to parenting measures helps disentangle parent-driven processes (included in shared environmental variance) from child-driven processes (included in genetic variance and non-shared environmental variance beyond measurement error).

Univariate Behavioral Genetic Studies of Parenting

Avinun and Knafo (2013) meta-analyzed 32 child-based twin studies and found that children's genetically driven characteristics explained 23% of variance in parenting, whereas environmental differences at the family level (i.e., shared environments) and those at the child level (e.g., non-shared environments) explained 43 and 34% of variance in parenting, respectively. Similarly, meta-analyzing 44 genetically informative studies conducted at the child level, Klahr and Burt (2014) observed that 23–40%, 27–39%, and 32–44% of variation in parenting was attributed to children's genetically driven characteristics, shared environments, and non-shared environments, respectively. Although results across studies converge to suggest that children exert a moderate influence on parenting, certain parenting practices are more susceptible to child influences than others. For example, Avinun and Knafo found that, among findings based on parent-report data, affect-based parenting practices (e.g., warmth) were more influenced by genetically driven child characteristics than those related to discipline (e.g., control; 25 versus 11%). Klahr and Burt also observed that genetically driven child characteristics explained a greater portion of individual differences in negativity (40%) than in warmth (26%) and control (23%). These findings indicate that child genetic effects on parenting vary by types of parenting behaviors.

Multidimensional Structure of Parenting

Parenting practices can generally be classified by their hypothesized impact on child development—positive parenting for practices that promote adaptive functioning or negative parenting for those that contribute to maladjustment. Bradley and Caldwell (1995) proposed a multidimensional approach to further classify parenting practices by their function, source, modality, intensity, reactivity, and complexity. For the purpose of this study, we construct a hierarchical structure of parenting practices based on their functions in facilitating or impeding child development: (1) sustenance, which emphasizes children's nutritional needs and physical development; (2) stimulation, which facilitates children's cognitive development; (3) support, which promotes children's regulatory skills and social-emotional adjustment; (4) structure, which emphasizes organization and predictability in relation to children's adaptive functioning; and (5) surveillance, which emphasizes children's safety and welfare.

Conceptual and empirical studies of parenting strongly indicate that distinct parenting practices are correlated at multiple levels and that caregivers modify their behaviors in response to genetically driven characteristics of their children. An outstanding question is whether infants and preschoolers shape parenting uniquely for each specific dimension, or evoke general parenting approaches spanning multiple dimensions and, therefore, contribute to the co-occurrence of distinct parenting practices. If general dimensions of parenting vary by children's genetically influenced characteristics, such child-to-parent effects would be evident as genetic influences on the higher-order parenting style(s). Alternatively, if a specific dimension of parenting varies by children's genetically influenced characteristics, such child-to-parent effects would be evident as genetic influences unique to that particular parenting practice.

The Current Study

Our study uses a twin sample to investigate whether child genetic and environmentally driven characteristics influence broad parenting approaches, specific parenting practices, or both. We first ascertain the phenotypic structure of parenting measures in the current study and then examine the loci of child genetic and environmental influences on parenting within this structure.

METHOD

Participants

Data for the current article came from a downward extension of the Texas Twin Project (Harden, Tucker-Drob, & Tackett, 2013) to the first 5 years of life. Families with twins or multiples of ages 0–5 years who lived in the state of Texas were identified using birth records provided by the Texas Department of State Health Services and then sent a recruitment letter. Recruitment also included attending annual conventions of Texas Mothers of Multiples, sending electronic recruitment letters to associated e-mail list serves, and accepting families for participation who registered on the Texas Twin Project website after hearing about the study from friends or from web searches. Data were collected and managed using a secure, web-based application designed for research data collection and management (Harris et al., 2009). Once a family enrolled in the study, the primary caregiver either received an online survey link that was unique to that particular family or, if he or she preferred, a paper survey. Participating families were sent longitudinal follow-up surveys until the twins or multiples turned 6 years old. Surveys were sent every 2 months after last survey completion for children from birth until 2 years, every 3 months for children between ages 2 and 3 years, every 5 months for children between ages 3 and 5 years, and one last survey after the twins or multiples turned 5 years old. Parenting items were administered only when the twins or multiples were equal to or older than 6 months old.

Recruitment and longitudinal follow-ups for the project are ongoing. For the current study, data were available from 236 individual twins. The average age of twins was 2.50 years (SD = 1.23) at the first survey wave. This twin sample is 73.73%

European American, 4.24% Latin American, 3.39% African American, and 13.56% ethnically mixed. Among these 236 individual twins, 1.69% of their primary caregivers reported the highest completed level of parental education as high school graduate, 8.47% as some college, 34.75% as college graduate, and 55.08% as beyond college. Most of these primary caregivers were the birth mothers of their twins (94.92%).

Zygosity was determined using ratings of physical similarity of twins in a pair; each primary caregiver rated on a 3-point Likert scale ranging from *not alike* to *exactly alike* on four items and on a dichotomous scale on eight other items. Ratings on the four items with a 3-point Likert scale were re-coded to have the same range of possible scores as the eight items with dichotomous scales. One item was reverse-coded so higher scores indicate greater physical similarity. We averaged the ratings on all 12 items for each twin pair to compute an overall score on physical similarity, resulting in a bimodal distribution with a range of 0–1. Pairs with a score of 0–.74 were assigned to be DZ twins and those with a score equal to .75 or higher were assigned to be MZ twins. Zygosity assignment using physical similarity ratings has been found to be highly reliable and comparable to results from DNA sampling (Forget-Dubois et al., 2003; Price et al., 2000; Rietveld et al., 2000). This resulted in our sample of 48 individual MZ twins (22 males and 26 females), 106 same-sex individual DZ twins (44 males and 62 females), 80 opposite-sex individual DZ twins (40 males and 40 females), and 2 individual DZ twins with incomplete sex information (1 male and 1 unreported).

Each family provided data for at least one wave (if the family completed the survey only at the baseline wave) and up to nine different waves (if the family completed the survey at the baseline wave as well as follow-up waves). When available, we included both data collected at the baseline wave and those collected at follow-up waves in our analyses. To account for non-independence of data obtained from the same individual across different survey waves, we used the Complex Survey option in *Mplus* statistical software (Muthén & Muthén, 2010) in all of our structural equation modeling. In other words, we considered observations on the same individual from different survey waves as independent data-points and preserved the precision of our estimates by accounting for potential biases from non-independence of data on the same individual across waves. With 86 individual twins providing observations only at the baseline wave and 150 individual twins providing 150 observations at the baseline wave and 306 observations at follow-up waves, our final sample contains a total of 542 observations. Among these 542 observations, the average age at measurement was 2.44 years ($SD = 1.21$).

Measures

Parental Cognitive Stimulation. Each primary caregiver rated the amount of *daily stimulating interactions* and *learning activities* each of their twins received from them. Twenty-one items on parental cognitive stimulation were created in-house to include activities that are commonly theorized as facilitating children's cognitive development. The 2-factor solution from our exploratory factor analysis (EFA) fit our data reasonably well, χ^2 (274, $N = 540$) = 523.03, $p < .05$, Root Mean Square Error of Approximation (RMSEA) = .03, Bentler's Comparative Fit Index (CFI) = .85, Tucker-Lewis Index (TLI) = .82, with the 2 factors correlating at .33 ($p < .05$). Sample items for *daily stimulating interactions* include "How often do you play peek-a-boo/hide-and-seek or hide a toy for your child to find?" and those for *learning activities* include "How often do you bring your child to outdoor educational activities or field trips (e.g., visiting the zoo, petting farm, science museum, nature center, etc.)?" Primary caregivers provided responses on a 7-point Likert scale ranging from *all the time* to *not at all/not applicable*. All items were reverse-coded so higher scores indicate higher levels of parental cognitive stimulation. Cronbach's alphas were .86 for the 12 items measuring *daily stimulating interactions* and .68 for the eight items measuring *learning activities*.

Parenting Young Children (PARYC). Primary caregivers rated their use of three different parenting practices on each twin separately: *supporting positive behavior, setting limits*, and *proactive parenting*. PARYC contains seven items for each of these three domains and was designed to measure caregivers' self-perceived use of various parenting practices with young children (McEachern et al., 2012). Primary caregivers reported their use of each strategy by marking on a continuum ranging from 0: *not at all* to 100: *most of the time*. Using a sample of 579 infants and preschoolers, McEachern and colleagues found the factor loadings to be moderately high for all PARYC items and a modest to moderate association between PARYC and standardized measures of parenting perceptions, child behaviors, and utilization of community services. Sample items for *supporting positive behavior* include "Reward your child when s/he did something well or showed a new skill," those for *setting limits* include "Stick to your rules and not change your mind," and those for *proactive parenting* include "Give reasons for your requests (such as *we must leave in 5 minutes, so it's time to clean up*)." We averaged the item ratings to obtain a factor score for each of the three domains and higher scores indicate greater use of that particular type of parenting strategies. Cronbach's alphas were .70 for the seven items measuring *supporting positive behavior*, .86 for those measuring *setting limits*, and .91 for those measuring *proactive parenting*.

Emotion Socialization Questionnaire (ESQ). Primary caregivers rated their levels of *emotional support, emotional magnification*, and *emotional neglect* toward each twin on nine items per domain from ESQ. ESQ is a self-report questionnaire adapted from the Emotions as a Child scale (EAC) designed to measure caregivers' reactions to children's expression of sadness, anger, and fear (Klimes-Dougan et al., 2007). Primary caregivers rated how typical they would react in a particular way to children's expression of negative emotions by marking on a continuum ranging from 0: *not at all typical* to 100: *very typical*. We averaged the item ratings for each domain so higher scores indicate greater extent for the primary caregiver to respond in that particular way. Previous work using EAC has found a moderately high correlation between administrations at different times and a moderate Cronbach's alpha for each EAC domain (Garside & Klimes-Dougan, 2002; Klimes-Dougan, Hastings, Granger, Usher, & Zahn-Waxler, 2001). Other studies have found modest to moderate associations between EAC and standardized measures of child behavioral maladjustment (i.e., Child Behavior Checklist, Youth Self-Report, and Teacher's Report Form; Brand & Klimes-Dougan, 2010; O'Neal & Magai, 2005). Sample items for *emotional support* include "Asked my child about it" and "Helped my child deal with the problem;" those for *emotional magnification* include "Got sad myself" when the child was sad and "Got angry with my child" when the child was angry; and those for *emotional neglect* include "Gave my child space to deal with it" and "I didn't respond." Cronbach's alphas were .75 for the nine items measuring *emotional support*, .79 for those measuring *emotional magnification*, and .70 for those measuring *emotional neglect*.

Parenting Scale (PS). Primary caregivers rated their use of three different types of discipline strategies on each twin separately: five items on *laxness-consistent parenting*, five items on *overreactivity*, and three items on *hostility*. PS was designed to measure caregivers' self-perceived use of maladaptive discipline in response to children's different misbehaviors (Arnold, O'Leary, Wolff, & Acker, 1993; Rhoades & O'Leary, 2007). Primary caregivers reported their use of each strategy by marking on a continuum ranging from 0 to 100, of which each end represented an opposite approach. Reitman and colleagues (2001) observed that PS was strongly correlated with standardized measures of other parenting practices and moderately correlated with parental characteristics, such as stress and parenting attitude. Sample items for *laxness* include "When I want my child to stop doing something: (ranging from 0) I firmly tell my child to stop (to 100) I coax or beg my child to stop;" those for *overreactivity* include "When my child misbehaves: (ranging from 0) I usually get into a long argument with my child (to 100) I don't get into an argument;" and those for *hostility* include "When my child misbehaves: (ranging from 0) I rarely use bad language or curse (to 100) I almost always use bad language." We reverse-coded seven items and averaged the item ratings to obtain a factor score for each of the three domains; higher scores indicate greater use of that particular ineffective disciplinary approach to child misbehavior. Cronbach's alphas were .80 for the five items measuring *laxness-consistent parenting*, .82 for the five items measuring *overreactivity*, and .41 for the three items measuring *hostility*. Cronbach's alpha for *hostility* was also lower in Rhoades and O'Leary (2007; i.e., .52 for maternal ratings and .49 for paternal ratings), who applied Spearman-Brown correction and obtained a corrected alpha of approximately .80 if the scale was based on 10 items. Similarly, we applied Spearman-Brown correction and obtained a corrected alpha of .70 for *hostility* if it was measured by 10 items. Moreover, *hostility* measures some severe forms of hostile behaviors toward a child that likely have a low base rate in the population; parents in Rhoades and O'Leary's study and those in our current study endorsed rare use of such parenting practices, which may have contributed to the relatively low alpha for *hostility*. Despite the low ratings on *hostility*, it is important to include this variable in our analyses because of its unique theoretical relevance for child development (Rhoades & O'Leary, 2007). Additionally, because being lax in discipline is indicative of a lack of consistent enforcement of discipline, we renamed *laxness* as *laxness-consistent parenting* in all our structural equation modeling.

Hierarchical Structure of Parenting Variables

Based on the theoretical classification of parenting outlined earlier, we grouped the parenting measures in this study by their impact on child development—*positive parenting* for parenting qualities that are thought to positively influence child development, and *negative parenting* for those that are thought to negatively influence child development. We then categorized the *positive parenting* measures into three domains: (1) *cognitive stimulation*—defined by *daily stimulating interactions* and *learning activities*, both of which facilitate children's cognitive development through engaging their attention and promoting information-processing skills; (2) *warmth*, defined by *supporting positive behavior* and *emotional support*—both of which facilitate children's social and emotional adjustment through promoting effective regulatory and coping skills; and (3) *structured parenting*—defined by *setting limits, proactive parenting*, and *laxness-consistent* *parenting*, all of which facilitate children's adaptive functioning through creating a predictable environment and promoting organizational skills. Similarly, we categorized the *negative parenting* measures into two domains: (1) *maladaptive emotional socialization*—defined by *emotional magnification* (i.e., matching children's negative emotional display) and *emotional neglect* (i.e., ignorance and indifference to children's negative emotional display), both of which impede children's social and emotional adjustment through modeling ineffective approaches to stress and dismissing their emotional needs; and (2) *escalation*—defined by *overreactivity* and *hostility*, both of which impede children's adaptive functioning through creating an unstable environment and modeling ineffective problem-solving skills.

RESULTS

Data Preparation and Descriptive Statistics

Depending on the degree of skewness, data for several variables were either square-root or log transformed to better conform to a normal distribution (Table 1). Additionally, because estimates from twin designs can be biased by influences of age and sex on phenotypes examined (McGue & Bouchard, 1984), we partialled out the linear and quadratic effects of age, sex, and the interactions of age and sex on all variables using multiple regression analyses prior to structural equation modeling (see supplementary table for unstandardized coefficients from these regression models). Table 2 provides the descriptive statistics and the correlation matrix for all 11 parenting variables. All positive parenting measures were moderately and positively correlated with each other, as were all the negative parenting measures. Correlations between positive and negative parenting measures were generally negative and moderate in magnitude. Table 2 also lists the number of observations available for each parenting variable.

Genetic and Environmental Contributions to Parenting Measures

To examine child genetic and environmental effects on primary caregivers' parenting behaviors, we analyzed our data with structural equation modeling using full-information maximum likelihood estimation in *Mplus* statistical software (Muthén

TABLE 1
Skewness Statistics of Variables Before and After Transformations

	Before			After	
	Kurtosis (*SE*)	Skewness (*SE*)	Transformation	Kurtosis (*SE*)	Skewness (*SE*)
Emotional support	.33 (.22)	−.85 (.11)	Square-root	−.81 (.22)	.09 (.11)
Laxness-consistent parenting	3.49 (.22)	1.27 (.11)	Square-root	−.35 (.22)	.04 (.11)
Emotional magnification	2.05 (.22)	1.27 (.11)	Square-root	−.31 (.22)	.36 (.11)
Emotional neglect	3.25 (.22)	.55 (.11)	Square-root	.41 (.22)	−.48 (.11)
Overreactivity	.19 (.22)	.77 (.11)	Square-root	−.12 (.22)	−.12 (.11)
Hostility	5.76 (.22)	2.17 (.11)	Log	−.84 (.22)	.23 (.11)

TABLE 2
Descriptive Statistics (Before Transformation and Standardization) and Correlations Between Parenting Measures

		N	*M* (*SD*)	1	2	3	4	5	6	7	8	9	10
1	Daily stimulating interactions	540	4.08 (1.39)	–									
2	Learning activities	540	3.78 (.92)	.49***	–								
3	Supporting positive behavior	510	81.69 (11.72)	.45***	.40***	–							
4	Emotional support	508	89.36 (8.90)	.20***	.19***	.39***	–						
5	Setting limits	506	77.47 (16.02)	.33***	.36***	.66***	.35***	–					
6	Proactive parenting	504	76.18 (20.62)	.54***	.30***	.59***	.37***	.74***	–				
7	Laxness-consistent parenting	494	19.61 (15.22)	−.19***	−.18***	−.42***	−.29***	−.52***	−.35***	–			
8	Emotional magnification	506	11.68 (11.02)	.06	−.03	−.25***	−.28***	−.32***	−.08	.22***	–		
9	Emotional neglect	508	21.03 (10.92)	.22***	.06	.03	−.14**	.05	.11*	.04	.28***	–	
10	Overreactivity	496	22.08 (16.58)	.16***	−.15**	−.27***	−.23***	−.35***	−.07	.15**	.55***	.25***	
11	Hostility	498	6.45 (8.78)	.04	−.05	−.16***	−.26***	−.19***	−.06	.09*	.37***	.22***	.50***

Note. *N* for each variable represents the number of observations available on that particular variable in our univariate analyses.
*$p < .05$; **$p < .01$; ***$p < .001$.

& Muthén, 2010). Rather than list-wise deletion of data from participants with only partial data, full-information maximum likelihood estimation in *Mplus* capitalizes on all available data under the assumption that any systematic patterns of missingness related to unobserved scores on the outcome variables are statistically accounted for by the available data included in the model. We first fit a univariate *ACE* model to each parenting measure to examine child genetic and environmental contributions to parenting. Variance in each parenting measure was decomposed into a linear combination of three biometric components: *A*, *C*, and *E*. Cross-twin correlations between corresponding *A*s were fixed to 1 for MZ twins, who share nearly all of their segregating genetic materials, and to .5 for DZ twins, who, on average, share approximately half of their segregating genetic materials. Cross-twin correlations between corresponding *C*s were fixed to 1 for all twin pairs. *E*s were uncorrelated.

In the context of this child-based design, in which the *A*, *C*, and *E* factors at the child level were fit to child experiences instead of child phenotypes, the interpretations of these factors are somewhat novel. *A* represents variation in parenting that associates with genetically driven child characteristics. *C* represents variation in parenting that associates with child environmental factors that contribute to similarities in parenting across children reared together. As Klahr and Burt (2014) described,

> shared environmental influences on parenting at the level of the child include such potentially important factors as the family's socioeconomic status, neighborhood characteristics, and culture. However, they also include the effects of parental characteristics (e.g., parent personality and other genetically influenced characteristics), at least to the extent that these characteristics create similarities in parenting across children regardless of the siblings' genetic relatedness. (p. 573)

E represents variation in parenting that associates with non-genetic differences between siblings in a pair as well as any measurement error. Measurement error, as its name implies, occurs only to variables at the measurement level. Therefore, *E* influences operating at the latent-factor levels suggest that primary caregivers consistently treat each twin differently due to environmental factors that are unique to each twin.

Results from the univariate *ACE* model are presented in Figure 2, which indicate that parenting practices are largely, although not exclusively, influenced by shared environmental factors (i.e., factors at the child level that contribute to similarities in parenting across twins reared together, after accounting for the twins' genetic relatedness). Although the estimates for child genetic effects on *laxness-consistent parenting* and *emotional neglect* did not reach statistical significance, these univariate findings indicate a general presence of child genetic influences on parenting. Univariate findings also indicate the presence of non-shared environmental variation in parenting behaviors. However, it is important to note that, in these univariate models, non-shared environmental influences include measurement error. To the extent that non-shared environmental variation exists beyond measurement error, this means that caregivers, to some extent, treat their twins differently for reasons unrelated to the twins' genetically influenced characteristics but possibly environmentally driven ones. In sum, the univariate results indicate that parenting largely reflects broad contextual and parental characteristics and, at the same time, varies within families for both genetic and non-genetic reasons.

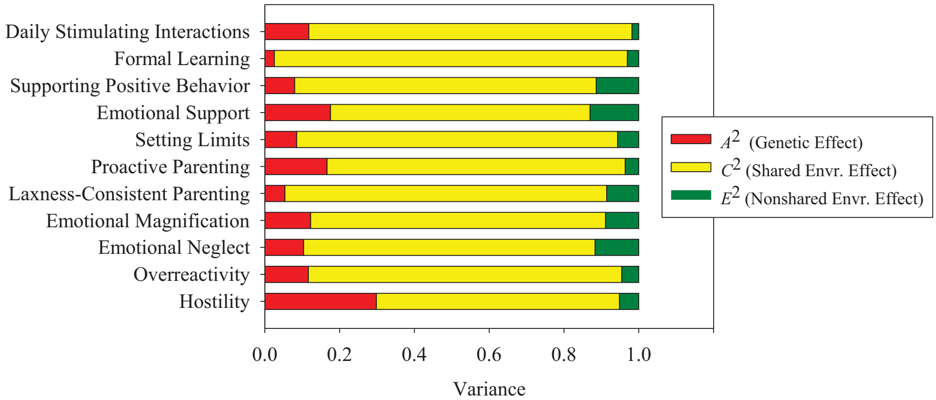

FIGURE 2

Proportion of total variance in each parenting measure explained by child genetic and environmental factors. Shared Envr. Effect: shared environmental effect. Non-shared Envr. Effect: non-shared environmental effect. All parameter estimates are standardized. All parameter estimates, except for child genetic effects on *laxness-consistent parenting* and *emotional neglect*, are statistically significant at $p < .05$.

Hierarchical Structure of Parenting

To ascertain the multivariate structure of the parenting measures employed, we conducted two confirmatory factor analyses (CFAs) at the phenotypic level. We first fit a model with only one level of latent factors representing the five hypothesized domains of parenting (CFA 1) and estimated the loadings of our parenting measures on these factors and the correlations among the five factors. A χ^2 goodness-of-fit test indicated that CFA 1 fit our data reasonably well, χ^2 (34, N = 540) = 90.94, $p < .01$, Maximum Likelihood Robust (MLR) scaling = 2.15, Akaike Information Criterion (AIC) = 14092.52, Bayesian Information Criterion (BIC) = 14277.05, RMSEA = .06, CFI = .92, TLI = .87. Correlations observed among the five domains of parenting are consistent with the existence of two higher-order dimensions—*positive parenting* and *negative parenting* (Table 3). We then fit a hierarchical model with five latent factors representing our parenting domains and two additional higher-order factors representing the clustering of these domains (CFA 2), which also fit our data well, χ^2 (38, N = 540) = 89.55, $p < .01$, MLR scaling = 2.33, AIC = 14097.70, BIC = 14265.07, RMSEA = .05, CFI = .93, TLI = .89. Results from CFA 2 are consistent with our proposed structure of parenting. A χ^2 goodness-of-fit comparison indicates that CFA 1 and CFA 2 fit our data equivalently well, $\Delta\chi^2$ = 3.41, Δdf = 4, $p > .05$ (see Table 3 for parameter estimates from both CFAs). CFA 2, being more parsimonious, is, therefore, the preferred phenotypic model in representing the multivariate structure of the parenting variables. This general pattern was also supported by results from our *post-hoc* EFA, which indicated that a 2-factor solution, χ^2 (34, N = 540) = 144.67, $p < .01$, MLR scaling = 2.01, AIC = 14187.74, BIC = 14372.27, RMSEA = .08, CFI = .84, TLI = .75, fit our data better than a 1-factor solution, χ^2 (44, N = 540) = 245.03, $p < .01$, MLR scaling = 2.37, AIC = 14458.53, BIC = 14600.15, RMSEA = .09, CFI = .72, TLI = .64, $\Delta\chi^2$ = 80.56, Δdf = 10, $p < .01$, with the correlation between the two factors estimated at –.46, $p < .05$. Table 4 lists the factor loadings estimated from these EFA solutions.

TABLE 3
Parameter Estimates (With Confidence Interval in Brackets) From Phenotypic Confirmatory Factor Analyses

Subordinate measures/factors		Higher-order factors	CFA 1	CFA 2[a]
Daily stimulating interactions	ON	Cognitive stimulation	.80 [.65, .94]***	.80 [.67, .93]***
Learning activities			.71 [.57, .85]***	.71 [.57, .84]***
Supporting positive behavior		Warmth	.78 [.67, .88]***	.78 [.68, .88]***
Emotional support			.50 [36, .64]***	.50 [.36, .64]***
Setting limits		Structured parenting	.94 [.89, .99]***	.94 [.88, 99]***
Proactive parenting			.80 [.74, .86]***	.80 [.74, .86]***
Laxness-consistent parenting			−.53 [−.65, −.40]***	−.53 [−.65, −.40]***
Emotional magnification		Maladaptive emotional socialization	.87 [.48, 1.25]***	.89 [.49, 1.29]***
Emotional neglect			.31 [.15, .48]***	.30 [.13, .47]***
Overreactivity		Escalation	.86 [.74, .97]***	.85 [.73, .97]***
Hostility			.56 [.43 .69]***	.56 [.44, .69]***
Cognitive stimulation		Positive parenting	–	.62 [.44, .80]***
Warmth				1.09 [.94, 1.23]***
Structured parenting				.82 [.70, .93]***
Maladaptive emotional socialization		Negative parenting	–	.70 [.40, .99]***
Escalation				.96 [.79, 1.13]***
Cognitive stimulation	WITH	Warmth	.69 [.48, .89]***	–
		Structured parenting	.50 [.31, .69]***	
		Maladaptive emotional socialization	−.17 [−.36, .02]	
		Escalation	−.43 [−.60, −.27]***	
Warmth		Structured parenting	.89 [.72, 1.05]***	
		Maladaptive emotional socialization	−.55 [−.85, −.25]***	
		Escalation	−.70 [−.86, −.24]***	
Structured parenting		Maladaptive emotional socialization	−.41 [−.59, −.24]***	
		Escalation	−.54 [−.71, −.37]***	
Maladaptive emotional socialization		Escalation	.68 [.36, 1.01]***	
Positive parenting		Negative parenting	–	−.68 [−.86, −.51]***

Note. CFA 1: Phenotypic confirmatory factor analysis with one level of higher-order parenting factors. CFA 2: Phenotypic confirmatory factor analysis with two levels of higher-order parenting factors.
***$p < .001$.
[a]Preferred model.

Genetic and Environmental Contributions to Parenting at Broad and Specific Dimensions

Having identified the structure of parenting that best fit the phenotypic data, we fit two multivariate common and specific *ACE* factors models to examine the distribution of child genetic and environmental influences within this structure of parenting. We first tested the model with independent pathways representing domain-general genetic and environmental influences across the five domains of parenting (Model 1; Figure 3). The

TABLE 4
Loading Estimates (With Confidence Interval in Brackets) From Exploratory Factor Analysis

		EFA 1[a]		EFA 2
Parenting measures		Factor 1	Factor 2	Single factor
Daily stimulating interactions	ON	.45 [.15, .75]*	−.06 [−.42, .29]	.50 [.36, .65]*
Learning activities		.45 [.16, .74]*	<.01 [−.31, .31]	.46 [.29, .62]*
Supporting positive behavior		.67 [.40, .95]*	−.14 [−.39, .11]	.77 [.71, .83]*
Emotional support		.25 [−.36, .86]	−.41 [−.78, −.04]*	.50 [.36, .64]*
Setting limits		.90 [.82, .98]*	<.01 [−.08, .08]	.86 [.80, .92]*
Proactive parenting		.87 [.71, 1.03]*	.13 [.01, .24]*	.76 [.68, .85]*
Laxness-consistent parenting		−.46 [−.75, −.16]*	.14 [−.13, .41]	−.55 [−.68, −.42]*
Emotional magnification		−.07 [−.85, .71]	.64 [.24, 1.04]*	−.45 [−.59, −.30]*
Emotional neglect		.20 [−.25, .66]	.45 [.21, .67]*	−.07 [−.24, .11]
Overreactivity		−.24 [−.99, .51]	.61 [.20, 1.02]*	−.59 [−.74, −.45]*
Hostility		.08 [−.69, .85]	.67 [.32, 1.01]*	−.32 [−.48, −.16]*

Note. EFA 1: Two-factor solution of our phenotypic exploratory factor analysis.
EFA 2: One-factor solution of our phenotypic exploratory factor analysis. In EFA 2, Factor 1 and Factor 2 are correlated at −.46, $p < .05$.
*$p < .05$.
[a]Preferred solution.

measure-specific (residual) variance of each specific parenting measure was decomposed into the three biometric components *A, C*, and *E* as described earlier, and variance in each broad parenting factor was constrained to be fully explained by nine components by way of a higher-order independent pathways structure: a general set of *A, C*, and *E* factors on which all five broad factors loaded (i.e., A_c, C_c, and E_c); *separate A, C*, and *E* factors representing either *positive* or *negative parenting* on which its subordinate broad factors loaded (i.e., A_p, C_p, E_p, A_n, C_n, and E_n); and *A, C*, and *E* factors specific to each broad parenting factor. A χ^2 goodness-of-fit test indicated that Model 1 fit our data well, χ^2 (444, $N = 271$) = 824.16, $p < .01$, MLR scaling = 1.07, AIC = 10432.13, BIC = 10813.95, RMSEA = .08, CFI = .93, TLI = .92.

We then fit a common pathways model in which we constrained the influences of A_p, C_p, and E_p to manifest through the higher-order factor *positive parenting* and those of A_n, C_n, and E_n to manifest through *negative parenting*, χ^2 (462, $N = 271$) = 822.91, $p < .01$, MLR scaling = 1.08, AIC = 10406.60, BIC = 10723.59, RMSEA = .08, CFI = .93, TLI = .93 (Model 2; Figure 4). Correlations between corresponding *A*s, *C*s, and *E*s on *positive parenting* and *negative parenting* were calculated to examine the child genetic and environmental influences common to both factors. Models 1 and 2 fit our data equivalently well, $\Delta\chi^2 = 7.27$, $\Delta df = 18$, $p > .05$. Model 2, being more parsimonious, is, therefore, the preferred behavioral genetic model in representing the distribution of child genetic and environmental influences within our hypothesized multivariate structure of parenting. Our results suggest that influences of *A, C*, and *E* common to multiple parenting domains are best represented by common pathways. Parameter estimates from the two multivariate *ACE* models are listed in Tables 5–8.

Figure 5 illustrates the results from the preferred multivariate *ACE* model (Model 2). Similar to the CFA results at the phenotypic level, this model indicated that the parenting measures could be categorized into five different domains, which formed two

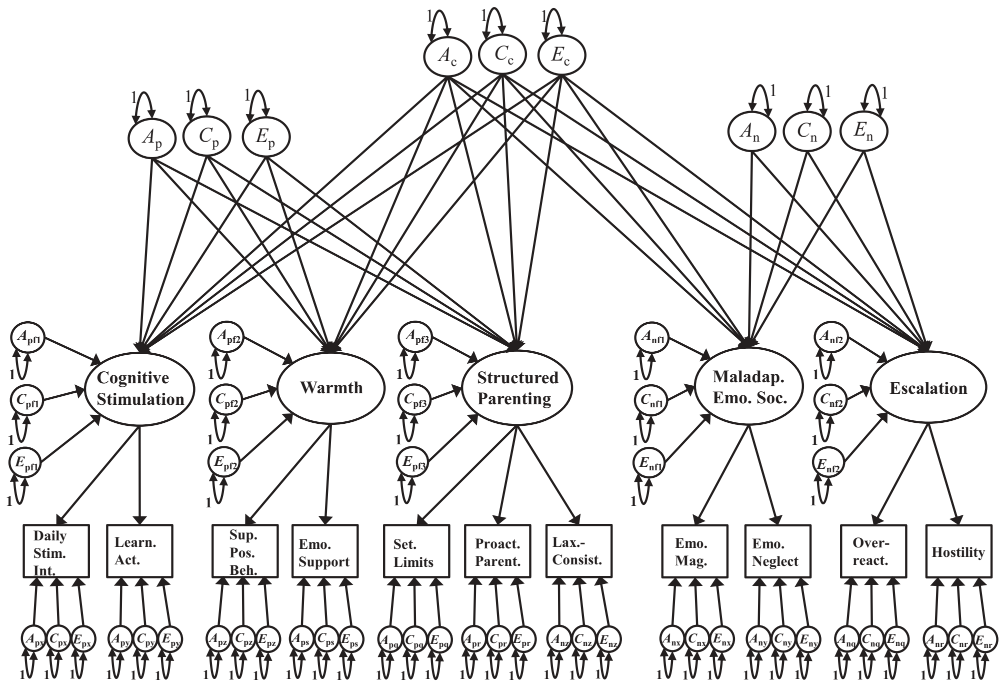

FIGURE 3
Multivariate independent pathways model (i.e., Model 1). Maladap. Emo. Soc.: maladaptive emotional socialization; Daily Stim. Int.: daily stimulating interactions; Learn. Act.: learning activities; Sup. Pos. Beh.: supporting positive behavior; Emo. Support: emotional support; Set. Limits: setting limits; Proact. Parent.: proactive parenting; Lax.-Consist.: laxness-consistent parenting; Emo. Mag.: emotional magnification; Emo. Neglect: emotional neglect; Overreact.: overreactivity.

clusters (Table 5), namely *positive parenting* and *negative parenting*. Shared environmental variance was .95 for *positive parenting* and .91 for *negative parenting*, and the correlation between C_p and C_n was –.76. Orthogonal to the shared environmental factors observed at the broadest level, shared environmental variance unique to *cognitive stimulation, structured parenting*, and *maladaptive emotional socialization* was .59, .26, and .47, respectively. At the measurement level, shared environmental variance unique to a given parenting measure was .15–.70, except that of *setting limits and emotional magnification* did not reach statistical significance.

We also observed some significant, albeit more modest, genetic influences at multiple levels in our multivariate structure of parenting. Genetic variance was .04 for *positive parenting* and .09 for *negative parenting*. Child genetic correlation between *positive parenting* and *negative parenting* was .66 but did not reach statistical significance ($p = .05$). Additional to the genetic variance observed at the broadest level, we observed a genetic variance of .03 unique to *cognitive stimulation*. Above and beyond these child genetic influences observed at the latent levels, genetic variance unique to a given parenting measure was .08 for *daily stimulating activities*, .16 for *emotional support*, .11 for *proactive parenting*, .06 for *overreactivity*, and .28 for *hostility*.

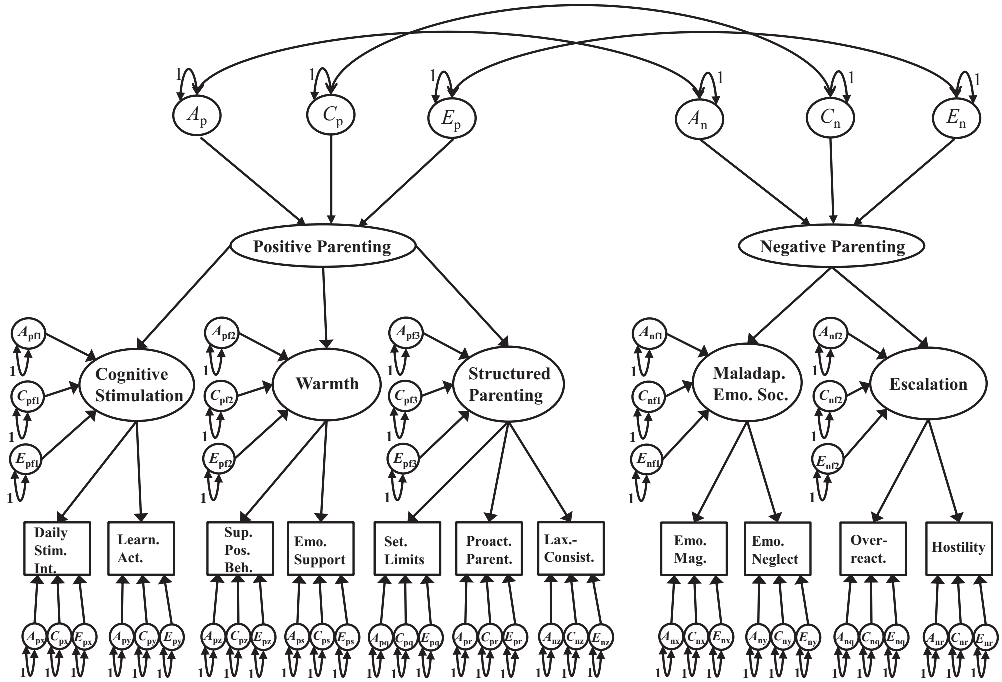

FIGURE 4
Multivariate common pathways model (i.e., Model 2). Maladap. Emo. Soc.: maladaptive emotional socialization; Daily Stim. Int.: daily stimulating interactions; Learn. Act.: learning activities; Sup. Pos. Beh.: supporting positive behavior; Emo. Support: emotional support; Set. Limits: setting limits; Proact. Parent.: proactive parenting; Lax.-Consist.: laxness-consistent parenting; Emo. Mag.: emotional magnification; Emo. Neglect: emotional neglect; Overreact.: overreactivity.

Similar to child genetic influences, child non-shared environmental influences were also observed at multiple levels in our multivariate structure of parenting. At the broadest level, child non-shared environmental variance was .01 for both *positive parenting* and *negative parenting*, and these non-shared environmental factors were correlated at –1.00. Orthogonal to the child non-shared environmental influences observed at the broadest level, we observed a non-shared environmental variance of .05 unique to *maladaptive emotional socialization*. Child non-shared environmental variance unique to a given parenting measure was .02–.13, except that of *emotional magnification* did not reach statistical significance. As discussed earlier, non-shared environmental factors at the measurement level include measurement error.

DISCUSSION

Behavioral genetic research has consistently observed modest to moderate child genetic influences on parenting and varying heritability across distinct but correlated parenting behaviors; a logical next step is to examine the generality or specificity of children's influences across multiple parenting practices. Although the socialization literature has pointed to a multidimensional structure along which parenting quality affects early

TABLE 5
Standardized Loading Estimates (With Confidence Interval in Brackets) From Behavioral Genetic Models

Subordinate measures/factors		Higher-order factors	Model 1	Model 2[a]
Daily stimulating interactions	ON	Cognitive stimulation	.86 [.59, 1.13]***	.84 [.68, .99]***
Learning activities			.65 [.32, .97]***	.67 [.49, .85]***
Supporting positive behavior		Warmth	.81 [.73, .89]***	.83 [.75, .90]***
Emotional support			.50 [.37, .64]***	.50 [.36, .64]***
Setting limits		Structured parenting	.94 [.89, .1.00]***	.94 [.88, 1.00]***
Proactive parenting			.80 [.73, .86]***	.80 [.74, .86]***
Laxness-consistent parenting			−.51 [-.65, -.36]***	−.51 [-.66, -.37]***
Emotional magnification		Maladaptive emotional socialization	.98 [.29, 1.67]**	.91 [.48, 1.33]***
Emotional neglect			.27 [.04, .49]*	.30 [.13, .48]**
Overreactivity		Escalation	.87 [.74, .99]***	.87 [.75, .99]***
Hostility			.55 [.43, .68]***	.54 [.42, .67]***
Cognitive stimulation		Positive parenting	–	.62 [.43, .80]***
Warmth				.99 [.92, 1.06]***
Structured parenting				.84 [.72, .95]***
Maladaptive emotional socialization		Negative parenting	–	.67 [.38, .97]***
Escalation				.94 [.75, 1.13]***

Note. Model 1: Multivariate independent pathways model.
Model 2: Multivariate common pathways model.
*$p < .05$; **$p < .01$; ***$p < .001$.
[a]Preferred model.

child development, child genetic and environmental influences on parenting have not been decomposed along similar scales. Our study used a multivariate behavioral genetic method to examine the loci of child genetic and environmental influences on parenting.

We observed shared environmental influences on both broad and specific dimensions of parenting. In this child-based study, shared environments represent environmental factors that contribute to consistent parenting across children reared together. Therefore, our results suggest that much variation in parenting is attributed to broad contextual factors (i.e., environments in which parents are embedded; e.g., socioeconomic status, cultural background, and family dynamics) and/or parental characteristics (e.g., parent's experience as a child, values, expectations, and personality). Such shared environmental influences were detected at all levels of generality and specificity: shared child environmental variance was .04–.64 at the domain-general dimensions and .15–.70 at the measure-specific dimension. On average, 30% of shared child environmental influences on a given measure were located at the broad dimensions (*range* = 0–79%) and 40% of those were located at the measurement level (*range* = 0–98%). At the broadest level, the strong and negative correlation between shared environmental effects on *positive parenting* and those on *negative parenting* suggests that a substantial portion of these broad contextual and parental influences exerts contrary effects on these two parenting styles (e.g., promoting parenting behaviors that are thought to positively influence child development while discouraging those that are thought to negatively influence child

TABLE 6
Standardized Parameter Estimates of A_c, C_c, E_c, A_p, C_p, E_p, A_n, C_n, and E_n Influences (With Confidence Interval in Brackets)

	Effects of	Model 1	Effects of	Model 1	Model 2[a]
Cognitive stimulation	A_c	.07 [−.31, .46]	A_p	.21 [.07, .35]**	–
Warmth		−.15 [−1.13, .83]		.16 [−.06, .38]	
Structured parenting		−.07 [−.44, .30]		.15 [−.17, .46]	
Positive parenting		–		–	.10 [.03, .18]**
Cognitive stimulation	C_c	.59 [.33, .85]***	C_p	.78 [.58, .98]***	–
Warmth		.96 [.85, 1.07]***		.08 [−.39, .55]	
Structured parenting		.84 [.70, .97]***		−.06 [−.49, .37]	
Positive parenting		–		–	.50 [.35, .66]***
Cognitive stimulation	E_c	−.03 [−.23, .16]	E_p	.01 [−.32, .35]	–
Warmth		.02 [−1.65, 1.68]		.15 [−.16, .46]	
Structured parenting		−.06 [−.81, .70]		.07 [−.49, .64]	
Positive parenting		–		–	.05 [.02, .08]**
Maladaptive emotional socialization	A_c	.28 [−.19, .75]	A_n	.22 [−.65, 1.09]	–
Escalation		−.04 [−.99, .91]		.24 [.10, .38]**	
Negative parenting		–		–	.29 [.18, .41]***
Maladaptive emotional socialization	C_c	−.43 [−.74, −.12]**	C_n	.46 [−.05, .97]	–
Escalation		−.67 [−.82, −.51]***		.55 [.41, .69]***	
Negative parenting		–		–	.95 [.92, .99]***
Maladaptive emotional socialization	E_c	−.06 [−1.00, .87]	E_n	.22 [.07, .38]**	–
Escalation		.03 [−.17, .23]		.05 [−.02, .12]	
Negative parenting		–		–	.09 [.02, .15]*

Note. Model 1: Multivariate independent pathways model.
Model 2: Multivariate common pathways model. In Model 2, A_p and A_n were correlated at .66 [−.01, 1.32], $p > .05$, C_p and C_n at −.76 [.57, .96], $p < .001$, and E_p and E_n at −1.00 [>−1.01, <−.99], $p < .001$.
*$p < .05$; **$p < .01$; ***$p < .001$.
[a]Preferred model.

development). We also uncovered domain-specific shared environmental influences on *cognitive stimulation*, *structured parenting*, and *maladaptive emotional socialization*, and myriad shared environmental factors at the measurement level. Simply put, some broad contextual and parental characteristics contribute broadly to overall parenting style, whereas others contribute uniquely to a particular domain of parenting or a specific parenting practice.

In contrast to the large and ubiquitous influences of child shared environmental factors across levels of analysis, child genetic influences were more modest. At the broadest level, our results suggest that caregivers somewhat alter their general parenting approaches in response to child characteristics driven by genes. We also observed child genetic influences unique to *cognitive stimulation*, a factor common to *daily stimulating interactions* and *learning activities*. This finding suggests that a non-trivial portion of variation in the amount of cognitive stimulation parents provide to their young

TABLE 7
Standardized Parameter Estimates of Domain-Specific *A*, *C*, and *E* Influences (With Confidence Interval in Brackets)

Effect of			Model 1	Model 2[a]
A	Uniquely On	Cognitive stimulation	<.01 [>−.01, <.01]	.16 [.08, .25]***
		Warmth	<.01 [>−.01, .01]	.10 [−.82, 1.02]
		Structured parenting	.19 [−.10, .48]	.19 [−.07, .46]
		Maladaptive emotional socialization	<.01 [−.01, .01]	.14 [−.76, 1.04]
		Escalation	<.01 [−.01, .01]	<.01 [>−.01, <.01]
C		Cognitive stimulation	−.01 [−.05, .04]	.77 [.63, .91]***
		Warmth	<.01 [>−.01, <.01]	<.01 [>−.01, <.01]
		Structured parenting	.48 [.22, .73]***	.51 [.31, .72]***
		Maladaptive emotional socialization	.65 [.04, 1.26]*	.69 [.35, 1.03]***
		Escalation	.43 [.24, .62]***	.34 [−.18, .86]
E		Cognitive stimulation	<.01 [>−.01, <.01]	<.01 [>−.01, <.01]
		Warmth	<.01 [>−.01, <.01]	.08 [-.35, .51]
		Structured parenting	<.01 [>−.01, <.01]	<.01 [>−.01, <.01]
		Maladaptive emotional socialization	<.01 [>−.01, <.01]	.23 [.04, .42]*
		Escalation	<.01 [>−.01, <.01]	<.01 [>−.01, <.01]

Note. Model 1 = Multivariate independent pathways model. Model 2 = Multivariate common pathways model.
*$p > .05$. **$p < .01$. ***$p < .001$.
[a]Preferred model.

children is attributed to child genetically linked characteristics that are independent from those broadly influencing overall parenting style. It is plausible that parents adjust their supply of cognitive stimulation to children's genetically disposed aptitude and interest (Tucker-Drob & Harden, 2012a; Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011). For example, children with genetic propensities for fast learning may find a diverse range of cognitive stimulation intriguing, whereas those with genetic propensities for slow learning may find it overwhelming. Other genetically driven child characteristics, such as openness, may also affect children's receptiveness to learning a wide range of information and may, in turn, reinforce or discourage parents' supply of cognitive stimulation. More research is required to clarify these child genetic influences on amount of cognitive stimulation received. Measure-specific child genetic influences were detected on *daily stimulating activities, emotional support, proactive parenting, overreactivity*, and *hostility*. These child genetic influences at the measurement level suggests that child genetic influences on parenting also occur via characteristics that cause caregivers to individually modify different specific parenting practices, above and beyond caregivers' overall parenting style.

Our overall findings on child genetic contribution to parenting are consistent with those from previous studies (e.g., Avinun & Knafo, 2013; Boivin et al., 2005; Button, Lau, Maughan, & Eley, 2008; Klahr & Burt, 2014; Knafo & Plomin, 2006; Neiderhiser et al., 2004; Pike, McGuire, Hetherington, Reiss, & Plomin, 1996; Plomin, Reiss, Hetherington, & Howe, 1994), all of which indicate that parents alter their parenting practices in response to genetically driven child characteristics. Importantly, our multivariate results add to the parenting literature by illustrating that child genetic influences operate on not only specific parenting behaviors (child genetic variance unique to a measure = .06–.28) but also broad dimensions of parenting, albeit to a much smaller

TABLE 8
Standardized Parameter Estimates of Measure-Specific *A*, *C*, and *E* Influences (With Confidence Interval in Brackets)

Effect of			Model 1	Model 2[a]
A	Uniquely On	Daily stimulating interactions	.26 [.11, .41]**	.27 [.16, .39]***
		Learning activities	.13 [−.09, .34]	.13 [−.07, .32]
		Supporting positive behavior	.22 [−.24, .68]	.21 [−.25, .66]
		Emotional support	.39 [.11, .67]**	.40 [.15, .65]**
		Setting limits	.18 [−.06, .42]	.16 [−.11, .43]
		Proactive parenting	.33 [.14, .52] **	.33 [.15, .51]***
		Laxness−consistent parenting	.22 [−.08, .52]	.23 [−.06, .51]
		Emotional magnification	.06 [−3.44, 3.33]	.26 [−.17, .70]
		Emotional neglect	.32 [−.02, .66]	.31 [−.03, .65]
		Overreactivity	.27 [.07, .46]**	.24 [.05, .44]*
		Hostility	.52 [.34, .70]***	.53 [.35, .71]***
C		Daily stimulating interactions	.42 [−.10, .93]	.46 [.16, .75]**
		Learning activities	.73 [.46, 1.00]***	.71 [.55, .88]***
		Supporting positive behavior	.44 [.29, .59]***	.41 [.26, .56]***
		Emotional support	.69 [.54, .83]***	.68 [.54, .83]***
		Setting limits	.16 [−.17, .50]	.19 [−.09, .47]
		Proactive parenting	.47[.34, .61]***	.47 [.34, .60]***
		Laxness−consistent parenting	.78 [.67, .88]***	.77 [.67, .88]***
		Emotional magnification	.09 [−7.40, 7.57]	.25 [−1.27, 1.78]
		Emotional neglect	.85 [.75, .94]***	.84 [.74, .93]***
		Overreactivity	.37 [.10, .65]**	.38 [.12, .64]**
		Hostility	.61 [.44, .78]***	.61 [.44, .79]***
E		Daily stimulating interactions	.13 [.08, .18]***	.13 [.07, .19]***
		Learning activities	.17 [.11, .24]***	.17 [.11, .23]***
		Supporting positive behavior	.32 [.19, .45]***	.33 [.21, .44]***
		Emotional support	.35 [.22, .48]***	.36 [.24, .47]***
		Setting limits	.22 [.15, .30]***	.23 [.16, .30]***
		Proactive parenting	.17 [.08, .26]***	.17 [.10, .25]***
		Laxness−consistent parenting	.30 [.21, .39]***	.29 [.20, .38]***
		Emotional magnification	.19 [−.23, .62]	.21 [−.02, .44]
		Emotional neglect	.34 [.19, .49]***	.33 [.18, .48]***
		Overreactivity	.21 [.09, .32]***	.20 [.12, .28]***
		Hostility	.23 [.14, .31]***	.23 [.14, .31]***

Note. Model 1: Multivariate independent pathways model.
Model 2: Multivariate common pathways model.
**p* > .05; ***p* < .01; ****p* < .001.
[a]Preferred model.

extent (child genetic variance shared with other measures = <.01–.06). On average, 16% of child genetic influences on a given measure were located at the broad dimensions (*range* = 0–50%) and 67% of those were located at the measurement level (*range* = 0–90%). This contrast indicates that, whereas caregivers modify both broad parenting style and specific practices in response to children's genetically driven characteristics, the role of child genetic characteristics in evoking differential parenting is more about refining the more specific aspects of parenting.

Our results also indicate some non-genetic sources of child-specific variance in parents' behaviors (i.e., non-shared child environmental effects). Non-shared environmental influences observed at the measurement level may not be surprising, as measure-specific non-shared environmental effects may simply reflect measurement

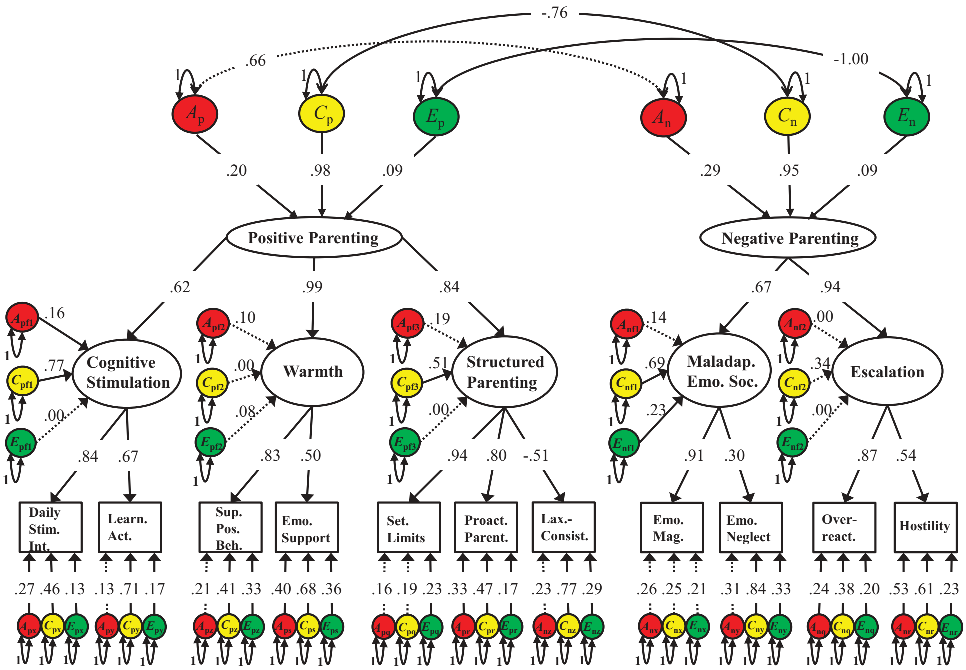

FIGURE 5

Results from the preferred behavioral genetic model (i.e., Model 2). Solid lines indicate statistically significant paths (i.e., $p < .05$) and dotted lines indicate statistically nonsignificant paths. Maladap. Emo. Soc.: maladaptive emotional socialization; Daily Stim. Int.: daily stimulating interactions; Learn. Act.: learning activities; Sup. Pos. Beh.: supporting positive behavior; Emo. Support: emotional support; Set. Limits: setting limits; Proact. Parent.: proactive parenting; Lax.-Consist.: laxness-consistent parenting; Emo. Mag.: emotional magnification; Emo. Neglect: emotional neglect; Overreact.: overreactivity.

error. However, we also detected a non-trivial amount of non-shared environmental effects specifically on *maladaptive emotional socialization* and broadly on both *positive parenting* and *negative parenting*. Non-shared child environmental influences observed at the latent factor level are independent of those operating at the measurement level and are thus free of measurement error; they may reflect child-specific parenting behaviors conceived by parents for unsystematic or idiosyncratic reasons (Caspi et al., 2004), or they may also reflect parental responses to non-genetic sources of variation in child characteristics such as different interactions with other caregivers. In particular, at the broadest level, the strong and negative correlation between non-shared environmental effects on *positive parenting* and those on *negative parenting* suggests that nearly all of these non-genetically driven child characteristics have contrary effects on these two parenting styles (e.g., evoking parenting behaviors that are thought to positively influence child development while suppressing parenting behaviors that are thought to negatively influence child development).

Considering our findings as a whole, both broad parenting style and specific practices in early childhood largely vary at the family level (i.e., across children reared in different families) and thus likely reflect broad contextual and parental characteristics; yet these specific practices and, to a smaller extent, broad parenting styles also vary across children reared together as a function of child genetic variability. Our results suggest that some genetically driven child characteristics contribute broadly, but modestly, to overall parenting style, whereas others contribute uniquely, but substantially, to a particular type of parenting behaviors or a specific parenting practice. It is important for future research to examine the developmental changes in such patterns. Influences of active and evocative *r*GE processes (e.g., Scarr & McCartney, 1983), and hence, child genetic influences on parenting, are expected to increase with age as children are afforded greater freedom in selecting environments that are congruent with their genetic dispositions. However, increasing active and evocative *r*GE could additionally, or even alternatively, result from children having greater opportunities for selecting and evoking extra-familial experiences over time (Tucker-Drob, Briley, & Harden, 2013; Tucker-Drob & Harden, 2012b). For instance, as children enter adolescence, they grow more autonomous in relation to their parents but less so in relation to their peers (Steinberg & Silverberg, 1986). From meta-analyzing studies that used samples of different ages, Klahr and Burt (2014) found that child genetic influences on parental warmth were about the same across ages but those on parental negativity decreased with child age, whereas Avinun and Knafo (2013) found more or less consistent child genetic influences on both maternal positivity and negativity across child ages. Additionally, the relation between age and child genetic influences on parenting may not be monotonic, first increasing as children grow more active in evoking specific behaviors from their caregivers, then decreasing as children spend more time in extra-familial settings. Future research should use longitudinal data to examine developmental changes in child genetic and environmental influences on parenting, especially around developmental transitions such as school entry, school transition, and the onset of puberty.

Our study is important in that, in addition to providing support for a transactional association between parenting and early child development, it is among the first to localize child genetic influences within a hierarchical structure of parenting. As suggested in the behavioral genetic literature on parenting (e.g., Avinun & Knafo, 2013; Kendler & Baker, 2007; Klahr & Burt, 2014), certain parenting practices are more susceptible to the influences of genetically driven child characteristics than are the others. By using a multivariate design, our findings demonstrate that influences of child genetic characteristics on parenting vary not only by type of parenting practices but also across general and specific dimensions of parenting. Furthermore, our study of children in their first 5 years of life indicated that these transactional associations between parenting and child characteristics potentially begin soon after birth.

Our findings should also be interpreted in light of some limitations. First, the number of twin pairs providing data for this study is relatively small when compared to the typical sample size in modern quantitative genetic research. Nonetheless, the use of latent variable models, in which factor loadings are moderate-to-high, has been shown to mitigate parameter imprecision that is typically associated with smaller sample sizes (MacCallum, Widaman, Zhang, & Hong, 1999; Preacher & MacCallum, 2002). We further boosted parameter precision and statistical power by incorporating longitudinal waves of measurement, while employing estimation methods to correct standard errors for the resulting non-independence of observations on the same individual across waves. Finally, instead of mining a large set of pairwise hypothesis tests for those surpassing thresholds for statistical significance, we employed multivariate approaches to model the overall patterns of variation and covariation in the entirety of the data, and we focused on effect sizes rather than significance levels in interpreting these overall patterns.

Second, all of our parenting measures are self-reports of parenting behaviors in the most recent 1 or 2 months. Self-report parenting measures are subject to biases, such as self-enhancement and social desirability (Bornstein et al., 2015). Nevertheless, participants completed their online surveys in the privacy of their home and were assured that their information would be kept confidential. These arrangements have been shown to reduce social desirability, especially when measuring personal behaviors (Richman, Kiesler, Weisband, & Drasgow, 1999). In the context of twin studies, parents rating both twins in the same pair can also be biased by contrast effects and introduce errors in the genetic and environmental estimates. Contrast effects operating similarly for MZ and DZ twins may downwardly bias shared environmental parameter estimates. If, however, contrast effects operate more substantially for DZ than for MZ twins, then genetic influences may be upwardly biased. Similarly, if MZ twins are more similarly treated by their parents than are DZ twins, simply as a result of their parent's knowledge of their zygosity, genetic influences may be overestimated (this is referred to as a violation of the equal environments assumption). Similar treatment results from parental responses to their children's genetically influenced characteristics should not bias parameter estimates (and not violate the equal environments assumption)—but simply reflect *r*GEs. Previous research has found the equal environment assumption to hold true under various conditions (Borkenau, Riemann, Angleitner, & Spinath, 2002; Conley, Rauscher, Dawes, Magnusson, & Siegal, 2013; Evans & Martin, 2000; Kendler, Neale, Kessler, Heath, & Eaves, 1993; Morris-Yates, Andrews, Howie, & Henderson, 1990; Scarr & Carter-Saltzman, 1979). Furthermore, parenting measures in our study provided concrete descriptions of scenarios and behaviors being assessed, which likely reduced the contrast effects in our study (Simonoff et al., 1998).

Third, parameter estimates for child genetic and environmental influences on parenting may vary by informants. Meta-analyzing more than 30 child-based studies (Avinun & Knafo, 2013; Klahr & Burt, 2014), parenting reported by parents themselves indicate greater child genetic influences (except for parental control) and smaller non-shared child environmental influences than those based on examiners' observation but indicate similar or smaller child genetic influences and greater shared child environmental influences than parenting reported by children. Different estimates across informants likely stem from the fundamental differences between survey- and observation-based assessments (Avinun & Knafo, 2013; Klahr & Burt, 2014). Because parent- and child-reports focused on general parenting behaviors across times and settings, they likely reflect greater influences of genetically driven child characteristics on parenting; whereas observational data are based on time-limited behaviors specific to the interaction observed, observational data likely reflect a greater influence of unique experiences (i.e., non-shared child environmental influences). Despite the differences in magnitude, estimates are generally significant and at least modest in size across informants (Avinun & Knafo, 2013; Klahr & Burt, 2014). Most importantly, our study focuses on the general distribution of child genetic and environmental influences across broad and specific dimensions of parenting rather than on any parameter estimate for a given factor or measure.

Fourth, it is unclear whether non-shared environmental influences observed are attributed to environmental factors that are unique to a child or to idiosyncratic or arbitrary factors that lead to differential treatment across children by the same parent. Fifth, our study design does not allow us to decompose shared child environmental variation in parenting into genetic and environmental components associated with parents themselves. For instance, heritable parental characteristics, such as personality, educational attainment, and cognitive ability, likely influence caregiving behaviors. These parental genetic influences on parenting are included as genetic factors in parent-based designs but shared environmental factors in child-based designs. Comparing results from the two designs is one way to clarify the extent to which parenting is attributed to parental versus child genetic factors (Neiderhiser et al., 2004), and a children-of-twins design (D'Onofrio et al., 2003; Narusyte et al., 2008) allows simultaneous estimation of parent-driven and child-driven genetic and environmental effects on parenting. Meta-analyzing nine parent-based studies, Klahr and Burt (2014) suggested that parenting is attributed moderately to parents' genetic dispositions and substantially to their unique experiences that include their upbringing, marital relationships, and, as observed in our study, characteristics of their children.

IMPLICATIONS FOR PRACTICE, APPLICATION, THEORY, AND POLICY

Both general and specific parenting practices largely reflect broad contextual and parental characteristics; yet, caregivers also adjust their broad parenting styles and particularly specific practices in response to genetically influenced characteristics of their children. Our findings demonstrate independent child genetic influences across broad and specific dimensions of parenting and highlight the importance of using a multidimensional approach to study parent- and child-driven processes during early childhood. Just as how specific parenting practices may be more malleable to genetically driven child characteristics than broad parenting styles, caregivers may respond to broad and specific child characteristics to different extents. Future research should use a multivariate framework to examine candidates for these independent genetically driven child characteristics affecting parenting at general versus specific dimensions. Such work may eventually inform the development of interventions and policies that focus on intervening in dynamic feedback processes between parents and their children to foster more positive behavioral repertoires on the parts of both parents and young children.

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