A Moderated Transactional Link Between Child Behavioral Problems and Parenting: A Longitudinal- and Behavioral- Genetic Study

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ABSTRACT

Parenting behaviors and a variety of behavioral problems in children covary. The current study first aimed to examine how and why parenting and child behavioral problems are linked in middle childhood. In particular, a longitudinal design (1364 children assessed from 54 months to 5^{th} grade) was used to examine whether the developmental link between parenting and child behavioral problems were reciprocal. A twin design (131 pairs of monozygotic and 173 pairs of dizygotic twins assessed from 6 to 8 years of age on average) was used to examine the underlying genetic and nongenetic etiology of this link. In addition, using these two samples, the current study also aimed to examine whether parental attributes, including negative affect, executive function, and social cognitive factors, modulate the link between parenting and child behavioral problems. Results across these two studies suggested that parenting and child behavioral problems mutually influenced the development of each other over time, potentially through both evocative and passive gene-environment correlation processes and environmental transmissions. In addition, maternal dispositional anger modulated the effects of child behavioral problems on changes in maternal parenting quality over time. Finally, implications of the current study were also discussed.

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Chapter 1 - Introduction

Parenting behaviors and a variety of behavioral problems in children, including angry outbursts, aggression, hyperactivity, inattention, and noncompliance, covary (Jaffee, Strait, & Odgers, 2012; Patterson, 1980). More negative and less positive parenting is generally associated with more behavioral problems in children. Given that early problem behaviors in children may later develop into chronic and more serious forms of interpersonal impairment in adolescence and adulthood (Farrington, 1989; Raine, 2002), it is important to understand how parenting contributes to the development of individual differences in these behavioral problems early on. At the same time, children's overt behavioral problems are also an important source of parenting stress that elicits reactive harsh parenting (Deater-Deckard, 2004). Therefore, it is also important to examine the mechanisms through which child behavioral problems contribute to various parenting practices that reciprocally reinforce these behavioral problems. Driven by these important research questions, the aim of the current study was to examine the developing relations between parenting behaviors and child behavioral problems in middle childhood using a longitudinal design and a behavioral genetic design. Specifically, the current study addressed the following four questions: Is the link between parenting and child behavioral problems developmentally transactional? Through what mechanisms are the two linked, genetic or nongenetic? Does the magnitude or the underlying mechanism of this relation change over time? Are parenting and child behavioral problems linked to the same degree in different parents with different characteristics?

1.1 - Parenting and Child Behavioral Problems: Who Affects Whom?

The systematic research on the relation between parenting and child development has a long history. There is a general consensus that parenting and child development covary; however, there is less agreement on the origin and the mechanism of this link. During the past several decades, the knowledge concerning this link has developed from being limited to a unidirectional effect from parenting to child development, to acknowledging the effect of child behaviors on parenting, and further to acknowledging the complex transactional relations between the two. Because the majority of the previous studies examined mothers' parenting behaviors, the label "parenting" in the following literature review generally refers to maternal behaviors. However, in the current study, parenting refers to both maternal and paternal behaviors.

1.1.1 - Environmental Influences of Parenting on Child Behavioral Problems

Early family research considers parenting as an environmental context in which children develop (Darling & Steinberg, 1993). Various behavioral problems in children are seen as direct results of "bad" parenting practices. According to Freudian psychodynamic theory, childhood experiences with parents play an important role in shaping developmental trajectories. For example, angry and aggressive behaviors are considered to arise directly from conflicts between internal biological forces and parental punishment and inconsistent discipline (Freud, 1914; Freud, 1933). The advent of behaviorism brought the view that parents influence early development of various characteristics in children through multiple forms of learning (Bandura, Ross, & Ross, 1963; Eron, 1987; Watson, 1924). According to this theory, children may become increasingly aggressive by observing adult caregivers' aggressive behaviors or via reinforcement (i.e., parental attention and reactivity) for being aggressive themselves. Attachment theory continues and integrates the traditions of psychodynamic and behavioristic perspectives, and argues that the parent-child attachment during early life serves as a "working model" that all future interpersonal behaviors are based on (Bowlby, 1988). In particular, insecure-avoidant attachment style is mostly seen in children whose parents are punitive and abusive, and is associated with higher levels of aggressive and impulsive behaviors (Finzi, Ram, Har-Even, Shnit, & Weizman, 2001; van IJzendoorn, 1997).

These theoretical propositions have stimulated numerous empirical research efforts aiming to identify the effect of a variety of parenting behaviors on the development of behavioral problems in children. The most studied parenting behaviors include parental warmth, responsiveness, and various forms of control (Darling & Steinberg, 1993; Maccoby & Martin, 1983). Parental warmth and responsiveness capture the emotional climate of parenting behaviors. A warm and responsive parent is emotionally sensitive and affectionate to the child. In contrast, the opposite of warmth and responsiveness is emotional distance, rejection, and is parent-centered. The various forms of control capture the behavioral and instrumental aspect of parenting that ranges from autonomy support to power assertion to a variety of discipline and punishment.

Parents who are emotionally warm, sensitive, and firm in their disciplinary style have children who are more compliant and cooperative (Baumrind & Black, 1967; Maccoby, 2000). Parental warmth and responsiveness are hypothesized to influence the development of child behavioral problems through affecting the parent-child relationship (Maccoby & Martin, 1983) and through affecting children's social cognitive processing (Dodge, Pettit, McClaskey,

& Brown, 1986). A close and trusting parent-child relationship is more easily built in parents who are affectionate and sensitive. Such a parent-child relationship facilitates a child's moral internalization that further inhibits the development of behavioral problems (Grusec & Goodnow, 1994; Maccoby, 1980). In contrast, a child is more likely to develop an angry and anxious attitude toward her/his relationship with a parent who is harsh and irresponsive, and is therefore more likely to be resistant and noncompliant with the parent's disciplines (Maccoby & Martin, 1983; Stayton, Hogan, & Anisworth, 1971). In addition, the child is also more likely to develop a hostile attribution style in such a parent-child relationship, which in turn, increases the likelihood of the development of aggressive symptoms (Dodge et al., 1986).

Parental control is considered to influence children's learning experiences that are related to the development of behavioral problems. Parents' consistent, firm, and preemptive disciplines are seen as better than inconsistent, lax, or reactive disciplines, because the former offer children consistent learning opportunities through repeated reinforcement and convey to children clear messages in terms of what is socially acceptable or not (Chamberlain & Patterson, 1995).

1.1.2 - Beyond the Singular View of Socialization

Despite the consistent findings across studies showing robust associations between parenting and child behavioral problems, an increasing number of researchers realized that there was a tendency to overstate the causal effects of parenting and socialization on child development based on study designs that were correlational in nature (Bell, 1968; Plomin, DeFries, Loehlin, 1977; Scarr & McCartney, 1983). In particular, the most frequently examined alternative explanations to these correlational findings include effects from children to parents and confounding genetic effects (Collins, Maccoby, Steinberg, Hetherington, & Bornstein, 2000).

On one hand, many studies have acknowledged that individual differences in a variety of attributes are present since a very young age (Kagan, 1971; Rothbart, 1986), and these individual differences are powerful elicitors of different parental responses (Bell, 1968). For example, infants who are more fussy and irritable are likely to elicit more maternal attention and soothing behaviors than infants who are generally calm (Moss, 1967).

The other major flaw of the socialization view is the failure to consider other confounding causal mechanisms. In particular, most studies examined biological parent-child dyads/triads, who shared not only environments but also genes (Rowe, 1994). Therefore, the observed correlation between parenting and child behavioral problems could reflect either environmental transmission, genetic transmission, or both. In biological families, because genes and environments are often entangled, the concept of gene-environment correlation (*r*GE) has been proposed to clarify this confound. Specifically, there are three types of *r*GE: passive *r*GE, evocative *r*GE, and active *r*GE (Plomin et al., 1977; Scarr & McCartney, 1983). Passive *r*GE refers to situations in which the same gene variants that influence parenting behaviors may be transmitted to children and further influence children's behaviors. One example is that a mother who possesses gene variants that are associated with more aggressive behaviors may transmit these genes to her child, who in turn, also exhibits high levels of aggression. In the meantime, the aggressive behaviors in the mother toward her child may exhibit as harsh discipline, which is correlated with, but does not cause, the child's high levels of aggression. Evocative *r*GE refers to situations in which a child's biologically based attributes elicit certain parenting behaviors. For example, harsh and punitive parenting behaviors may be evoked by genetically influenced aggressive behaviors in children (DiLalla, 2002).Therefore, rather than being an environmental causative factor, harsh and punitive parenting may be a result of genetically influenced attributes in the child. Active *r*GE means that children may actively seek environmental niches that best fit their genetically influenced characteristics. For example, a child who possesses gene variants that are associated with high levels of aggression may actively seek out deviant peer groups. Because children cannot choose who their biological parents are, active *r*GE is of less relevance than passive and evocative *r*GE in the family context.

In order to answer the question of "who affects whom through what mechanisms" in the parent-child relationship, researchers have begun to utilize study designs that could better clarify the direction and the mechanisms. In particular, experimental, longitudinal, and quasi-experimental designs are the most applied methods (Jaffee et al., 2012).

Experimental designs. Causal relations can be definitively determined in experimental designs. Due to practical and ethical concerns, most experimental designs in family research are constrained to prevention/intervention studies that randomly assign families into different treatment groups and follow changes in these families over time (Howe, Reiss, & Yuh, 2002). If intervention programs that target improving harsh parenting are effective in reducing child behavioral problems compared to untreated families, harsh parenting has probably caused the increase or maintenance in child behavioral problems over time, and vice versa. Results based on this type of experimental design have been mixed. Some studies have supported the causal effect of parenting on the development of child behavioral problems by showing that parent-based training programs improved parenting skills and reduced behavioral problems in children in the treatment groups (Brestan & Eyberg, 1998; Dishion & Kavanagh, 2000; Forgatch & DeGarmo, 1999). However, other studies have indicated that it is the combination of parent-based and child-based training programs that are most effective in mitigating children's conflicting relationships with peers and parents (Greene & Doyle, 1999; Webster-Stratton & Hammond, 1997), suggesting the presence of both parent- and child-effects. However, because most experimental studies involve clinical populations, the findings may or may not be generalizable to nonclinical populations (Cicchetti & Rogosch, 2002).

Longitudinal designs. Compared to a cross-sectional study, a well-designed longitudinal study can provide more direct information concerning the direction of the correlational effect. The essence of longitudinal designs is to examine whether one construct can predict changes in another construct over time.

Driven by the tradition of focusing on parent's effects on child development in developmental science, many studies have explored whether and how parenting behaviors can predict changes in child behavioral problems over time. Findings from these studies generally showed that maternal harsh reactive control and mother-child coercive interactions predicted increases in externalizing and conduct problems during early and middle childhood and adolescence (Bullock & Dishion, 2007; Campbell, Pierce, Moore, Marakovitz, & Newby, 1996; Gardner, Sonuga-Barke, & Sayal, 1999; Nix et al., 1999). Other studies showed that children of mothers who were coercive and harsh followed a distinctive developmental trajectory that was characterized by chronic high levels of antisocial behaviors from early to middle childhood (Shaw, Gilliom, Ingoldsby, & Nagin, 2003; Tremblay et al., 2004).

With increasing awareness of the active role that children play in creating their own environments, more recent longitudinal designs have explicitly tested not only parent effects on children, but also children's effects on parents. It is shown that the effects of child behavioral problems on parenting are as strong as the effects of parenting on child development. Specifically, child conduct and externalizing symptoms predicted more parental hostility and harsh discipline, and less warmth, support, and involvement during early childhood (Scaramella, Neppl, Ontai, & Conger, 2008) and middle childhood through adolescence (Burke, Pardini, & Loeber, 2008; Hipwell et al., 2008; Huh, Tristan, Wade, & Stice, 2006; Pardini, Fite, & Burke, 2008; Richmond & Stocker, 2008). In turn, more parental hostility and harsh discipline, and less parental warmth and involvement predicted increases in conduct and externalizing symptoms over time (Hipwell et al., 2008; Pardini et al., 2008; Richmond & Stocker, 2008; Scaramella et al., 2008).

In summary, longitudinal designs that aim to examine changes in constructs over time can better reveal the direction of the link between two constructs, such as parenting and child behavioral problems. Most studies that have explicitly tested both child- and parent-effects provide supporting evidence of a bi-directional relation between parenting and child behavioral problems in which parents and children mutually influence each other through transactions (Patterson, 1980; Sameroff, 2009).

Quasi-experimental designs. Alternatively, findings based on quasi-experimental designs, behavioral genetic designs in particular, have also been informative. Although definitive causal inference cannot be reached based on quasi-experimental designs, this type of design is rather useful in ruling out confounding causal factors; genetic-nongenetic confounding to be exact. Therefore, behavioral genetic designs have been widely used to explore the underlying genetic and nongenetic etiology of the links between parenting and child behavioral problems.

The most common behavioral genetic designs include twin and adoption designs. Twin designs rely on behavioral genetic analyses that decompose variance in phenotypes into latent genetic and nongenetic components according to differential genetic similarity between monozygotic (MZ) and dizygotic (DZ) twins. The basic variance decomposition (Figure 1) equation is: $1 = A^2 + C^2 + E^2$. In this equation, phenotypic (i.e., observed) variance in construct X is decomposed into three components A^2, C^2, and E^2. A^2 represents the proportion of phenotypic variance that is explained by genetic influence. C^2 represents the proportion of phenotypic variance explained by nongenetic influence that leads to familial resemblance. E^2 represents the remaining variance which includes the nongenetic influence that does not lead to familial resemblance plus measurement error. Therefore, both the A^2 and C^2, but not E^2, are parts of variance that explain twin resemblance (i.e., shared between twins within each family). To explain the "shared part" of the variance better, the equation $T1 = b0 + b1*T2 + b2*R + b3*T2*R$ represents how the genetic and nongenetic factors explain the correlation between twin1's and twin2's observed scores. In this equation, T1 and T2 respectively represent twin1 and twin2 phenotypic scores. R is the coefficient of the relationship (R = 1 for MZ twins and R = 0.5 for DZ twins). Therefore, b3 represents the proportion of the phenotypic correlation between the twin1 and twin2 scores that depends on twins' genetic relatedness (i.e., A^2); b1 represents the phenotypic correlation between the twin1 and twin2 phenotypic scores independent of their genetic relatedness (i.e., C^2).

When A^2 is found in parenting in twin designs, it suggests that the observed correlation between parenting toward twin1 and parenting toward twin2 varies as a function of genetic relatedness between twin1 and twin2, which further suggests an evocative *r*GE process in parenting (Kendler & Baker, 2007). Alternatively, when C^2 is found in parenting in twin designs, it suggests that the observed correlation between parenting toward twin1 and parenting toward twin2 does not vary as a function of twins' genetic relatedness. As such, this shared source of variance could be due to anything but twins' shared DNA structures. The most common explanations to the C^2 are shared environmental influences and passive *r*GE processes. In this case, a children-of-twin design is usually helpful in determining whether the C^2 component in parenting reflects pure environmental transmission or passive *r*GE process (Neiderhiser et al., 2004). Table 1 shows variance decomposition and potential explanations to various variance components in parenting in a twin design.

A recent review of findings based on the twin design showed that A^2 accounted for a moderate and a modest proportion of variance in parental warmth and parental control, respectively; most variance in parental control was explained by C^2 and E^2 (Kendler & Baker, 2007). In addition, several studies that applied the children-of-twin design showed that the C^2 estimates in parental control mainly reflected a passive *r*GE process (Losoya, Callor, Rowe, & Goldsmith, 1997; Spinath & O'Connor, 2003; Wade & Kendler, 2000).

Furthermore, more recent progress in behavioral genetic modeling allows researchers to more directly address the underlying etiology of the link between parenting and child behavioral problems. More specifically, bivariate behavioral genetic models can be utilized to partition the covariance between parenting and child behavior problems into genetic and nongenetic components, through which the confounding between genetic and nongenetic factors can be better clarified. Most studies that applied this design have shown that A^2 mediates the phenotypic links between both parental warmth and parental control and various forms of child behavioral problems, including difficultness, aggression, and antisocial behaviors throughout infancy, middle childhood, and adolescence (Boivin et al., 2005; Jaffee et al., 2004; Narusyte, Andershed, Neiderhiser, & Lichtenstein, 2007; Pike, McGuire, Heterington, Reiss, & Plomin, 1996; South, Krueger, Johnson, & Iacono, 2008). Some studies have also found significant C^2 in the links between child externalizing behaviors and negative parenting during middle childhood and early adolescence (Burt, McGue, Krueger, & Iacono, 2005; Larsson, Viding, Rijsdijk, & Plomin, 2008), suggesting that parenting is not only an evoked response to the genetically influenced behavioral problems in children, but also a nongenetic (environmental or passive *rGE*) risk factor that reciprocally exacerbates these problem behaviors.

Another commonly used behavioral genetic design is the adoption design. The rationale behind the adoption design is that problem behaviors in the biological parents and parenting behaviors in the adoptive parents can respectively serve as genetic and environmental risk indices toward developing behavioral problems in the adoptee. When a link is observed between biological parents' behavioral problems and adoptive parents' parenting behaviors, an evocative *r*GE process is implied. Studies utilizing the adoption design have found supporting evidence of evocative *r*GE processes in the link between children's antisocial behaviors and adoptive parents' harsh negative parenting behaviors (Ge et al., 1996; O'Connor, Deater-Deckard, Fulker, Rutter, & Plomin, 1998).

In summary, quasi-experimental behavioral genetic designs have been informative in clarifying the confounding between shared genetic and nongenetic variants between biological parent-child pairs in the family context. The joint findings across behavioral genetic designs and longitudinal designs have indicated that genetically influenced behavioral problems in children elicit changes in a variety of parenting behaviors, which in turn affect the development of more behavioral problems in children through both genetic and nongenetic transmission. When the two methodologies are combined and the findings are consistent, researchers can reach conclusions with more confidence concerning both the direction as well as the underlying genetic and nongenetic etiology of the link between parenting and child behavioral problems.

However, despite the overwhelming evidence supporting a reciprocal link between parenting and child behavioral problems, most behavioral genetic and longitudinal studies were either limited to a short-term effect that lasted no longer than 2 years (e.g., Gardner et al., 1999), or limited to no more than 2 time points of assessments (e.g., Burke et al., 2008; Hipwell et al., 2008; Pardini et al., 2008). These limitations constrain the power to detect potential shifts in the magnitude and the underlying mechanism of the bidirectional transactions over time. For example, the mutual influence of a parent and a child on each other may increase over time as a result of the repeated transactions between the two; or the mutual influence may decrease over time as the child gradually gain autonomy and increasingly focus on other interpersonal relations such as peer relationships. By the same token, the underlying genetic and nongenetic etiology of the link between parenting and child behavioral problems may also shift over time (Scarr & McCartney, 1983). Therefore, the first aim of the current study was to address these questions and limitations in the previous literature by examining the long-term links between parenting and child behavioral problems using a longitudinal design and a repeated cross-sectional twin design throughout middle childhood. Based on findings from previous literature, there were two hypotheses and one exploratory question:

Hypothesis 1: There would be longitudinal transactional links between parenting and child behavioral problems. Specifically, poorer parenting quality would predict more increases in child behavioral problems over time. More child behavioral problems would also predict more decreases in parenting quality over time. This hypothesis was tested using a longitudinal design.

Hypothesis 2: The link between parenting and child behavioral problems would be explained by both genetic (evocative *r*GE) and nongenetic (environmental or passive *r*GE) factors. This hypothesis was tested using a cross-sectional twin design.

Exploratory question: Would the strength and the etiology of the link between parenting and child behavioral problems change over time? This exploratory question was tested using both a longitudinal design and a repeated cross-sectional twin design.

1.2 - Parenting and Child Behavioral Problems: Heterogeneously Linked in Different Parents?

Although the effects of parenting on child behavioral problems have been replicated across studies, the magnitude of the effects is generally modest. Thus, not all children who receive harsh and negative parenting develop high levels of problem behaviors: some children are more vulnerable whereas others are more resilient to the influences of parenting. Studies have shown that individual differences in children’s attributes such as affective reactivity, self-regulation, and social-cognitive factors are all important modulators that render children differential vulnerability/resilience to the impact of parenting (Belsky & Pluess, 2009; Wang & Deater-Deckard, 2013). By the same token, the magnitude of the impacts of child behavioral problems on parenting is also modest. Not all parents react to child behavioral problems harshly and negatively. However, very few studies have examined characteristics in parents that potentially differentiate them in their parenting strategies in response to provocation from their children. Therefore, the second aim of the current study was to address this gap in the literature by examining the roles that parental negative affect, executive function, and social cognitive factors play in modulating the effects of child behavioral problems on parenting.

1.2.1 - Negative Affect

Negative affect, such as anger and anxiety, represents stable individual differences in the excitability and intensity of the negative emotional reactivity in response to external stimuli. Both affective anger and anxiety have been implicated in the etiology of negative parenting. Specifically, parental anger is associated with more harsh discipline and abusive tendencies (Francis & Wolfe, 2008; Kayama, Sagami, Watanabe, Senoo, & Ohara, 2004; Mammen, Kolko, & Pilkonis, 2002; Nomellini & Katz, 1983; Rhoades & O'Leary, 2007; Shay & Knutson, 2008), and trait anxiety is associated with more intrusiveness and less warmth and sensitivity (Bogels & van Melick, 2004; Feldman et al., 2009; Nicol-Harper, Harvey, & Stein, 2007; Whaley, Pinto, & Sigman, 1999; Woodruff-Borden, Morrow, Bourland, & Cambron, 2002).

The etiology of the links between negative affect and parenting behaviors may be related to the role negative affect plays in reactive aggression. With regard to anger, it is known that individuals with higher levels of anger are more easily irritated by provocation from others and are more likely to react to such provocation via reactive aggression (for a review, see Wilkowsky & Robinson, 2008). Therefore, compared to parents who are less angry, parents with higher levels of trait anger may be more easily frustrated at child behavioral problems and more likely to exhibit hostile and punitive parenting as a result of such frustration. With regard to anxiety, one theory is that anxious individuals are usually likely to withdraw from provocation. However, when the pathway to withdrawal is blocked, anxious individuals "fight" instead of "flee" (Bubier & Drabick, 2009). Therefore, compared to non-anxious parents, anxious parents may be more likely to act increasingly hostile toward their own children to terminate their behavioral problems after chronic exposure to such aversive behaviors (i.e., when "flight" is not an option). According to these accounts, child behavioral problems may be more predictive of more negative and less positive parenting over time in parents with higher levels of anger and anxiety than in parents with lower levels of anger and anxiety.

1.2.2 - Executive Function

Another important parental attribute that has been implicated in the etiology of parenting behaviors is executive function. Executive function refers to the cognitive regulation of attention and memory that underlies effective emotional and behavioral self-regulation (Friedman et al., 2008; Ochsner & Gross, 2008). Both animal and human studies have suggested that good executive functioning is crucial in sensitive and responsive parenting (Afonso, Sison, Lovic, & Fleming, 2007; Deater-Deckard, Sewell, Petrill, &

Thompson, 2011; Deater-Deckard, Wang, Chen, & Bell, 2012; Lovic & Fleming, 2004) because effective parenting requires a parent to inhibit reactive emotional impulses, flexibility switch attention across different situational demands, and mentally manipulate multiple pieces of information at the same time in order to coordinate the emotions and behaviors with situational needs (Barrett & Fleming, 2011). More specifically, although executive function may not be directly associated with parenting, it attenuates maternal negative reactivity in the face of child behavioral problems (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012). It is under the stressful and challenging situations that parents must rely on their executive function to regulate their aversive feelings and to reappraise the consequences of their behaviors in order to parent more effectively. Therefore, child behavioral problems may be more predictive of more negative and less positive parenting in parents with poorer executive function who are less able to regulate their emotions and behaviors under stress.

1.2.3 - Social Cognitive Factors

How parents react to child behavioral problems may also depend on parental social cognitive factors, such as parents' beliefs and attitudes about the correct and optimal way to rear a child. Some parents hold more progressive and child-centered rearing attitudes that are characterized by encouragement of child autonomy and respect for child individuality, whereas other parents have more traditional and parent-centered rearing attitudes which highlight the importance of parental authority and child compliance (Schafer & Edgerton, 1985). Parents with more traditional rearing attitudes use less reasoning, more control, and more physical discipline in their parenting (Fisher & Fagot, 1993; Greene & Garner, 2012; Schafer & Edgerton, 1985; Straus, Gelles, & Steinmetz, 1980).

Although parental rearing attitudes have been mostly examined as independent predictors of a variety of parenting outcomes, the definition of rearing attitude suggests that it may be better conceptualized as a moderator of the link between child behavioral problems and parenting. Specifically, because parents with strong traditional and weak progressive rearing attitudes highly value parental authority and child compliance, they may be more likely to reactively defend their authority when their own children challenge their authority via noncompliance than when their children behave respectfully. With regard to parents with strong progressive and weak traditional rearing attitudes, child behavioral problems may not elicit much parental overreactivity as these behaviors are not seen as threats to parental authority. As such, parental rearing attitudes might interact with child behavioral problems to predict parenting whereby child behavioral problems are more predictive of more negative and less positive parenting in parents with strong traditional and weak progressive rearing attitude.

Some researchers conceptualize authoritarianism and neuroticism as partially overlapping constructs, and argue that people holding authoritarian attitudes are more neurotic and mentally unhealthy (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950). However, more researchers, using a variety of measures of authoritarianism and neuroticism across different populations, fail to find supporting evidence of such an argument (Davids & Eriksen, 1957; Ray, 1972). In the current study, correlational analyses suggested that parental traditional rearing belief and negative affect were minimally correlated, and therefore were examined separately as moderators in the link between parenting and child behavioral problems.

In summary, a variety of parental attributes, including negative affect, executive function, and social cognitive factors, might serve as important modulators in the effects of child behavioral problems on parenting. According to the above review, the 3rd hypothesis of the current study is that parental anger and anxiety (i.e., two facets of negative affect), working memory (i.e., one component of executive function), and rearing belief (i.e., a social cognitive factor) would moderate the effects of child behavioral problems on parenting. Specifically, child behavioral problems would more strongly predict more negative and less positive parenting behaviors in mothers and fathers with higher anger and anxiety, poorer working memory, and stronger traditional and weaker progressive rearing beliefs. Due to limitations in data availability, the hypothesis concerning anger and anxiety was only tested in the longitudinal study, and the hypothesis concerning working memory was only tested in mothers in the behavioral genetic study.

Chapter 2 – Method

2.1 - SECCYD Longitudinal Study

2.1.1 - Sample

The data are from the National Institute of Child Health and Development Study of Early Child Care and Youth Development (SECCYD; http://www.nichd.nih.gov/research/supported/ seccyd/ data-sets. cfm). In total, 1364 children (48% female) and their families from 9 states in the United States (Arkansas, California, Kansas, New Hampshire, North Carolina, Pennsylvania, Virginia, Washington, and Wisconsin) participated in the study. The analyses used the demographic information collected when children were 1 month of age, and measures of the main study variables collected when children were 4.5 years of age, in 1st grade, 3rd grade, and 5th grade. Child's race was 80% White, 13% African American, 2% Asian, and 5% other. When children were 1 month old, mothers were 28 years of age on average (*SD* = 5.63; range = 18 - 46). Parent's highest education level was (for mother/father): 31/31% high school or less, 33/30% some college, 21/22% bachelor's degree, and 15/18% postgraduate education or degree. Fifteen percent of the families had annual family income lower than 10000USD, 28% between 10000 and 25000, 34% between 25000 and 50000, 18% between 50000 and 100000, and 5% higher than 100000. Eighty-six percent of the parents were married or living together.

2.1.2 - Measures

Anger and anxiety. When children were in the 1st, 3rd, and 5th grade, mothers and fathers were asked to report their feelings of anger and anxiety over the past week using the state anger subscale from the State-Trait Anger Scale (Spielberger, Jacobs, Russell, & Crane, 1983) and the state anxiety subscale from the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The state anger subscale and the state anxiety subscale each includes 10 items that are rated on a 4-point Likert type scale (1 = not at all; 4 = very much). One sample item from the state anger subscale is "I was furious". One sample item from the state anxiety subscale is "I was worrying over the possibility of misfortune". Both the anger and the anxiety subscales were internally consistent, with Cronbach's αs ranging from .86 to .90 for mother's reports, and from .84 to .91 for father's reports, depending on longitudinal waves. Among the 1364 parents, 1009 mothers and 666 fathers had anger and anxiety scores when their children were in the 1st grade, 1005 mothers and 635 fathers in the 3rd grade, and 994 mothers and 629 fathers in the 5th grade. Although both subscales are intended to measure affective state rather than affective trait, both the anger and the anxiety scores were moderately stable across the 3 waves (stability = .42 to .55 for anger and .48 to .54 for anxiety). Therefore, a composite score was computed for both anger and anxiety, separately for mothers and fathers, to capture the stable component of trait anger and trait anxiety by averaging scores across the 3 waves. A minimum of 2 out of 3 assessments were required to compute the composite score.

Parental rearing attitude. When children were in the 1st grade, mothers and fathers reported their rearing attitude using the traditional and progressive attitude subscales from the Parental Modernity Scale (Schaefer & Edgerton, 1985). Items are rated on a 5-point Likert type scale (1 = strongly disagree, 5 = strongly agree). The traditional beliefs subscale (Cronbach's αs = .89 for mother's report and .88 for father's report) includes 22 items that measure authoritarian child rearing attitude. One sample item from the traditional beliefs subscale is "children should not question the authority of their parents". The progressive beliefs subscale (Cronbach's αs = .64 for both mother's and father's reports) includes 7 items that measure the beliefs that children should be treated and respected as individuals. One sample item from the progressive beliefs subscale is "children have a right to their own point of view and should be allowed to express it". Data are available for 1001 mothers and 666 fathers on the progressive beliefs subscale, and 1006 mothers and 669 fathers on the traditional beliefs subscale.

Parenting. Trained observers rated parenting behaviors during a structured 15-minute parent-child interaction when children were 54 months old, and again in the 1st, 3rd, and 5th grade. In each wave, the mother and the father were video-taped separately while playing with their child. The two games in each wave were too difficult for the child to carry out independently and consequently required the parent's assistance. In 54 months, the two activities were to complete a maze and to build rectangular models using wooden blocks. In the 1st grade, the two activities were to draw a house and a tree using an Etch-A-sketch, and to fill in three geometric cutout frames using parquet pattern blocks. In the 3rd and 5th grades, the two activities were a discussion task and a planning activity. Observational data were collected in 1040 mother-child and 699 father-child dyads in 54 months, 1004 and 661 in the 1st grade, 960 and 593 in the 3rd grade, and 906 and 581 in the 5th grade.

Observers rated maternal and paternal behaviors including supportive presence, respect for autonomy, stimulation of cognitive development, quality of assistance, and hostility (hostility scores were not available for fathers in the 3rd grade due to extremely low inter-rater reliability) on a 7-point Likert type scale (1 = very low, 7 = very high; Egeland &

Hiester, 1993; Pianta, 1994). Inter-rater reliability was calculated using the Pearson correlation in 20% to 30% of the sample, and ranged from .53 to .77 depending on the specific item and longitudinal wave. Principle component analyses on the above 5 indicators in each of the 4 waves separately for mother and father all suggested a single component solution, with component loadings all above .47 and total variance explained ranging from 61% to 69%. Therefore, a composite parenting quality score was computed in each wave separately for mothers and fathers by averaging the 5 items (all items but hostility were reverse-coded). Higher scores represented poorer parenting quality.

Child behavioral problems. Mothers, fathers, and teachers provided reports on children's aggressive, delinquent , hyperactive, and inattentive behaviors using the Child Behavior Checklist (CBCL; parent's report; Achenbach, 1991a) and the Teacher Report Form (TRF; teacher's report; Achenbach, 1991b) in all 4 waves. Items in both the CBCL and the TRF are rated on a 3-point Likert type scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true). Among the 1364 children, complete data on mother reported CBCL, father reported CBCL, and teacher reported TRF are available for 1054, 724, and 723 children in 54 months, 1007, 668, and 1007 in the 1st grade, 1003, 636, and 978 in the 3rd grade, and 992, 631, and 926 in the 5th grade.

The aggressive behavior subscale was used to measure children's aggressive behaviors. The CBCL aggressive behavior subscale includes 20 items and the TRF aggressive behavior subscale includes 25 items such as "attacks" and "temper tantrums or hot temper". Cronbach's αs ranged from .87 to .95, depending on the reporter and longitudinal wave. The aggressive behavior score was computed by averaging scores across all items in each wave for each reporter. Stability of aggressive behavior scores ranged from .59 to .73 for mother's reports, from .51 to .66 for father's reports, and from .23 to .52 for teacher's reports. Principle component analyses on mother, father, and teacher reported aggressive behaviors in each of the 4 waves all suggested a single component solution (component loadings = .61 to .83, total variance explained = .55 to .60). Therefore, a composite aggression score was computed in each wave by averaging the mother, father, and teacher reports. Scores from at least 2 informants were required to compute the composite score. Higher scores were scaled to represent more aggressive behaviors.

The CBCL delinquency subscale includes 13 items and the TRF delinquency subscale (not available when children were 54 months old) includes 9 items such as "lies and cheats" and "uses alcohol and drugs for non-medical purposes". Cronbach's αs ranged from .51 to .70, depending on the reporter and longitudinal wave. The delinquent behavior score was computed by averaging scores across all items in each wave for each reporter. Stability of delinquent behavior scores ranged from .40 to .60 for mother's reports, from .32 to .55 for father's reports, and from .39 to .42 for teacher's reports. Principle component analyses on mother, father, and teacher reported delinquent behaviors in each of the 4 waves all suggested a single component solution, with component loadings ranging from .63 to .83 and total variance explained ranging from 49% to 63%. Therefore, a composite delinquent behavior score was computed in each wave by averaging the mother, father, and teacher reports. Scores from at least 2 informants were required to compute the composite score. Higher scores represented more delinquent behaviors.

Two items from the CBCL "cannot sit still, restless, or hyperactive" and "impulsive or acts without thinking" and 3 items from the TRF "cannot sit still, restless, or hyperactive", "fidgets", and "impulsive or acts without thinking" were used to measure children's hyperactive behaviors. The correlations between the two items from the CBCL were from .37 to .48, depending on the reporter and longitudinal wave. A hyperactivity composite score was computed in each wave by averaging the two items using mother's and father's reports separately. The three items from the TRF were correlated from .50 to .75, and were averaged to form a teacher-reported hyperactivity score for each wave. Stability of the hyperactivity score ranged from .51 to .65 for mother's reports, from .32 to .54 for father's reports, and from .20 to .48 for teacher's reports. Principle component analyses on mother, father, and teacher reported hyperactive behavior scores in each of the 4 waves all suggested a single component solution (component loadings = .62 to .83, total variance explained = .53 to .61). Therefore, a composite hyperactivity score was computed for each wave by averaging the mother, father, and teacher reports. Scores from at least 2 informants were required to compute the composite score. Higher scores represented more hyperactive behaviors.

One item from the CBCL "cannot concentrate/pay attention for long" and two items from the TRF "cannot concentrate/pay attention for long" and "inattentive, easily distracted" were used to measure children's inattentive behaviors. The two items from the TRF were correlated from .67 to .82, and were averaged to form a teacher reported inattention score for each wave. Stability of the inattention score ranged from .35 to .58 for mother's reports, from .23 to .48 for father's reports, and from .24 to .50 for teacher's reports. Principle component analyses on mother, father, and teacher reported inattentive behavior scores in each of the 4 waves all suggested a single component solution (component loadings = .62 to .83, total variance explained = .56 to .63). Therefore, a composite inattention score was computed for each wave by averaging the mother, father, and teacher reports. Scores from at least 2 informants were required to compute the composite score. Higher scores represented more inattentive behaviors.

Finally, aggression, delinquency, hyperactivity, and inattention scores in each wave were subjected to a principle component analysis, and results in 4 waves all suggested a single component solution (component loadings = .72 to .90, total variance explained = 65% to 72%). Subsequently, a composite child behavioral problem score was computed for each wave by averaging the aggression, delinquency, hyperactivity, and inattention scores. A minimum of 2 out of 4 behavior problem scores were required to compute the composite score.

In addition, because 2-group models were used to test the 3rd hypothesis, the same principle component analyses were also conducted separately in the two groups that were created by dividing the sample at the mean of the moderators in order to examine whether the same component structure could be obtained in the two groups. This procedure was repeated for all moderators. Results suggested that the component structures obtained in the two groups created by each moderator were very similar to one another and to the component structure obtained in the whole sample.

2.1.3 - Missing Data

Because the current study aimed to examine changes in constructs, model-fitting procedures only included families that had at least 2 out of the 4 time points of both the observed parenting quality score and the composite child behavioral problem score. A multivariate analysis of variance was conducted to examine whether there were mean differences in the demographic information (i.e., child sex and race, maternal age, parental education level, family income, and marital and living status) between the included and the excluded families. Demographic variables were used as outcome variables and whether or not the families met the inclusion criterion (0 = no, 1 = yes) was used as the predictors. Results suggested that the included and excluded families significantly differ on mean levels of all demographic variables examined. Compared to the included families, the excluded families were more likely to have boys, be ethnic minorities, have lower education and income, and have younger and more percentage of single mothers.

2.1.4 - Analytic Strategy

All analyses were conducted using SPSS and AMOS 21.0 (Armonk, NY: IBM Corp.). Full information maximum likelihood was used for all model-fitting procedures.

First, descriptive and bivariate correlational analyses were conducted to examine the basic properties of the data. Outliers that were defined as values of 4 standard deviations away from the mean of each variable were excluded from the analyses. Variables that were not normally distributed were transformed using the natural log transformation.

Second, to test the 1st hypothesis that there would be longitudinal transactional link between parenting and child behavioral problems, a bivariate latent difference score model (LDS model; McArdle & Hamagami, 2001) was used. The bivariate LDS model has several advantages over other longitudinal analytic approaches. Specifically, the bivariate LDS model evaluates the time-based dynamic longitudinal transactions between two constructs using reliable latent difference scores (McArdle, 2009). In addition, compared to the panel analysis which does not accurately capture the bidirectional effects when there are any apparent mean-level changes or variance changes in either variable, the bivariate LDS model has no such limitation (Ferrer & McArdle, 2009).

A generic bivariate latent difference score model is shown in Figure 2. For simplicity, correlations between intercepts and slopes of the two variables are not shown in the figure, but were estimated in the analyses. In this model, two constructs *a* and *b* are each measured 4 times. Each measured variable (e.g., *a*) is decomposed into the true score (e.g., *a_true1*) and the measurement error (e.g., *a_e1*): *a = a_true1 + a_e1*. Changes over time are estimated using the difference scores (e.g., *a_d1*) between two consecutive true scores *a_d1 = a_true2 – a_true1*. Each difference score is further decomposed into two parts: a proportional change that is a function of the true score at a previous time point (e.g., *a1 * a_true1*), and a constant change (1 * a_s): *a_d1 = a1 * a_true1 + 1 * a_s*. Paths *a1*, *a2*, and *a3* represent the degree to which the change in construct *a* between time *t* and time *t +1* varies as a function of *a* measured at time *t*. Paths *a_bd1*, *a_bd2*, and *a _bd3* are of particular interest to the current study because they represent cross-lagged predictions from one construct to changes in the other construct. Specifically, they estimate the degree to which the change in construct *b* between time *t* and time *t+1* varies as a function of *a* measured at time *t*. In the current analyses, construct a was substituted with child behavioral problems and construct b was substituted with maternal or paternal parenting behaviors. To test the statistical significance of these cross-lagged predictions, predictions from child behavioral problems to parenting and predictions from parenting to child behavioral problems were each fixed at 0, and χ^2 difference tests were conducted to compare the model fits between the constrained and the unconstrained models. A significant χ^2 difference between the constrained and the unconstrained models indicates that constraining the paths to be 0 significantly worsens the model fit, suggesting that the cross-lagged predictions cannot be fixed at 0.

Third, to test the 3rd hypothesis that parental anger and anxiety, and parental traditional and progressive rearing beliefs would moderate the effects of child behavioral problems on parenting, two-group bivariate latent difference score models were estimated. Specifically, the total sample was divided into two groups at the mean of the hypothesized moderator (e.g., parental anger). The same bivariate latent difference score model (Figure 2) was estimated in the two groups separately, once with all parameters freely estimated (unconstrained model) and once with all cross-lagged predictions from child behavioral problems to parenting constrained to be equal across the two groups (constrained model). A χ^2 difference test was conducted to compare the model fits between the constrained and the unconstrained models. A significant χ^2 difference between the two models indicates that constraining the paths to be equal across the two groups significantly worsens the model fit, suggesting that the cross-lagged predictions are different in the high versus low moderator groups. Further visual comparison indicates in which group the influences of child behavioral problems on parenting are stronger. The same procedure was used for all moderators including parental anger, anxiety, progressive rearing beliefs, and traditional rearing beliefs.

Finally, power analyses for testing differences between nested covariance structure models (Satorra & Saris, 1985) were used to examine the power to detect differences between the nested LDS models. Specifically, the constrained model was compared to the unconstrained model, and the $\chi 2$ discrepancy function was calculated. Given the current sample size and a probability level of .05, the observed power of detecting the statistical significance of a particular path was calculated based on a non-central $\chi 2$ distribution with the non-centrality parameter equal to the $\chi 2$ discrepancy function and the *df* equal to the *df* discrepancy between the nested models.

2.2 - WRRP Behavioral Genetic Study

2.2.1 - Sample

The data are from the first 3 annual waves of a longitudinal twin study (Western Reserve Reading Project; Petrill, Deater-Deckard, Thompson, DeThorne, & Schatschneider, 2006). In this study, families were recruited from Cincinnati, Cleveland, and Columbus, Ohio. In total, there were 131 pairs of monozygotic twins (MZ twins; 61% female) and 173 pairs of dizygotic twins (DZ twins; 56% female). On average, twins were 6.08 years old in the 1st wave (*SD* = .68, range = 4.33 – 7.92), 7.15 in the 2nd wave (*SD* = .67, range = 6.00 – 8.83), and 8.30 in the 3rd wave (*SD* = .75, range = 6.50 – 10.00). Child's race was: 91% White, 5% African American, 2% Asian, and 2% other. Mothers were 37.57 years of age on average in the 1st wave (*SD* = 5.19, range = 22 - 53). Fathers were 39.29 years on average in the 1st wave (*SD* = 5.81, range = 26 - 61). Parent's highest education level was (for mother/father): 11/16% high school or less, 27/23% some college, 31/32% bachelor's degree, and 26/24% postgraduate education or degree. Ninety-three percent of the families lived in single detached houses, and 7% lived in subsidized housing, apartment, or townhouse. Ninety-seven percent of the parents were married or living together.

2.2.2 - Measures

Maternal working memory. Maternal working memory was assessed in the 1st wave using the raw score of the digit span subtest (including forward and backward span) from the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997). Among the 304 mothers, 282 mothers have the digit span subtest score. Given the verbal component of the performance on this task, verbal ability, which was measured using the vocabulary subtest from the WAIS-III, was statistically controlled for in the analyses. The digit span score and the vocabulary score were correlated at .42. The vocabulary score was partialled out from the digit span score, and the standardized residual score was used as an index of maternal working memory in the analyses.

Parental rearing attitude. Mothers and fathers reported their rearing attitudes using the traditional and progressive beliefs subscales from the Parental Modernity Scale (Schaefer & Edgerton, 1985) in the 1st wave. Scale description can be found under the Measures section in the SECCYD sample. Cronbach's *α*s for the traditional and progressive beliefs subscales were .83 and .59, respectively. Among the 304 parents, 276 mothers and 154 fathers reported their traditional and progressive rearing beliefs.

Parenting. Mothers and fathers reported their positivity and negativity directed toward each child using the Parenting Feeling Questionnaire (Deater-Deckard, 1996; Deater-Deckard, 2000) in all 3 waves. The negativity scale includes 13 statements about feelings toward each child (e.g., every once in a while my child's behavior can bring out the worst in me) that are rated on a 5-point Likert-type scale (1 = definitely untrue, 5 = definitely true) and 5 negative emotions toward each child (i.e., angry, frustrated, furious, hostile, and sad) that are rated on a 10-point frequency scale (1 = never, 10 = all the time). Parental negativity score was computed separately for mothers and fathers by standardizing and averaging the 2 negativity subscales scores, and standardizing the averaged score again. The positivity scale consists of 11 statements about positive feelings toward each child (e.g., I enjoy hugging and cuddling with my child) that are rated on the 5-point Likert type scale and 5 positive emotions toward each child (i.e., amused, excited, happy, joyful, and proud) that are rated on the 10-point frequency scale. Parental positivity score was computed separately for mothers and fathers by standardizing and averaging the 2 positivity subscales scores, and standardizing the averaged score again. Positivity score was scaled so that higher scores represented lower parental positivity. Cronbach's αs ranged from .80 to .93 for maternal negativity, from .67 to .81 for maternal positivity, from .83 to .93 for paternal negativity, and from .67 to .87 for paternal positivity, depending on the specific twin, subscale, and longitudinal wave. Among the 608 children, maternal parenting scores are available for 554 children in the 1st wave, 502 in the 2nd wave, and 436 in the 3rd wave. Paternal parenting scores are available for 301 children in the 1st wave, 272 in the 2nd wave, and 191 in the 3rd wave.

Child behavioral problems. Mothers, fathers, and observers provided reports on child behavioral problems in all 3 waves. Mothers and fathers rated child externalizing behaviors using the validated 33-item externalizing behavior scale (including aggressive and delinquent behaviors) from the Child Behavior Checklist (Achenbach, 1991a). Scale description can be found under the Measures section in the SECCYD sample. Cronbach's αs ranged from .86 to .87 for mother's reports and from .83 to .89 for father's reports. Among the 608 children, 554 have mother reported externalizing behaviors in the 1st wave, 502 in the 2nd wave, and 436 in the 3rd wave. Three hundred and seven children have father reported externalizing behaviors in the 1st wave, 274 in the 2nd wave, and 190 in the 3rd wave. Correlations between mothers' and fathers' reports of externalizing behaviors ranged from .44 to .58. Therefore, mother's and father's reports were averaged to obtain a single externalizing behaviors score for each twin in each wave.

Mothers and fathers also provided reports on child inattentive, hyperactive, and oppositional defiant behaviors using the Disruptive Behavior Rating Scale (DBRS; Barkley & Murphy, 1998). The inattention subscale includes 9 items (e.g., child fails to give close attention to details or makes careless mistakes in his/her work). The hyperactivity subscale includes 9 items (e.g., child fidgets with his/her hands or feet or squirms in his/her seat). The oppositional defiant behaviors subscale includes 8 items (e.g., child actively refuses to comply with adults' requests or rules). Items are rated on a 4-point Likert type scale (0 = never or rarely, 3 = very often). Cronbach's αs ranged from .86 to .92 for inattention subscale, from .80 to .88 for hyperactivity subscale, and from .82 to .88 for the oppositional defiant behaviors scale. A principle component analysis was conducted on the three subscales for each twin in each wave, separately for mother's and father's reports. A consistent single component solution was suggested (component loadings = .74 to .91; total variance explained = .65 to .77). Therefore, a total DBRS behavioral problems score was computed by averaging the 3 subscales for each twin in each wave, separately for mother's and father's reports. Among the 608 children, 554 have mother-reported DBRS total behavioral problems scores in the 1st wave, 502 in the 2nd wave, and 436 in the 3rd wave. Three hundred and seven children have father-reported DBRS total behavioral problems scores in the 1st wave, 274 in the 2nd wave, and 191 in the 3rd wave. Correlations between the mother and father reported total behavioral problem scores ranged from .44 to .60. Therefore, mother's and father's reports were averaged to obtain a single total behavioral problems score for each twin in each wave.

Lastly, trained testers rated child behaviors after observing the child during a 3 hour cognitive assessment using the Bayley's Behavior Record (Bayley, 1969). A different tester rated each child in each wave. Items are rated on a 5-point Likert-type scale. Four items were selected to measure child behavioral problems: negative affect (1 = three or more intense negative affect, 5 = no negative affect displayed), attention to tasks (1 = constantly off task, 5 = constantly attends), persistence in attempting to complete tasks (1 = consistently lacks persistence, 5 = consistently persistent), and hyperactivity (1 = consistently hyperactive, 5 = consistently not hyperactive). Principle component analyses were conducted on the 4 items and a single component solution was obtained for each child in each wave (component loadings = .62 to .89; total variance explained = 55% to 67%). Cronbach's αs for this scale ranged from .71 to .83. Therefore, an observed child behavioral problem score was obtained for each twin in each wave by averaging the 4 items. Among the 608 children, testers provided ratings on child behavioral problems for 595 children in the 1st wave, 545 in the 2nd wave, and 511 in the 3rd wave. Higher scores were scaled to represent more behavioral problems.

To obtain a more reliable child behavioral problem score that was less constrained by rater and instrument biases, a principle component analysis was conducted for each twin in each wave on the CBCL externalizing behaviors scores, the DBRS total behavioral problems scores, and tester rated behavioral problems scores to examine if a composite child behavioral problems score can be obtained. Results suggested a consistent single component solution: total variance explained were all above 59% and component loadings were all above .35 (except for a .28 loading of twin1's BBR score in the 3rd wave). Therefore, a composite score was computed by standardizing and averaging the 3 scores for each twin in each wave, and standardizing the averaged composite score again. Two out of 3 scores were required to compute the composite behavioral problems score.

2.2.3 - Missing Data

Given that the current study involved 3 annual assessments, missing data analyses examined whether there were mean differences in the demographic information (i.e., child age, sex, and race, parents' ages, parental education level, marital and living status, and household type) and in the initial assessment of the main study variables (i.e., maternal working memory and parental rearing attitude, parenting, and child behavioral problems) between children who do versus who do not have missing values on the main study variables in the 3rd wave. Demographic and main study variables assessed in the 1st wave were used as outcome variables, and whether or not there are missing values on each of the main study variables in the 3rd wave (0 = yes, 1 = no for each variable) were used as predictors in a multivariate analysis of variance, separately for each twin. Results suggested that none of the tested variables had mean level differences between children who do versus who do not have missing values on the demographic or main study variables in the 3rd waves ($F_{(22, 91)}$ = .89 to 1.27; Wilks' λ = .77 to .82). Raw maximum likelihood was used for all the model-fitting procedures.

2.2.4 - Analytic Strategy

All analyses were conducted using SPSS 21.0 (Armonk, NY: IBM Corp.) and Mx (Neale, 1997). As in the SECCYD sample, descriptive and bivariate correlation analyses were conducted first.

Second, the correlations between the main study variables were compared to the correlation matrix obtained in the SECCYD sample to examine whether the overall pattern of the links between the main study variables were comparable between the two studies.

Third, to test the 2nd hypothesis that the links between parenting and child behavioral problems would be explained by both genetic and nongenetic factors, a bivariate ACE Cholesky decomposition model was conducted. A generic bivariate ACE Cholesky decomposition model is shown in Figure 3 (the left side; shown for only one twin for simplicity). In this model, the observed phenotypic variance of and covariance between construct *x* and *y* are decomposed into latent common A, C, and E shared between constructs x and y, and latent residual a, c, and e variance specific to construct *y*. Because MZ twins share all of their alleles and DZ twins share 50% of their alleles on average, the correlation for both common and residual genetic factors is set as 1 for MZ twins and .5 for DZ twins.

The correlation for both common and residual shared environmental factors between twins is set as 1 for both MZ and DZ twins. The correlation for both common and residual nonshared environmental factors between twins is set as 0 for both MZ and DZ twins. Nine parameters were estimated in this model: A^2, C^2, and E^2 for construct *x*, A^2, C^2, and E^2 for construct *y*, and the parts of A^2, C^2, and E^2 that are shared by *x* and *y* (i.e., A_{cov}, C_{cov}, and E_{cov}). In the current analyses, construct *x* was substituted with child behavioral problems and *y* with maternal or paternal parenting behaviors. To test the statistical significance of these correlations, A_{cov}, C_{cov}, and E_{cov} were individually fixed at 0 (constrained models). Subsequently, the constrained models were compared to the full model using χ^2 difference tests. A significant difference in the model fit between the constrained model and the full model suggests that fixing a particular path leads to a significant decrease in the model fit, which in turn suggests that the particular path is statistically significant. This procedure was repeated for each of the 3 waves.

Next, to test the 3rd hypothesis that maternal working memory and parental traditional and progressive rearing beliefs would moderate the effects of child behavioral problems on parenting, ACE Cholesky decomposition models with a continuous moderator were conducted (Dick & York, 2010; Purcell, 2002). A generic ACE Cholesky decomposition model with a continuous moderator is shown on the right side of Figure 3. Because the aim was to test whether the evocative effects of child behavioral problems on parenting differed in parents with different levels of the moderator variable (e.g., working memory), the effects of the moderator were only tested on the A pathways. In this model, the genetic variance is a linear function of the moderator variable, $A_{total} = A' + \beta M$. A' represents the additive genetic influence. M is the value of the moderator variable. The parameter β indicates the magnitude of the influences of the moderator on the total genetic variance. Therefore, β_x, β_{cov}, and β_y represent the magnitudes of the influences of the moderator on the total genetic variance of *x*, genetic covariance between *x* and *y*, and residual genetic variance for *y*, respectively. In the current study, construct *x* was substituted with child behavioral problems and construct *y* with maternal/paternal parenting behaviors. To test the statistical significance of the moderation effects, the moderation parameter on the covariance between *x* and *y* (i.e., β_{cov}) and the moderation parameter on the residual variance of *y* (i.e., β_y) were each fixed at 0 (i.e., constrained model). Subsequently, the constrained model was compared with the full model using a χ^2 difference test. A significant difference in the model fit between the two nested models suggests that fixing the moderation effect at 0 leads to a significant decrease in the model fit, which in turn suggests that the moderation effect is statistically significant. In this case, a post-hoc analysis was conducted to probe the moderation effect. Specifically, the genetic correlation between parenting and child behavioral problems was calculated at 2SD below the mean, 1 SD below the mean, the mean, 1SD above the mean, and 2SD above the mean of the moderator. The 5 values were then compared to examine whether the moderation effect was consistent with the hypothesis. This procedure was repeated for each moderator at each of the 3 waves.

Finally, power analyses for testing differences between nested covariance structure models (Satorra & Saris, 1985) were used to examine the power to detect differences between the nested bivariate Cholesky decomposition models. Specifically, the constrained model was compared to the full model, and the $\chi 2$ discrepancy function was calculated. Given the current sample size and a probability level of .05, the observed power of detecting the statistical significance of a particular path was calculated based on a non-central $\chi 2$ distribution with the non-centrality parameter equal to the $\chi 2$ discrepancy function and the *df* equal to the *df* discrepancy between the nested models.

Chapter 3 – Results

3.1 - SECCYD Sample

3.1.1 - Descriptive and Correlational Analyses

Descriptive statistics of the main study variables are shown in Table 2. On average, both mothers and fathers showed modest levels of anger and anxiety. The distributions of both maternal and paternal anger were positively skewed and kurtotic. Mothers and fathers also exhibited similar levels of both progressive and traditional rearing beliefs. Parental rearing beliefs scores were distributed widely and normally. Both mothers' and fathers' parenting scores were distributed normally, with mothers showing on average slightly poorer parenting quality compared to fathers. On average, children showed modest levels of behavioral problems which decreased over time. The distributions of the behavioral problems scores were slightly positively skewed and kurtotic.

Screening of outliers (i.e., over 4SDs away from the mean of each variable) suggested that 17 outliers should be eliminated. Subsequently, maternal and paternal anger, and child behavioral problems assessed in all 4 waves were natural-log transformed. These transformations successfully created variables that more closely approximated normal distributions.

Correlations between all main study variables are shown in Table 3. Anger and anxiety were moderately positively correlated within parents, and both anger and anxiety were modestly correlated across parents. Progressive and traditional rearing beliefs negatively covaried within parents to a moderate degree. Mothers and fathers showed modest and moderate consistency in their progressive and traditional rearing beliefs, respectively. Generally, parental negative affect (i.e., anger and anxiety) and parental rearing beliefs were minimally correlated. Parenting quality was moderately stable over the 4 waves of assessments, with the stability being particularly strong for maternal parenting. Mothers and fathers showed modest levels of consistency in their parenting quality. Lower maternal parenting quality in all 4 waves was consistently associated with higher maternal anger and anxiety, fewer progressive rearing beliefs, and more traditional rearing beliefs. Note that maternal parenting quality was fairly strongly correlated with mothers' traditional rearing beliefs. In contrast, paternal parenting quality was minimally correlated with paternal anger and anxiety and was associated with fathers' rearing beliefs such that fathers holding more progressive and fewer traditional rearing beliefs exhibited higher parenting quality. Child behavioral problems were highly stable throughout the 4 waves of assessments. Correlations between child behavioral problems and parental variables were generally modest. More child behavioral problems were correlated with more parental anger and anxiety, more traditional and fewer progressive rearing beliefs, and lower parenting quality. Child behavioral problems were slightly more strongly related to maternal parenting and attributes than to paternal parenting and attributes.

3.1.2 - Hypothesis 1: Bidirectional Transaction.

Bivariate LDS models were used to test the 1st hypothesis concerning the bidirectional predictions between parenting and child behavioral problems. An unconstrained model was first fit in which all parameters were freely estimated. Subsequently, predictions from parenting to changes in child behavioral problems and predictions from child behavioral problems to changes in parenting were separately fixed at 0 in 2 different models to test the significance of these cross-lagged predictive effects. Note that none of the models involving paternal parenting quality converged. Therefore, only models involving maternal parenting quality are presented.

Model fit and comparison information is shown in Table 4. According to χ^2 difference tests, constraining the predictions from child behavioral problems to changes in maternal parenting quality to 0 (model b) resulted in poorer model fit compared to the unconstrained model (model a), whereas fixing the predictive paths from maternal parenting quality to changes in child behavioral problems at 0 (model c) did not worsen model fit. Therefore, results from model c were interpreted and parameter estimates from model c are presented in Figure 4. The figure at the top of Figure 4 presents means and variances for the intercepts, slopes, and residuals, and unstandardized parameter estimates for the predictive paths. The figure at the bottom of Figure 4 presents covariance between intercepts and slopes. The results suggested that maternal parenting quality did not predict proportional changes (i.e., d1, d2, and d3) in child behavioral problems over time. However, a lower initial level of maternal parenting quality was associated with more additive increases or less additive decreases (i.e., slope) in child behavioral problems. Child behavioral problems at 54 months did not predict proportional changes (i.e., d1) in maternal parenting quality between 54 months and 1st grade. However, child behavioral problems predicted changes in maternal parenting quality between 1st and 3rd grades (i.e., d2) significantly and between 3rd and 5th grades (i.e., d3) marginally significantly. The effects of child behavioral problems on parenting appeared to increase from the 1st to the 2nd and 3rd waves. Initial levels of child behavioral problems were not correlated with additive changes in maternal parenting quality over time. In summary, a transactional predictive pattern was not found, and hypothesis 1 was not supported.

Given the current sample size and a probability level of .05, observed power analyses indicated that there was sufficient power to detect the effects from child behavioral problems to changes in maternal parenting quality; however, power was insufficient to detect the effects from parenting quality to changes in child behavioral problems.

3.1.3 - Hypothesis 3: Parental Attributes as Moderators

Two-group bivariate LDS models were used to test the moderated effects of a variety of parental attributes in the predictions from child behavioral problems to parenting. A series of 2 groups were created by splitting the sample at the mean of each moderator. Therefore, 8 sets of 2 groups were formed: high vs. low maternal/paternal anger groups, high vs. low maternal/paternal anxiety groups, high vs. low maternal/paternal traditional rearing belief groups, and high vs. low maternal/paternal progressive rearing belief groups. To test whether the effects of child behavioral problems on changes in parenting quality were similar in each set of the 2 groups, unconstrained 2-group models were first fit in which all parameters were freely estimated. Subsequently, constrained 2-group models were fit in which equality constraints were imposed with respect to the effects of child behavioral problems on changes in parenting. Note that none of the models involving paternal parenting quality converged. Therefore, only models involving maternal parenting quality are presented.

Model fit and comparison indices are shown in Table 5. The χ^2 difference tests indicated that the constrained models fit better when using maternal anxiety, and maternal traditional and progressive rearing beliefs as moderators, suggesting that the effects of child behavioral problems on changes in maternal parenting quality did not differ as functions of maternal anxiety or maternal rearing beliefs. However, when examining maternal anger as the moderator, the unconstrained model fit better, suggesting that the effects of child behavioral problems on changes in maternal parenting quality were different in high vs. low anger groups. In mothers with lower levels of anger, child behavioral problems at 54 months, 1st grade, and 3rd grade consistently predicted larger decreases or smaller increases in maternal parenting quality from 54 months to 1st grade (b = 1.75, $p < .05$), from 1st to 3rd grades (b = 2.99, $p < .001$), and from 3rd to 5th grades (b = 2.63, $p < .001$). In mothers with higher levels of anger, child behavioral problems did not consistently predict changes in maternal parenting quality: child behavioral problems at 54 months significantly predicted smaller decreases or larger increases in maternal parenting quality from 54 months to1st grade (b = -

2.33, $p < .05$), whereas child behavioral problems at neither 1st grade nor 3rd grade significantly predicted subsequent changes in maternal parenting quality ($b = -1.02$ and -1.72, $p > .05$). Therefore, the overall result pattern did not support hypothesis 3.

Given the current sample size and a probability level of .05, observed power analyses indicated that there was sufficient power in the current study to detect the difference in the effects from child behavioral problems to changes in maternal parenting quality between low versus high anger groups, but not between any other set of 2 groups.

In summary, the analyses using the SECCYD sample showed that, in general, child behavioral problems were predictive of the proportional changes in maternal parenting quality. Such predictive effects appeared to be increasing over time. However, maternal parenting quality was not predictive of the proportional changes in child behavioral problems. Instead, initial levels of maternal parenting quality were associated with additive changes in child behavioral problems over time. In addition, maternal anger moderated the effects of child behavioral problems on changes in maternal parenting quality whereby child behaviors only consistently predicted changes in maternal parenting quality in mothers with lower levels of anger.

3.2 - WRRP Sample

3.2.1 - Descriptive and Correlational Analyses

Descriptive statistics of the main study variables are presented for twin1 and twin 2 separately in Table 6. Because parental attributes were family-level data, descriptive statistics for these variables are only presented once. Variables concerning parental rearing beliefs were mostly normally distributed. Maternal traditional rearing beliefs were slightly positively kurtotic but were not transformed for further analyses in order to maintain scale consistency for all rearing belief variables. On average, parents possessed higher levels of progressive than traditional beliefs. The presented maternal digit span score was a standardized residual score, and therefore had a mean of 0 and a standard deviation of 1. The digit span residual score was also distributed normally. Because all parenting variables and child behavioral problem variables were computed using standardized composite scores, they all had means of 0 and standard deviations of 1. Note that parenting positivity has been reverse-scored so that higher scores represented less positivity. Parental positivity and negativity were distributed widely in all 3 waves with parents reporting higher levels of positivity than negativity on average. Both parental positivity and negativity across the 3 waves were modestly to severely positively skewed and kurtotic. Natural log transformations were conducted on these variables before further analyses. Child behavioral problem scores in all 3 waves were distributed widely with average children exhibiting modest levels of behavioral problems. Behavioral problem scores were modestly positively skewed and kurtotic, and were natural log transformed before further analyses.

Screening of outliers (i.e., 4SD away from mean of each variable) suggested that 5 outliers be eliminated from further analyses in the 1st wave, 6 be eliminated in the 2nd wave, and 5 be eliminated in the 3rd wave. In addition, before further analyses, child age and sex were residualized out from all variables because shared age and sex within twins yield spuriously shared environmental effects. Subsequently, a natural log transformation was conducted on parental positivity and negativity and child behavioral problems to create variables that more closely approximated normal distributions. Finally, to prepare for the moderation analyses, all variables were standardized for centering purpose.

Bivariate correlations between main study variables are presented separately for twin 1 (Table 7) and twin 2 (Table 8). The general pattern of correlations was consistent across twins. Higher progressive beliefs were modestly correlated with lower traditional beliefs for both mothers and fathers. Mothers and fathers showed modest consistency in their progressive and traditional rearing beliefs. Maternal digit span was minimally associated with all other main study variables. Both mothers and fathers reported high levels of stability in their positivity and negativity across the 3 waves of assessments. Higher parental positivity was moderately correlated with lower parental negativity for both mothers and fathers, and mothers and fathers exhibited modest consistency in their negativity and positivity toward each twin. Parental negativity and positivity were minimally correlated with parental rearing beliefs. Individual differences in child behavioral problems across the 3 waves were highly stable and were generally not correlated with parental attributes. Child behavioral problems were associated with more parental negativity and less parental positivity. In addition, child behavioral problems were slightly more strongly related to parental negativity than parental positivity.

When comparing the correlational statistics across the SECCYD and the WRRP samples, some consistencies were found. Both studies revealed a modest positive correlation between mothers' and fathers' rearing beliefs as well as modest negative correlations between traditional and progressive rearing beliefs within parents. In addition, maternal and paternal parenting behaviors were modestly consistent with each other in both studies. Stability in child behavioral problems was also comparable between the 2 studies. However, some inconsistent results were also found. In the SECCYD sample, parent rearing beliefs were modestly correlated with both parenting and child behavioral problems. In contrast, parent rearing beliefs were minimally correlated with parenting and child behavioral problems in the WRRP sample. In addition, stability in parenting was higher in the WRRP sample than in the SECCYD sample. Lastly, parenting and child behavioral problems were more strongly correlated in the WRRP sample than in the SECCYD sample.

Cross-twin correlations between individual-level variables were also computed separately for MZ (Table 9) and DZ (Table 10) twins. These correlations are presented to provide a general sense of the genetic and nongenetic variance/covariance components in and between the main study variables. The specific point estimates of the genetic and nongenetic variance in and covariance between the main study variables were computed using bivariate Cholesky models. The correlation estimates that are underlied were the focus of the current study. Overall, both intra-variable and inter-variable correlations were greater in MZ twins than in DZ twins, suggesting the presence of genetic variance in and covariance between the main study variables. In addition, both intra-variable and inter-variable correlations in MZ twins were no greater than 2 times the correlations in DZ twins, suggesting the presence of shared environment variance in and covariance between the main study variables.

3.2.2 - Hypothesis 2: Genetic and Nongenetic Etiology.

To examine the genetic and nongenetic etiology of the relations between parenting and child behavioral problems, bivariate Cholesky decomposition models were used. Standardized genetic, shared environmental, and nonshared environmental variance of and covariance between parenting and child behavioral problems were estimated. To test the significance of genetic and environmental correlations, genetic, shared environmental, and nonshared environmental covariance were each individually dropped from the full model. Model fit indices and parameter estimates are shown in Table 11 through Table 14. For the purpose of comparison, parameter estimates obtained from the full model are shown even if a more parsimonious model fit better than the full model.

Maternal negativity and child behavioral problems. Results concerning the link between maternal negativity and child behavioral problems are shown in Table 11. Across all 3 waves, variance in both child behavioral problems and maternal negativity was mainly explained by genetic and shared environmental influences. Nonshared environmental variance was modest. The genetic and nongenetic variance estimates in both constructs were comparable across the 3 waves.

The full model was the best fitting model in the 1st and 3rd wave, but not in the 2nd wave in which dropping the shared environmental correlation improved the model fit. The phenotypic correlations between maternal negativity and child behavioral problems across all

3 waves were accounted for by moderate levels of genetic correlations, modest to moderate shared environmental correlations, as well as modest levels of nonshared environmental correlations. Genetic correlations slightly increased from the 1st to the 2nd and 3rd waves, and shared environmental correlations slightly decreased from the 1st to the 2nd and 3rd waves.

Maternal positivity and child behavioral problems. Table 12 shows results concerning the link between maternal positivity and child behavioral problems. Genetic and nongenetic variance estimates in child behavioral problems were consistent with those estimated in the models involving maternal negativity and child behavioral problems, confirming the stability in these estimates. Variance in maternal positivity was accounted for by modest genetic and nonshared environmental influences and moderate shared environmental influences in all 3 waves.

Model fit indices suggested that the full model was the best fitting model only in the 1st wave. In the 2nd wave, fixing both the shared and nonshared environmental correlations at 0 resulted in improvement in model fit. In the 3rd wave, the model without the nonshared environmental correlation fit the data best. The phenotypic correlation between maternal positivity and child behavioral problems was mainly accounted for by genetic correlations in all 3 waves. Shared environmental correlation was modest in the 1st and 3rd wave and negligible in the 2nd wave. Nonshared environmental correlation between maternal positivity and child behavioral problems was modest in the 1st wave and negligible in the 2nd and 3rd wave. Genetic correlations increased from the 1st to the 3rd wave. There was no apparent trend of change in the shared environmental correlations. Nonshared environmental correlations decreased from the 1st to the 3rd wave.

Paternal negativity and child behavioral problems. Model fit indices and parameter estimates of the models involving paternal negativity and child behavioral problems are shown in Table 13. Phenotypic variance in paternal negativity was accounted for by modest genetic influences and moderate shared environmental influences in all 3 waves. Nonshared environmental influences were minimal.

Model fit indices suggested that the full model was the best fitting model in the 1st wave, whereas fixing the nonshared environmental correlation in the 2nd wave and fixing the genetic correlation in the 3rd wave at 0 resulted in better model fits. Observation of the genetic and nongenetic correlations across the 3 waves indicated that genetic correlations decreased whereas shared environmental correlations increased substantially from the 1st to the 3rd wave. Nonshared environmental correlation was modest in the 1st and 3rd wave and was negligible in the 2nd wave.

Paternal positivity and child behavioral problems. Results regarding the link between paternal positivity and child behavioral problems are shown in Table 14. There was modest genetic and nonshared environmental variance and moderate shared environmental variance in paternal positivity in all 3 waves.

With regards to the correlation between paternal positivity and child behavioral problems, model fit indices suggested that fixing both genetic and nongenetic correlations in the 1st wave at 0 resulted in the best model fit. In the 2nd wave, the best fitting model constrained the shared and nonshared environmental correlations at 0. In the 3rd wave, dropping the nonshared environmental correlation resulted in the best fit. More specifically, the genetic correlation increased slightly from the 1st to the 3rd wave. In addition, there was a modest increase in the shared environmental correlations.

Power analyses. Observed power analyses were conducted, and results are shown in the last column in Table 11 through Table 14. For models involving maternal parenting and child behavioral problems, given the current sample size, ratio of MZ to DZ twins, and a probability level of .05, the power was sufficient to detect a genetic correlation above .5, a shared environmental correlation above .6, and a nonshared environmental correlation above .25. For models involving paternal parenting and child behavioral problem, given the current sample size, ratio of MZ to DZ twins, and a probability level of .05, there was sufficient power to detect a genetic correlation above .7, a shared environmental correlation above .7, and a nonshared environmental correlation above .3.

3.2.3 - Hypothesis 3: Parental Attributes as Moderators

Bivariate Cholesky decomposition models were used to test the moderated effects of a variety of parental attributes on the genetic correlations between parenting and child behavioral problems. In particular, the full model was tested first. Subsequently, moderation on the common genetic pathway and moderation on the residual genetic pathway were constrained to be 0 both individually and together to test whether or not the moderation effect on the genetic correlation was statistically significant. Due to the small sample size, models involving paternal attributes and paternal parenting behaviors produced unstable parameter estimates (i.e., parameter estimates and model convergence depended on starting values provided); thus, results of these models are not presented. Results obtained from models involving maternal parenting behaviors are shown in Table 15 through Table 17.

Maternal digit span as the moderator. The moderating effect of digit span was first tested on the genetic correlations between maternal negativity and child behavioral problems. Results are shown in the first 4 rows in Table 15. Model comparisons suggested that in all 3 waves, the moderation effects on both the common and the residual genetic pathways can be fixed at 0 without worsening model fits, suggesting no moderating effects of maternal digit span on the genetic correlations between maternal negativity and child behavioral problems.

Models examining the moderating effect of digit span on the genetic correlations between maternal positivity and child behavioral problems are shown in the last 4 rows in Table 15. Results showed that the models without the moderation effects fit better than the full models in all 3 waves, suggesting no moderation effects of maternal digit span on the genetic correlations between maternal positivity and child behavioral problems.

Maternal traditional rearing beliefs as the moderator. The moderating effects of maternal traditional rearing beliefs on the genetic correlations between maternal negativity and child behavioral problems are shown in the top 4 rows in Table 16. Model comparisons indicated that fixing the moderating effects at 0 on both the common and the residual genetic pathways did not worsen model fits in any of the 3 waves, suggesting that traditional rearing beliefs did not significantly moderate the genetic correlations between maternal negativity and child behavioral problems.

Results concerning the moderating effect of traditional rearing beliefs on the genetic correlations between maternal positivity and child behavioral problems are shown in the bottom 4 rows in Table 16. The models with no moderating effects fit the data best in the 1st and 2nd waves. In the 3rd wave, dropping the moderating effect on the common genetic pathway worsened the model fit, suggesting that traditional rearing beliefs significantly moderated the genetic correlation between maternal positivity and child behavioral problems in the 3rd wave. A post-hoc analysis on this moderating effect was conducted and results are shown in Table 18. As levels of traditional rearing beliefs increased, the genetic correlations between maternal positivity and child behavioral problems substantially increased, a pattern that was consistent with the 3rd hypothesis.

Maternal progressive rearing beliefs as the moderator. Models testing the moderating effect of maternal progressive rearing beliefs on the genetic links between maternal negativity and child behavioral problems are presented in the top 4 rows in Table 17. Model comparisons showed that the models with no moderating effects were the best fitting models in the 1st and the 3rd waves. In the 2nd wave, constraining the moderating effect on the residual genetic pathway worsened the model fit compared to the full model, suggesting that maternal progressive rearing beliefs significantly moderated the genetic correlation between maternal negativity and child behavioral problems in the 2nd wave. A post-hoc analysis was conducted, and results are shown in Table 18. As levels of the progressive rearing beliefs increased, the genetic correlations between maternal negativity and child behavioral problems decreased, a pattern that was consistent with 3rd hypothesis.

Results concerning the moderating effect of progressive rearing beliefs on the genetic links between maternal positivity and child behavioral problems are shown in the bottom 4 rows in Table 17. In all 3 waves, dropping the moderating effects on both the common and the residual genetic pathways resulted in improvement in model fits, suggesting that progressive rearing beliefs did not moderate the genetic correlations between maternal positivity and child behavioral problems.

Power analyses. Observed power analyses were conducted to examine the observed power to detect the moderation effects of the above moderators. These results are shown in the last column in Table 15 through Table 17. These numbers represented the observed powers to detect the corresponding moderating effects that were dropped from the models given the current sample size, the ratio of MZ to DZ twins, and a probability level of .05. As shown, the current sample was vastly underpowered to detect the majority of the moderating effects. The only exception was the moderating effect of maternal traditional rearing beliefs on the genetic correlation between maternal positivity and child behavioral problems in the 3rd wave. A post-hoc analysis suggested that this moderating effect was substantial and resulted in dramatic increases in the genetic correlations between maternal positivity and child behavioral problems as levels of the moderator increased. Therefore, the current study probably provided sufficient power to detect only very large moderating effects on the genetic correlations.

In summary, the analyses using the WRRP sample showed that the links between parental parenting behaviors and child behavioral problems were accounted for by both genetic and environmental influences, a result that was consistent with the 2nd hypothesis. In addition, the genetic correlations between paternal negativity and child behavioral problems decreased whereas the genetic correlations between child behavioral problems and both maternal and paternal positivity increased across time. Shared environmental correlations between child behavioral problems and both paternal negativity and positivity increased over time. The moderation analyses showed that the current study was vastly underpowered to detect the moderating effects of a variety of parental attributes on the genetic correlations between parenting and child behavioral problems. However, some moderating effects regarding maternal traditional and progressive rearing beliefs were found, and the pattern of the moderating effects were consistent with the 3rd hypothesis.

Chapter 4 – Discussion

The notion that parents and children exert mutual influence on each other through their daily transactions has been accepted widely in developmental science. However, much is still unknown about the intertwining relationship of parenting and child development. A special section of the Journal of Abnormal Child Psychology (2008) on "bidirectional parent-child relationships" proposed 3 challenges in the field that remained unaddressed: extending macro-level analysis of transaction to moment-to-moment interactions between parents and children, developing improved models to study changes across development, and identifying the underlying mechanisms of the bidirectionality (Pettit & Arsiwalla, 2008). The current study aimed to address the latter two issues using a longitudinal design (SECCYD sample) and a repeated cross-sectional behavioral genetic design (WRRP sample) spanning the entire period of middle childhood. Three specific hypotheses were tested, all directed towards further developing our knowledge of the underlying etiology of how parenting and child behavioral problems are reciprocally linked throughout development.

4.1 - Hypothesis 1: Transactional Nature (SECCYD)

To address the first hypothesis, bivariate LDS models were used to examine the dynamic relation between parenting and child behavioral problems. Maternal parenting behaviors did not predict proportional change scores in child behavioral problems. However, child behavioral problems in 1st and 3rd grade predicted proportional change scores in parenting from 1st to 3rd and from 3rd to 5th grade. Although the current results did not support a dynamic transactional relation between parenting quality and child behavioral problems, the findings did suggest a bidirectional reciprocal effect. Although time-dynamic predictions from parenting to child behavioral problems were negligible, lower initial levels of parenting quality at 54 months were associated with higher constant increases in child behavioral problems over time. This finding is consistent with several previous studies examining growth trajectories in child behavioral problems (Shaw et al., 2003; Tremblay et al., 2004).

Therefore, there appear to be distinct mechanisms at work in the effects of parents and children on one another. Specifically, child behavioral problems on parenting are time-locked, and dependent on prior existing conditions of the system. Levels of parenting quality, on the other hand, influence the general trend of child behavioral problem development over time, regardless of initial system conditions. Examined together, a lower parenting quality appears to set the stage for the development of increasing levels of child behavioral problems, which in turn reinforces and accelerates the impacts of low parenting quality. This subtle difference between the mechanisms of parent-effects and child-effects on one another is a unique finding of the current study, most likely attributed to the modeling approach applied in the current analyses. LDS models offer several advantages over other longitudinal modeling approaches. In particular, it combines features of both panel analysis and LGM approach in examining longitudinal changes (Hamagami & McArdle, 2001; King et al., 2006; McArdle, 2001). That is, both time-dynamic longitudinal transactions as well as links between general trends of changes can be examined within the same model, allowing for such a subtle difference between the mechanisms of the parent- and child- effects to be detected. In addition, unlike panel analysis which uses residual scores to capture changes, LDS models use difference scores allowing for the accounting of mean level changes without violating model assumptions or biasing interpretations of parameter estimates (King et al., 2006). Accordingly, given that most previous studies used regression or panel analysis (Hipwell et al., 2008; Pardini et al., 2008; Reitz, Dekovic, & Meijer, 2006; Scaramella et al., 2008), the inconsistency between the current and previous findings is not surprising. However, additional studies are needed in the future to replicate the current findings using the LDS models before any assertion can be made regarding the different mechanisms by which parenting and child behavioral problems influence each other.

The time-locked effects of child behavioral problems on parenting increased from the 1^{st} to 2^{nd} and 3^{rd} waves, indicating a potentially increasing impact of the child as the parent-child dyad evolves over time. Considering that the majority of previous longitudinal studies either applied LGMs or only included two time points in the panel analysis (e.g., Burke et al., 2008; Reitz et al., 2006; Richmond, & Stocker, 2008), few studies are available to compare the current findings with. Conceptually, the increasingly stronger effects of child behavioral problems on parenting may be a result of the repeated challenging transactions between the parent and the child. Through the recurrent transactions, the negatively arousing effects of child behavioral problems may accumulate over time and eliciting increasingly poorer parenting quality, including increasing levels of harsh reactivity and lack of warmth. The rising effects of child behavioral problems on parenting may also reflect an increasing level of incompatibility between parental expectations and actual levels of child problem behaviors (Dix, Ruble, Grusec, & Nixon, 1986). As children develop, parental expectations of a child’s knowledge and self-control ability also increase. Therefore, when levels of problem behaviors persist or even increase, parents are more likely to attribute these problem behaviors to a child's intentions and dispositions, and hence are more likely to react to such behaviors negatively and harshly (Dix et al., 1986).

Furthermore, the influence of child behavioral problems in 1st grade on changes occurring in parenting between 1st and 3rd grade were particularly salient. The timing of this particular effect coincides with the transition to formal schooling, and therefore likely reflects a meaningful period of distinct interaction pattern between the parent and the child (Gross, Shaw, & Moilanen, 2008). The beginning of formal education places great demands on children's self-regulation ability, social skills, academic readiness, and general adaptability to new environments, which is significantly challenging for many children (Rimm-Kaufman & Pianta, 2000; Rimm-Kaufman, Pianta, & Cox, 2000). Therefore, such a transition potentially generates a stressful period for both the child and the parent, rendering them more vulnerable and increasing the likelihood that they are emotionally and behaviorally reactive to one another. Consistent with the current findings, two previous studies demonstrated that the mutual impacts of child behavioral problems and parenting behaviors or parental psychopathology in middle childhood were strongest during the critical period in which children first enter elementary school (Gross et al., 2008; Jaffee & Poulton, 2006).

Unfortunately, the models involving paternal parenting behaviors did not converge, therefore eliminating the possibility of directly comparing maternal and paternal parenting behaviors. As a result, the different parenting behaviors and their relations to child behavioral problems were examined through correlation matrices. In general, mothers and fathers only showed modest consistency in their parenting behaviors, a finding that has been replicated in other developmental periods (Forehand & Nousiainen, 1993; Winsler, Madigan, & Aquilino, 2005). In addition, the correlations between child behavioral problems and parenting were weaker for fathers compared to mothers, indicating a stronger bidirectional influence within mother-child dyads as compared to father-child dyads. This finding is consistent with the attachment literature in which maternal attachment shows greater impacts on child development than paternal attachment (for a review, see Lewis & Lamb, 2003). However, the developmental patterns of the correlations between parenting and child behavioral problems were similar for mothers and fathers. For both mothers and fathers, the lagged correlations between parenting at time t and child behavioral problems at time t+1 increased over time. The lagged correlations between child behavioral problems at time t and parenting at time t+1 increased from 54 months to the 1st and 3rd grades, peaking at the 1st grade. This pattern was found to be similar in mothers and fathers, as well as consistent with the modeling results.

Therefore, despite the fact that mothers and fathers may use their unique ways to communicate and interact with their children (e.g., mothers provide more nurture and basic needs whereas fathers involve in more in plays and academic performance; Lewis & Lamb, 2003), the link between the development of child behavioral problems and general parenting quality indicated by warmth, respect, support, and stimulation of cognitive development may be similar for mothers and fathers (for a review, see Russell & Saebel, 1997).

4.2 - Hypothesis 2: Genetic and Nongenetic Etiology (WRRP)

The second hypothesis of the current study addressed the genetic and nongenetic etiology of the links between child behavioral problems and parenting. A series of bivariate Cholesky decomposition models were used to test this hypothesis. At the individual variable level, individual differences in child behavioral problems were accounted for by moderate levels of genetic influence, and modest shared and nonshared environmental variance. These estimates confirmed findings from several meta-analytic studies on the genetic and nongenetic etiology of aggression, delinquency, and antisocial behaviors in childhood (DiLalla, 2002; Rhee & Waldman, 2002). Maternal negativity was explained by equal proportions of genetic and shared environmental influences and modest nonshared environmental influence. Maternal positivity, paternal negativity, and paternal positivity were accounted for by modest genetic variance, moderate shared environmental variance, and negligible nonshared environmental variance. The genetic and nongenetic estimates of parental positivity and negativity were in similar ranges with estimates from prior studies (Deater-Deckard, Fulker, & Plomin, 1999; Deater-Deckard, & O'Connor, 2000; Neiderhiser, Reiss, Lichtenstein, Spotts, & Ganiban, 2007; Neiderhiser et al., 2004).

How do genetic and nongenetic factors account for the phenotypic links between parenting and child behavioral problems? First, both positivity and negativity showed moderate genetic correlations with child behavioral problems. Shared and nonshared environment correlations were higher for parental negativity than positivity. That is, child behavioral problems were equally likely to elicit parental negativity and withdrawal of positivity through evocative *r*GE processes, whereas parental negativity was more likely than positivity to be linked with child behavioral problems through shared (or passive *r*GE) and nonshared environmental mechanisms. Therefore, the current findings supported the second hypothesis. Several cross-sectional and longitudinal behavioral genetic studies have examined similar research questions but focused on a variety of distinct parenting dimensions throughout different developmental stages (Burt et al., 2005; Larsson et al., 2008; Pike et al., 1996; Shelton et al., 2008). Together with the current study, results all converge in suggesting that genetically influenced child behavioral problems elicit less warmth and more harsh reactivity in parents which in turn exacerbate these behavioral problems through genetic and nongenetic mechanisms.

The unique design of the current study also allowed for the comparison between the genetic and nongenetic etiologies linking child behavioral problems with maternal versus paternal parenting behaviors. Similar genetic and nongenetic correlation patterns between positivity and child behavioral problems were found in mothers and fathers: moderate genetic correlations, modest shared environmental correlations, and negligible nonshared environmental correlations. Additionally, mothers and fathers also exhibited similar levels of genetic and shared environmental correlations between negativity and child behavioral problems. Nonshared environmental correlations between negativity and child behavioral problems, however, were slightly stronger for mothers. A previous study focusing on the links between parental negativity and adolescents' antisocial behaviors and depression showed similar genetic and nongenetic correlations between parenting and adolescent functioning for mothers and fathers (Pike et al., 1996). Therefore, overall, the genetic and nongenetic etiology of links between parenting and child behavioral problems were comparable for mothers and fathers. Although there are limited findings comparing the etiologies relating maternal versus paternal parenting with child behavioral problems, several studies have examined the genetic and nongenetic etiologies in parenting itself (O'Connor, Hetherington, Reiss, & Plomin, 1995; Plomin, Reiss, Hetherington, & Howe, 1994; Rowe, 1981), and few have suggested meaningful differences between mothers and fathers.

The transition of the underlying etiology was also examined. Genetic correlations between positivity and child behavioral problems slightly increased overtime for both mothers and fathers, suggesting increasingly stronger evocative *r*GE processes. This is consistent with the findings from the SECCYD sample in which child behavioral problems more strongly predicted decreases in parenting quality over time. However, a dramatic decrease in the genetic correlations between paternal negativity and child behavioral problems was evident. Given the short interval of time between current assessments (three years), such a dramatic change was an unexpected finding. Furthermore, shared environment correlations between child behavioral problems and both positivity and negativity increased, but only for fathers. This potentially suggests the increasing importance of fathers' parenting behaviors in the development of behavioral problems in children through siblings' shared experiences. However, to our knowledge, no previous studies have explored the developmental transitions of the genetic and nongenetic etiologies linking parenting and child behavioral problems. In order to confirm the current findings and further our understanding in this regard, it is necessary to include additional assessment points across an even longer timespan

4.3 - Hypothesis 3: Parental Attributes as Potential Moderators (SECCYD and WRRP Samples)

The idea of examining parental attributes as moderators in parental reactions to child behaviors has been proposed for 2 decades (Bates & Pettit, 1981; Belsky, 1984). However, empirical efforts designed to test this specific notion have been sparse (Bugental, Caporael, & Shennum, 1980; Deater-Deckard et al., 2010; Deater-Deckard et al., 2012; Matthews, 1977). Therefore, the third aim of the current study was to expand on the current findings by examining how parental attributes, including parents' negative affect, parenting rearing beliefs, and parents' working memory, moderated the links between parenting and child behavioral problems. Unfortunately, the models involving paternal parenting behaviors failed to converge, most likely due to small sample sizes. Therefore, the following discussion focused on maternal attributes and maternal behaviors.

Of the four proposed moderators in the SECCYD sample (i.e., maternal anger, anxiety, and traditional and progressive rearing beliefs), only maternal anger significantly moderated the cross-lagged predictions from child behavioral problems to changes in maternal parenting quality. However, the direction of the moderation effects was the opposite of the hypothesis. That is, child behavioral problems more strongly predicted changes in parenting quality for mothers with lower levels of anger as compared to mothers with higher levels of anger. Additional analyses (not presented here) suggested that mean levels of parenting quality were consistently lower in the high anger group compared to the low anger group. Moreover, there was a quadratic relation between maternal anger and parenting quality whereby maternal parenting quality decreased as maternal anger increased but only in mothers with high anger. Together, these results indicated that maternal parenting quality was consistently poor in mothers with high levels of anger. Maternal parenting quality, on the other hand, was only affected in mothers with low levels of anger when children exhibited high levels of behavioral problems. This complex interplay between maternal attribute and child behavioral problems contradicts a previous theory arguing the relative importance of parental attributes versus child attributes in the etiology of parenting (Belsky, 1984). This theory minimizes the relative importance of child behaviors on parenting when compared to parents' attributes, particularly when parental psychological and social resources are sufficient (Belsky, 1984).

Conversely, the current findings, suggest that even for emotionally healthy and nonreactive mothers, high levels of child behavioral problems still produced deleterious effects on parenting quality.

Closely tied in to the above results are findings drawn from studies exploring the moderating effect of maternal executive function on the association between child behavioral problems and maternal harsh reactivity (Deater-Deckard et al., 2010; Deater-Deckard et al., 2012). Executive function refers to the cognitive regulation of attention and memory (Friedman et al., 2008), which potentially underlies effective emotion self-regulation (Ochsner & Gross, 2008). Only mothers with poorer executive function have been found to be strongly reactive to child behavioral problems (Deater-Deckard et al., 2010). Collectively, these findings suggest that although emotional reactivity and emotion regulation are generally negatively correlated, emotion reactivity and emotion regulation may serve distinct functions in modulating maternal responses to difficult child behaviors. Strong executive function may attenuate the link between child behavioral problems and harsh reactive parenting in mothers who are modestly emotionally reactive. However, it is still unclear how executive function and child behavioral problems jointly affect parenting in mothers who are highly emotionally reactive. Therefore, the co-moderating effect between parental emotion regulation and emotion reactivity in the relation between child behavioral problems and parenting is an important new direction to be taken in future research.

It is unclear why maternal anxiety did not moderate the effects of child behavioral problems on changes in parenting quality. One possible explanation is that, unlike the intrusive and explosive nature of anger, anxiety mostly represents an emotional and behavioral withdrawal tendency (Davidson, 1998; Gray, 1994). As a result, it may only be associated with "fight" behaviors once a certain threshold is surpassed (Bubier & Drabick, 2009). Given that the current study targeted a community sample, few mothers reached extreme high levels of anxiety. Therefore, these mothers may be more likely to withdraw from conflicts or neglect their children when facing high levels of behavioral problems than to respond with high levels of hostility and intrusiveness. Future studies would benefit from additional investigation specifically designed to compare the moderating role of maternal anxiety on both harsh reactivity and neglect in both community and clinical samples.

In the WRRP sample, no moderator demonstrated a consistent effect on the genetic correlations between maternal parenting behaviors and child behavioral problems. Specifically, maternal working memory measured using digit span scores failed to moderate the genetic correlations between parenting and child behavioral problems in any wave. Using the same sample, one previous study revealed that mothers' digit span scores moderated the phenotypic link between differential maternal negative reactivity and sibling differences in behavioral problems (Deater-Deckard et al., 2010). These results together suggest that maternal working memory may influence the phenotypic association between child behavioral problems and maternal negativity through moderating the nonshared environment correlations. In other words, a mother with lower working memory is more likely to react differentially negatively toward her two children based on different levels of sibling's behavioral problems regardless of their genetic similarity. However, it is challenging to test this possibility as it requires the examination of the effect of a continuous moderator on the nonshared environmental correlation. The computation of nonshared environmental correlation includes the moderated residual nonshared environment variance which is potentially unreliable due to measurement errors. One way to more easily and more powerfully test this idea is employing the discordant MZ twin design in which differences in siblings can only be attributed to nonshared environmental influences (Plomin, DeFries, McClearn, & McGuffin, 2008).

Maternal traditional and progressive rearing beliefs did not consistently moderate the genetic links between parenting and child behavioral problems. Although two significant moderation effects were detected, they did not replicate across time. This is consistent with findings from the SECCYD sample in which maternal rearing beliefs failed to moderate the phenotypic links between child behavioral problems and changes in maternal parenting quality. One potential explanation for the null results is that parenting constructs used in the current study more closely captured the affective aspect of parenting, whereas parental rearing beliefs have more influence on the disciplinary aspects of parenting (Fisher & Fagot, 1993; Greene & Garner, 2012; Schafer & Edgerton, 1985; Straus et al., 1980).

Overall, a sample size similar to that of the WRRP sample is vastly underpowered to detect moderating effects of modest sizes (Purcell, 2002). Post-hoc analyses suggested that the two significant moderating effects found in the current study were moderate to very large in size: genetic correlations changed substantially from one end to the other of the moderator variables. Therefore, the null results should not dissuade future exploration in this area. To our knowledge, no previous study has examined how parental attributes moderate the genetic and nongenetic links between parenting and child behavioral problems. However, several recent studies have successfully shown that child attributes moderate the genetic links between parenting and temperament/ personality in childhood and adolescence using larger samples (Ganiban, Ulbricht, Saudino, Reiss, & Neiderhiser, 2011; South et al., 2008). In addition, as molecular genetics progresses, having both genes and environments as measured variables marks a more powerful way to detect the moderating role of parental attributes in the genetic correlations between parenting and child behaviors (Heath et al., 2002).

4.4 - Integration of the SECCYD and the WRRP Samples

Together, results from the SECCYD sample and the WRRP sample complimented each other. The longitudinal SECCYD sample showed reciprocal influences between development in child behavioral problems and parenting. The repeated cross-sectional WRRP sample suggested that genetically-influenced behavioral problems in children elicited more parental negativity and less positivity, which potentially in turn intensified child behavioral problems through environmental (and /or passive *r*GE) processes. Both studies indicated that the negative impacts of child behavioral problems on parenting gradually increased overtime. Furthermore, both studies implied a potentially feasible and fruitful direction to examine how mothers' attributes would moderate the effects of child behavioral problems on parenting. In particular, maternal emotional reactivity and regulation would be ideal candidates. Additionally, efforts should be directed towards enhancing the power in order to detect these moderating effects. This includes using continuous moderators in the LDS model and using larger samples in the moderated bivariate Cholesky decomposition model.

4.5 - Limitations and Implications

Despite the many strengths of the current study, there are still limitations that should be addressed in future investigation. First, neither study allowed for a multi-informant multi-method composite score be computed for parenting, potentially limiting the reliability of the parenting constructs. Secondly, to test the third hypothesis concerning the moderation effect in the SECCYD sample, the continuous moderators were dichotomized. This could be problematic because the effect of dichotomizing a continuous variable can be unpredictable. It could lead to reduced power and too conservative statistics, or it could produce spurious interactive effect when there in fact is a nonlinear relation between the predictors and the outcome (Maxwell & Delaney, 1993). Thirdly, the current twin design did not allow one to determine whether the shared environment correlations in the WRRP sample could be attributed to passive *r*GE effects or shared environmental influences. Fourthly, the WRRP sample was too underpowered to detect moderation effects of modest sizes. Finally, the current moderators (i.e., parental attributes) may influence children's behavioral problems through genetic and nongenetic transmissions, however, neither the longitudinal design nor the twin design controlled for the parent's effects on child when examining the moderated child's effects on parenting.

Despite these limitations, the current study contributes to the literature in several ways. First, multi-wave longitudinal and behavioral genetic designs addressed limitations of previous studies and clarified the potential transitions in underlying etiology of the link between parenting and child behavioral problems throughout middle childhood. In addition, the current study explored the modulating effects of various parental attributes, revealing the heterogeneous nature of the relations between child behavioral problems and parenting in mothers with different levels of dispositional anger. These findings could potentially inform prevention/intervention programs aimed at improving effective parenting strategies and reducing child behavioral problems. More specifically, these findings suggest that given its persistent effects on the development of child behavioral problems, parenting quality should be the focus of these programs from the earliest stages of the parent-child relationships in order to ensure optimal efficiency. As children grow older, intervention and treatment programs should also gradually take more into consideration the effects of child behaviors as they seek to build healthy households. Along the same lines, these programs may also benefit from assisting families during transitional periods when both parents and children are particularly vulnerable to stressors (e.g. a child's entrance into formal education) Moreover, the ability to screen and target different components within families according to their specific needs may also be instrumental in improving the efficacy of an intervention or treatment programs. For example, it may be more advantageous to first focus efforts on maternal anger management rather than treatment of child behavioral problems in a family exhibiting high maternal anger.

The current findings may also have implications for future molecular genetic studies on gene-environment correlations. Previous studies have demonstrated that the links between structural variation in DNA and individual differences in behaviors are not deterministic; instead, genes and behaviors are differentially linked under different environments (Belsky & Pluess, 2009). The results of this study imply that the causative effect of structural variation in DNA on the environment may also depend on environmental contexts. In other words, although individuals actively build their environmental niches, this process is also constrained or modulated by the environment. Although it takes much larger sample sizes to statistically detect such effects, to better understand the molecular genetic underpinnings of how individuals create their own environments, it is crucial to also take into consideration specific environmental contexts in which these gene-environment correlation processes are examined.

References

Achenbach, T. M. (1991a). *Manual for the Child Behavior Checklist/4-18 and Profile*. Burlington, VT: University of Vermont, Department of Psychiatry.

Achenbach, T. M. (1991b). *Manual for the Teacher's Report Form and Profile*. Burlington, VT: University of Vermont, Department of Psychiatry.

Adorno, T. W., Frenkel-Brunswik, E., Levinson, D., J., & Sanford, R. N. (1950). *The authoritarian personality*. Oxford, UK: Harpers.

Afonso, V. M., Sison, M., Lovic, V., & Fleming, A. S. (2007). Medial prefrontal cortex lesions in the female rat affect sexual and maternal behavior and their sequential organization. *Behavioral Neuroscience, 121*, 515-526.

Bandura, A., Ross, D., & Ross, S. (1963). Imitation of film-mediated aggressive models. *Journal of Abnormal and Social Psychology, 66*(1), 3-11.

Barkley, R. A., & Murphy, K. (1998). *Attention-deficit hyperactivity disorder: A clinical workbook* (2nd ed.). New York: Guildford Press.

Barrett, J., & Fleming, A. S. (2011). All mothers are not created equal: Neural and psychobiological perspectives on mothering and the importance of individual differences. *Journal of Child Psychology and Psychiatry, 52*(4), 368-397.

Bates, J. E., & Pettit, G. S. (1981). Adult individual differences as moderators of child effects. *Journal of Abnormal Child Psychology, 9*(3), 329-340.

Baumrind, D., & Black, A. E. (1967). Socialization practices associated with dimensions of competence in preschool boys and girls. *Child Development, 38*(2), 291-327.

Bayley, N. (1969). *Bayley Scales of Infant Development*. New York: Psychological Corp.

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

Belsky, J. (1984). The determinants of parenting: A process model. *Child Development, 55*(1), 83-96.

Belsky, J., & Pluess, M. (2009). Beyond diathesis stress: Differential susceptibility to environmental influences. *Psychological Bulletin, 135*(6), 885-908.

Bogels, S. M., & van Melick, M. (2004). The relationship between child-report, parent self-report, and partner report of perceived parental rearing behaviors and anxiety in children and parents. *Personality and Individual Differences, 37*, 1583-1596.

Boivin, M., Perusse, D., Dionne, G., Saysset, V., Zoccolillo, M., Tarabulsy, G. M., … Tremblay, R. E. (2005). The genetic-environmental etiology of parents' perceptions and self-assessed behaviors toward their 5-month-old infants in a large twin and singleton sample. *Journal of Child Psychology and Psychiatry, 46*, 612-630.

Bowlby, J. (1988). *A secure base: Parent-child attachment and healthy human development*. New York: Basic Books.

Brestan, E. V., & Eyberg, S. M. (1998). Effective psychosocial treatments of conduct-disordered children and adolescents: 29 years, 82 studies, and 5272 kids. *Journal of Clinical Child Psychology, 27*, 180-189.

Bubier, J. L., & Drabick, D. A. G. (2009). Co-occurring anxiety and disruptive behavior disorder: The roles of anxious symptoms, reactive aggression, and shared risk processes. *Clinical Psychology Review, 29*, 658-669.

Bugental, D. B., Caporael, I., & Shennum, W. A. (1980). Experimentally-produced child uncontrollability: Effects on the potency of adult communication patterns. *Child Development, 1980, 51*, 520-528.

Bullock, B. M., & Dishion, T. J. (2007). Family processes and adolescent problem behavior: Integrating relationship narratives into understanding development and change. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*, 396-407.

Burke, J. D., Pardini, D. A., & Loeber, R. (2008). Reciprocal relationships between parenting behavior and disruptive psychopathology from childhood through adolescence. *Journal of Abnormal Child Psychology, 36*, 679-692.

Burt, S. A., McGue, M., Krueger, R. F., & Iacono, W. G. (2005). How are parent-child conflict and childhood externalizing symptoms related over time? Results from a genetically informative cross-lagged study. *Development and Psychopathology, 17*, 145-165.

Campbell, S. B., Pierce, E. W., Moore, G., Marakovitz, S., & Newby, K. (1996). Boys' externalizing problems at elementary school age: Pathways from early behavior problems, maternal control, and family stress. *Development and Psychopathology, 8*, 701-719.

Chamberlain, P., & Patterson, G. R. (1995). Discipline and child compliance in parenting. In M. H. Bornstein (Ed.), *Handbook of parenting: vol. 4. Applied and practical parenting* (pp. 205-225). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cicchetti, D., & Rogosch, F. A. (2002). A developmental psychopathology perspective on adolescence. *Journal of Consulting and Clinical Psychology, 70*(1), 6-20.

Collins, W., Maccoby, E. E., Steinberg, L., Hetherington, E. M., & Bornstein, M. H. (2000). Contemporary research on parenting: The case for nature and nurture. *American Psychologist, 55*, 218-232.

Darling, N., & Steinberg, L. (1993). Parenting style as context: An integrative model. *Psychological Bulletin, 113*(3), 487-496.

Davids, A., & Eriksen, C. W. (1957). Some social and cultural factors determining relations between authoritarianism and measures of neuroticism. *Journal of Consulting Psychology, 21*, 155-159.

Davidson, R. J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. *Cognition & Emotion, 12*, 307-330.

Deater-Deckard, K. (1996). *The Parent Feelings Questionnaire*. London, UK: Institute of Psychiatry.

Deater-Deckard, K. (2000). Parenting and child behavioral adjustment in early childhood: A quantitative genetic approach to studying family processes. *Child Development, 71*(2), 468-484.

Deater-Deckard, K. (2004). *Parenting Stress*. New Haven, CT: Yale University Press.

Deater-Deckard, K., Fulker, D. W., & Plomin, R. (1999). A genetic study of the family environment in the transition to early adolescence. *Journal of Child Psychology and Psychiatry, 40*(5), 769-775.

Deater-Deckard, K., & O'Connor, T. G. (2000). Parent-child mutuality in early childhood: Two behavioral genetic studies. *Developmental Psychology, 36*(5), 561-570.

Deater-Deckard, K., Sewell, M. D., Petrill, S. A., & Thompson, L. A. (2010). Maternal working memory and reactive negativity in parenting. *Psychological Science, 21*, 75-79.

Deater-Deckard, K., Wang, Z., Chen, N., & Bell, M. A. (2012). Maternal executive function, harsh parenting, and child conduct problems. *Journal of Child Psychology and Psychiatry, 53*(10), 1084-1091.

Dick, D., & York, T. (2010). *Gene-environment interaction & correlation* [PowerPoint slides]. Retrieved from http://www.vipbg.vcu.edu/vipbg/HGEN619/GE%20presentation%2010-19-10.pdf

DiLalla, L. F. (2002). Behavior genetics of aggression in children: Review and future directions. *Developmental Review, 22*(4), 593-622.

Dishion, T. J., & Kavanagh, K. (2000). A multilevel approach to family-centered prevention in schools: Process and outcome. *Addictive Behaviors, 25*, 899-911.

Dix, T., Ruble, D. N., Grusec, J. E., & Nixon, S. (1986). Social cognition in parents: Inference and affective reactions to children of three age levels. *Child Development, 57*(4), 879-894.

Dodge, K. A., Pettit, G. S., McClaskey, C. L., & Brown, M. M (1986). Social competence in children*. Monographs of the Society for Research in Child Development, 51*(2), 1-85.

Egeland, B., & Hiester, M. (1993). *Teaching task rating scales.* Institute of Child Development, University of Minnesota.

Eron, L. D. (1987). The development of aggressive behavior from the perspective of a developing behaviorism. *American Psychologist, 42*(5), 435-442.

Farrington, D. P. (1989). Early predictors of adolescent aggression and adult violence. *Violence and Victims, 4*(2), 79-100.

Feldman, R., Granat, A., Pariente, C., Kanety, H., Kuint, J., & Gilboa-Schechtman, E. (2009). Maternal depression and anxiety across the postpartum year and infant social engagement, fear regulation, and stress reactivity. *Journal of the American Academy of Child and Adolescent Psychiatry*, *48*(9), 919-927.

Ferrer, E., & McArdle, J. (2003). Alternative structural models for multivariate longitudinal data analysis. *Structural Equation Modeling: A Multidisciplinary Journal*, *10*(4), 493-524.

Finzi, R., Ram, A., Har-Even, D., Shnit, D., & Weizman, A. (2001). Attachment styles and aggression in physically abused and neglected children. *Journal of Youth and Adolescence, 30*(6), 769-786.

Fisher, P. A., & Fagot, B. I. (1993). Negative discipline in families: A multidimensional risk model. *Journal of Family Psychology, 7*(2), 250-254.

Forehand, R., & Nousiainen, S. (1993). Maternal and paternal parenting: Critical dimensions in adolescent functioning. *Journal of Family Psychology, 7*(2), 213-221.

Forgatch, M. S., & DeGarmo, D. S. (1999). Parenting through change: An effective prevention program for single mothers. *Journal of Consulting and Clinical Psychology, 67*, 711-724.

Francis, K. J., & Wolfe, D. A. (2008). Cognitive and emotional differences between abusive and non-abusive fathers. *Child Abuse & Neglect, 32*(12), 1127-1137.

Freud, S. (1914). Some reflections on schoolboy psychology. In J. Strachey (Ed.), *The standard edition of the complete psychological works of Sigmund Freud* (Vol. 13, pp. 211-238). London, UK: Hogarth Press.

Freud, S. (1933). *New introductory lectures in psychoanalysis*. New York: Norton.

Friedman, N. P., Miyake, A., Young, S. E., DeFries, J. C., Corley, R. P., & Hewitt, J. K. (2008). Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General, 137*, 201-225.

Ganiban, J. M., Ulbricht, J., Saudino, K. J., Reiss, D., & Neiderhiser, J. M. (2011). Understanding child-based effects on parenting: Temperament as a moderator of genetic and environmental contributions to parenting. *Developmental Psychology, 47* (3), 676-692.

Gardner, F. E. M., Sonuga-Barke, E. J. S., & Sayal, K. (1999). Parents anticipating misbehavior: An observational study of strategies parents use to prevent conflict with behavior problem children. *Journal of Child Psychology and Psychiatry, 40*, 1185-1196.

Ge, X., Conger, R. D., Cadoret, R. J., Neiderhiser, J. M., Yates, W., Troughton, E., & Steward, M. A. (1996). The developmental interface between nature and nurture: A mutual influence model of child antisocial behavior and parent behavior. *Developmental Psychology, 32*, 574-589.

Gray, J. A. (1994). Framework for a taxonomy of psychiatric disorder. In S. H. M. Van Goozen, N. E. Van de Poll, & J. A. Sergeant (Eds.), *Emotions: Essays on emotion theory* (pp. 29-59). Hillsdale, NJ: Erlbaum.

Greene, K., & Garner, P. W. (2012). African American mothers' disciplinary responses: Associations with family background characteristics, maternal childrearing attitudes, and child manageability. *Journal of Family and Economic Issues*, *33*, 400-409.

Greene, R. W., & Doyle, A. E. (1999). Toward a transactional conceptualization of oppositional defiant disorder: Implications for treatment and assessment. *Clinical Child and Family Psychology Review, 2,* 129-148.

Gross, H. E., Shaw, D. S., & Moilanen, K. I. (2008). Reciprocal associations between boys' externalizing problems and mothers' depressive symptoms. *Journal of Abnormal Child Psychology, 36*, 693-709.

Grusec, J. E., & Goodnow, J. J. (1994). Impact of parental discipline methods on the child's internalization of values: A reconceptualization of current points of view. *Developmental Psychology, 30,* 4-19.

Hamagami, F., & McArdle, J. J. (2001). Advanced studies of individual differences linear dynamic models for longitudinal data analysis. In G. Marcoulides & R. Schumacker (Eds.), *New developments and techniques in structural equation modeling* (pp. 203-246). Mahwah, NJ: Erlbaum.

Heath, A., Todorov, A., Nelson, E., Madden, P., Bucholz, K., & Martin, N. (2002). Gene-environment interaction effects on behavioral variation and risk of complex disorders: The example of alcoholism and other psychiatric disorders. *Twin Research, 5*, 30-37.

Hipwell, A., Keenan, K., & Kasza, K., Loeber, R., Stouthamer-Loeber, M., & Bean, T. (2008). Reciprocal influences between girls' conduct problems and depression, and parental punishment and warmth: A six year prospective analysis. *Journal of Abnormal Child Psychology, 36*, 663-677.

Howe, G. W., Reiss, D., & Yuh, J. (2002). Can prevention trials test theories of etiology? *Development and Psychopathology, 14*, 673-694.

Huh, D., Tristan, J., Wade, E., & Stice, E. (2006). Does problem behavior elicit poor parenting? A prospective study of adolescent girls. *Journal of Adolescent Research, 21*, 185-204.

Jaffee, S. R., Caspi, A., Moffitt, T. E., Polo-Tomas, M., Price, T. S., & Taylor, A. (2004). The limits of child effects: Evidence for genetically mediated child effects on corporal punishment but not on physical maltreatment. *Developmental Psychology, 40*, 1047-1058.

Jaffee, S. R., & Poulton, R. (2006). Reciprocal effects of mothers' depression and children's problem behaviors from middle childhood to early adolescence. In A. C. Huston, M. N. Ripke, & J. McCord (Eds.), *Developmental contexts in middle childhood: Bridges to adolescence and adulthood* (pp. 107-129). New York: Cambridge University Press.

Jaffee, S. R., Strait, L. B., & Odgers, C. L. (2012). From correlates to causes: Can quasi-experimental studies and statistical innovations bring us closer to identifying the causes of antisocial behavior? *Psychological Bulletin, 138*(2), 272-295.

Kagan, J. (1971). *Change and continuity in infancy.* New York: Wiley.

Kayama, M., Sagami, A., Watanabe, Y., Senoo, E., & Ohara, M. (2004). Child abuse prevention in Japan: An approach to screening and intervention with mothers. *Public Health Nursing, 2*, 513-518.

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

King, L. A., King, D. W., McArdle, J. J., Saxe, G. N., Doron-LaMarca, S., & Orazem, R. J. (2006). Latent difference score approach to longitudinal trauma research. *Journal of Traumatic Stress, 19*(6), 771-785.

Larsson, H., Viding, E., Rijsdijk, F. V., & Plomin, R. (2008). Relationships between parental negativity and childhood antisocial behavior over time: A bidirectional effects model in a longitudinal genetically informative design. *Journal of Abnormal Child Psychology, 36*, 633-645.

Lewis, C., & Lamb, M. E. (2003). Fathers' influences on children's development: The evidence from two-parent families. *European Journal of Psychology of Education, 18*(2), 211-228.

Losoya, S. H., Callor, S., Rowe, D. C., & Goldsmith, H. H. (1997). Origins of familial similarity in parenting: A study of twins and adoptive siblings. *Developmental Psychology, 33*, 1012-1023.

Lovic, V., & Fleming, A. S. (2004). Artificially-reared female rats show reduced prepulse inhibition and deficits in the attentional set shifting task – reversal of effects with maternal-like licking stimulation. *Behavioral Brain Research, 148,* 209-219.

Maccoby, E. E. (1980). *Social Development*. New York: Harcourt, Brace, Jovanovich.

Maccoby, E. E. (2000). Parenting and its effects on children: On reading and misreading behavior genetics. *Annual Review of Psychology, 51*, 1-27.

Maccoby, E. E., & Martin, J. A. (1983). Socialization in the context of the family: Parent-child interaction. In P. H. Mussen (series Ed.) & E. M. Hetherington (Vol. Ed.), *Handbook of child psychology: vol. 4. Socialization, personality, and social development* (4^{th} ed., pp. 1-101). New York: Wiley.

Mammen, O. K., Kolko, D. J., & Pilkonis, P. A. (2002). Negative affect and parental aggression in child physical abuse. *Child Abuse & Neglect*, *26*, 407-424.

Matthews, K. A. (1977). Caregiver-child interactions in the type A coronary-prone behavior pattern. *Child Development, 48,* 1852-1856.

Maxwell, S. E., & Delaney, H. D. (1993). Bivariate median splits and spurious statistical significance. *Psychological Bulletin, 113,* 181-190.

McArdle, J. J. (2001). A latent difference score approach to longitudinal dynamic structural analysis. In R. Cudeck, S. Du Toit, & D. Sorborn (Eds.), *Structural equation modeling present and future: A Festschrift in honor of Karl Joreskog* (pp. 342-380). Lincolnwood, IL: Scientific Software International.

McArdle, J. J. (2009). Latent variable modeling of differences and changes with longitudinal data. *Annual Review of Psychology, 60,* 577-605.

McArdle, J. J., & Hamagami, F. (2001). Latent difference score structural models for linear dynamic analyses with incomplete longitudinal data. In L. M. Collins, & A. G. Sayer (Eds.), *New methods for the analysis of change* (pp. 139-175). Washington, DC: American Psychological Association.

Moss, H. A. (1967). Sex, age, and state as determinants of mother-infant interaction. *Merill-Palmer Quarterly, 13*, 19-36.

Narusyte, J., Andershed, A. K., Neiderhiser, J. M., & Lichtenstein, P. (2007). Aggression as a mediator of genetic contributions to the association between negative parent-child relationships and adolescent antisocial behavior. *European Child and Adolescent Psychiatry, 16*, 128-137.

Neale, M. (1997). *Mx: Statistical modeling* (4th ed.). Richmond, VA: Virginia Commonwealth University, Department of Psychiatry.

Neiderhiser, J. M., Reiss, D., Lichtenstein, P., Spotts, E. L., & Ganiban, J. (2007). Father-adolescent relationships and the role of genotype-environment correlation. *Journal of Family Psychology, 21*(4), 560-571.

Neiderhiser, J. M., Reiss, D., Pedersen, N. L., Lichtenstein, P., Spotts, E. L., Hansson, K., … Elthammer, O. (2004). Genetic and environmental influences on mothering of adolescents: A comparison of two samples. *Developmental Psychology, 40*(3), 335-351.

Nicol-Harper, R., Harvey, A. G., & Stein, A. (2007). Interactions between mothers and infants: Impact of maternal anxiety. *Infant Behavior and Development*, *30*(1), 161-167.

Nix, R. L., Pinderhughes, E. E., Dodge, K. A., Bates, J. E., Pettit, G. S., & McFadyen-Ketchum, S. A. (1999). The relation between mothers' hostile attribution tendencies and children's externalizing behavior problems: The mediating role of mothers' harsh discipline practices. *Child Development, 70*, 896-909.

Nomellini, S., & Katz, R. C. (1983). Effects of anger control training on abusive parents. *Cognitive Therapy and Research, 7*, 57-67.

Ochsner, K., & Gross, J. (2008). Cognitive emotion regulation: Insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science, 17*, 153-158.

O'Connor, T. G., Deater-Deckard, K., Fulker, D., Rutter, M., & Plomin, R. (1998). Genotype-environment correlations in late childhood and early adolescence: Antisocial behavioral problems and coercive parenting. *Developmental Psychology, 34*, 970-981.

O'Connor, T. G., Hetherington, E. M., Reiss, D., & Plomin, R. (1995). A twin-sibling study of observed parent-adolescent interactions. *Child Development, 66*(3), 812-829.

Pardini, D. A., Fite, P. J., & Burke, J. D. (2008). Bidirectional associations between parenting practices and conduct problems in boys from childhood to adolescence: The moderating effect of age and African-American ethnicity. *Journal of Abnormal Child Psychology, 36,* 647-662.

Patterson, G. R. (1980). Mothers: The unacknowledged victims. *Monographs of the Society for Research in Child Development, 45*(5), 1-64.

Petrill, S. A., Deater-Deckard, K., Thompson, L., DeThorne, L., & Schatschneider, C. (2006). Genetic and environmental effects of serial naming and phonological awareness on early reading outcomes. *Journal of Educational Psychology, 98,* 112-121.

Pettit, G. S., & Arsiwalla, D. D. (2008). The continuing evolution of dynamic, transactional models of parenting and youth behavior problems. *Journal of Abnormal Child Psychology, 36*, 711-718.

Pianta, R. C. (1994). *Rating scales for parent-child interaction in preschoolers*. University of Virginia.

Pike, A., McGuire, S., Heterington, E., Reiss, D., & Plomin, R. (1996). Family environment and adolescent depressive symptoms and antisocial behavior: A multivariate genetic analysis. *Developmental Psychology, 32*, 590-604.

Plomin, R., DeFries, J. C., & Loehlin, J. C. (1977). Genotype-environment interaction and correlation in the analysis of human behavior. *Psychological Bulletin, 84*, 309-322.

Plomin, R., DeFries, J. C., McClearn, G. E., & McGuiffin, P. (2008). *Behavior genetics*. New York: NY, Worth Publishers.

Plomin, R., Reiss, D., Hetherington, E. M., & Howe, G. W. (1994). Contributions to measures of the family environment. *Developmental Psychology, 30*(1), 32-43.

Purcell, S. (2002). Variance components models for gene-environment interaction in twin analysis. *Twin Research and Human Genetics, 5*, 554-571.

Raine, A. (2002). Biosocial studies of antisocial and violent behavior in children and adults: A review. *Journal of Abnormal Child Psychology, 30*(4), 311-326.

Ray, J. J. (1972). Militarism, authoritarianism, neuroticism, and antisocial behavior. *The Journal of Conflict Resolution, 16,* 319-340.

Reitz, E., Dekovic, M., & Meijer, A. M. (2006). Relations between parenting and externalizing and internalizing problem behavior in early adolescence: Child behavior as moderator and predictor. *Journal of Adolescence, 29*, 419-436.

Rhee, S. H., & Waldman, I. D. (2002). Genetic and environmental influences on antisocial behavior: A meta-analysis of twin and adoption studies. *Psychological Bulletin, 128*(3), 490-529.

Rhoades, K. A., & O'Leary, S. G. (2007). Factor structure and validity of the parenting scale. *Journal of Clinical Child and Adolescent Psychology, 36*(2), 137-146.

Richmond, M. K., & Stocker, C. M. (2008). Longitudinal associations between parents' hostility and siblings' externalizing behavior in the context of marital discord. *Journal of Family Psychology, 22*, 231-240.

Rimm-Kaufman, S. E., & Pianta, R. C. (2000). An ecological perspective on the transition to kindergarten: A theoretical framework to guide empirical research. *Journal of Applied Developmental Psychology, 21*, 491-511.

Rimm-Kaufman, S. E., Pianta, R. C., & Cox, M. J. (2000). Teachers' judgments of problems in the transition to kindergarten. *Early childhood Research Quarterly, 15*, 147-166.

Rothbart, M. K. (1986). Longitudinal observation of infant temperament. *Developmental Psychology, 22*(3), 356-365.

Rowe, D. C. (1981). Environmental and genetic influence on dimensions of perceived parenting: A twin study. *Developmental Psychology, 17*(2), 203-208.

Rowe, D. C. (1994). *The limits of family influence: Genes experience, and behavior*. New York: Guilford Press.

Russell, A., & Saebel, J. (1997). Mother-son, mother-daughter, father-son, and father-daughter: Are they distinct relationships? *Developmental Review, 17*, 111-147.

Sameroff, A. (2009). *The transactional model*. Washington, DC: American Psychological Association.

Satorra, A., & Saris, W. E. (1985). Power of the likelihood ratio test in covariance structure analysis. *Psychometrika, 50*(1), 83-90.

Scaramella, L., Neppl, T., Ontai, L., & Conger, R. (2008). Consequences of socioeconomic disadvantage across three generations: Parenting behavior and child externalizing problems. *Journal of Family Psychology, 22*, 725-733.

Scarr, S., & McCartney, K. (1983). How people make their own environments: A theory of genotype-environment effects. *Child Development, 54*, 424-435.

Schaefer, E. S., & Edgerton, M. (1985). Parents and child correlates of parental modernity. In I. E. Sigel (Ed.), *Parental belief systems* (pp. 83-105). Hillsdale, NJ: Erlbaum.

Shaw, D. S., Gilliom, M., Ingoldsby, E. M., & Nagin, D. S. (2003). Trajectories leading to school-age conduct problems. *Developmental Psychology, 39*, 189-200.

Shay, N. L., & Knutson, J. F. (2008). Maternal depression and trait anger as risk factors for escalated physical discipline. *Child Maltreatment, 13*(1), 39-49.

Shelton, K. H., Harold, G. T., Fowler, T. A., Rice, F. J., Neale, M. C., Thapar, A., & van de Bree, M. B. M. (2008). Parent-child relations, conduct problems and cigarette use in adolescence: Examining the role of genetic and environmental factors on patterns of behavior. *Journal of Youth Adolescence, 37*, 1216-1228.

South, S. C., Krueger, R. F., Johnson, W., & Iacono, W. G. (2008). Adolescent personality moderates genetic and environmental influences on relationships with parents. *Journal of Personality and Social Psychology, 94*(5), 899-912.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory (Form Y)*. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., Jacobs, G. A., Russell, S. F., & Crane, R. S. (1983). Assessment of anger: The State-Trait Anger Scale. In J. N. Butcher & C. D. Spielberger (Eds.), *Advances in personality assessment: Vol. 2.* (pp. 161-189). Hillsdale, NJ: Erlbaum.

Spinath, F. M., & O'Connor, T. G. (2003). A behavioral genetic study of the overlap between personality and parenting. *Journal of Personality, 71*, 785-808.

Stayton, D. J., Hogan, R., & Anisworth, M. D. S. (1971). Infant obedience and maternal behavior: The origins of socialization reconsidered. *Child Development, 42*, 1057-1069.

Straus, M. A., Gelles, R. J., & Steinmetz, S. K. (1980). *Behind closed doors: Violence in the American family*. Grand City: NY: Doubleday/Anchor.

Tremblay, R. E., Nagin, D. S., Seguin, J. R., Zoccolillo, M., Zelazo, P. D., Boivin, M., … Japel, C. (2004). Physical aggression during early childhood: Trajectories and predictors. *Pediatrics, 114*, e43-e50.

Van IJzendoorn, M. H. (1997). Attachment, emergent morality, and aggression: Toward a developmental socioemotional model of antisocial behavior. *International Journal of Behavioral Development, 21*(4), 703-727.

Wade, T. D., & Kendler, K. S. (2000). The genetic epidemiology of parental discipline. *Psychological Medicine, 30*, 1303-1313.

Wang, Z., & Deater-Deckard. K. (2013). Resilience in gene-environment transactions. In S. Goldstein & R. Brooks (Eds.), *Handbook of resilience in children* (2nd ed. pp. 57-72). New York: Plenum.

Watson, J. B. (1924). *Behaviorism*. Chicago: University of Chicago Press.

Webster-Stratton, C., & Hammond, M. (1997). Treating children with early-onset conduct problems: A comparison of child and parent training interventions. *Journal of Consulting and Clinical Psychology*, *65*, 93-109.

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale- Third Edition*. San Antonio, TX: Psychological Corp.

Whaley, S. E., Pinto, A., & Sigman, M. (1999).Characterizing interactions between anxious mothers and their children. *Journal of Consulting and Clinical Psychology, 67*, 826-836.

Wilkowski, B. M., & Robinson, M. D. (2008). The cognitive basis of trait anger and reactive aggression: An integrative analysis. *Personality and Social Psychology Review, 12*, 3-21.

Winsler, A., Madigan, A. L., & Aquilino, S. A. (2005). Correspondence between maternal and paternal parenting styles in early childhood. *Early Childhood Research Quarterly, 20*, 1-12.

Woodruff-Borden, J., Morrow, C., Bourland, S., & Cambron, S. (2002). The behavior of anxious parents: Examining mechanisms of transmission of anxiety from parent to child. *Journal of Clinical Child and Adolescent Psychiatry, 31*, 364-374.

Table 1

Variance Decomposition in a Twin Design (WRRP Sample).

Variance components in twin1 phenotypic score Total = 1		Relation to other variance components	Depend on twins' genetic relatedness? (MZ = 1, DZ = .05)	Explanation when find in parenting
Part 1: shared with twin 2 R_{mz} or R_{dz}	A^2	$A^2 = R_{mz} – C^2$ $A^2 = R_{dz} - .5C^2$ $A^2 = 1-E^2-C^2$	Yes	Evocative *r*GE
	C^2	$C^2 = R_{mz} – A^2$ $C^2 = R_{dz} - .5A^2$ $C^2 = 1-E^2-C^2$	No	Shared environment or passive *r*GE
Part 2: nonshared with twin2	E^2	$E^2 = 1-A^2-C^2$	No	Nonshared environment

Table 2

Descriptive Statistics of the Main Study Variables (SECCYD Sample).

	Maternal anger	Maternal anxiety	Paternal anger	Paternal anxiety	Maternal progressive beliefs	Maternal traditional beliefs	Paternal progressive beliefs	Paternal traditional beliefs	Maternal parenting 54month	Maternal parenting 1st grade	Maternal parenting 3rd grade	Maternal parenting 5th grade	Paternal parenting 54month	Paternal parenting 1st grade	Paternal parenting 3rd grade	Paternal parenting 5th grade	Child behaviors 54month	Child behaviors 1st grade	Child behaviors 3rd grade	Child behaviors 5th grade
M	13.86	17.51	13.60	16.71	32.67	58.03	32.33	59.40	2.81	2.82	2.82	2.90	2.57	2.74	2.66	2.74	.38	.32	.32	.27
SD	3.46	4.36	3.60	4.10	3.75	14.84	3.81	13.87	1.00	1.05	.87	.80	.87	.87	.86	.76	.26	.26	.28	.26
Skewness	1.53	.80	1.80	.85	-.55	.29	-.41	.08	.78	.78	.56	.44	.69	.65	.59	.59	1.06	1.05	1.09	1.38
Kurtosis	3.01	.89	5.34	1.26	.32	-.29	-.11	-.36	.69	.37	.20	.00	.83	.69	.15	.30	1.45	.75	.80	2.03
Min	10.00	10.00	10.00	10.00	18.00	26.00	19.00	26.00	1.00	1.00	1.00	1.20	1.00	1.00	1.00	1.00	.00	.00	.00	.00
Max	32.50	37.33	38.00	36.50	40.00	106.0	40.00	99.00	6.60	6.40	6.00	5.80	6.40	5.80	5.50	5.40	1.68	1.44	1.41	1.55

Table 3

Correlations between the Main Study Variables (SECCYD Sample).

	1 maternal anger	2 maternal anxiety	3 paternal anger	4 paternal anxiety	5 maternal progressive beliefs	6 maternal traditional beliefs	7 paternal progressive beliefs	8 paternal traditional beliefs	9 maternal parenting 54month	10 maternal parenting 1st grade	11maternal parenting 3rd grade	12maternall parenting 5th grade	13 paternal parenting 54month	14paternal parenting 1st grade	15 paternal parenting 3rd grade	16 paternal parenting 5th grade	17 child behaviors 54 month	18 child behaviors 1st grade	19 child behaviors 3rd grade	20 child behaviors 5th grade
2	.65[c]	1																		
3	.20[c]	.19[c]	1																	
4	.10[b]	.18[c]	.60[c]	1																
5	-.05	-.10[b]	-.09[a]	-.08	1															
6	.14[c]	.18[c]	.03	.07	-.38[c]	1														
7	-.06	-.03	.03	-.01	.27[c]	-.24[c]	1													
8	.06	.05	-.04	.09	-.24[c]	.41[c]	-.44[c]	1												
9	.13[c]	.18[c]	.09[a]	.09[a]	-.22[c]	.41[c]	-.15[c]	.23[c]	1											

10	.18[c]	.17[c]	.02	.04	-.24[c]	.46[c]	-.18[c]	.30[c]	.53[c]	1										
11	.18[c]	.18[c]	.09[a]	.08[a]	-.24[c]	.45[c]	-.18[c]	.26[c]	.46[c]	.54[c]	1									
12	.17[c]	.19[c]	.08	.10[a]	-.21[c]	.40[c]	-.20[c]	.26[c]	.41[c]	.49[c]	.51[c]	1								
13	.03	.00	.10[a]	.10[a]	-.12[b]	.15[c]	-.20[c]	.26[c]	.23[c]	.25[c]	.26[c]	.25[c]	1							
14	.02	.04	.03	.09[a]	-.16[c]	.25[c]	-.24[c]	.36[c]	.24[c]	.29[c]	.24[c]	.24[c]	.40[c]	1						
15	.12[b]	.07	.07	.11[a]	-.18[c]	.23[c]	-.24[c]	.26[c]	.26[c]	.26[c]	.33[c]	.28[c]	.35[c]	.37[c]	1					
16	.11[b]	.14[b]	.10[a]	-.01	-.12[b]	.24[c]	-.24[c]	.24[c]	.29[c]	.23[c]	.32[c]	.30[c]	.32[c]	.27[c]	.36[c]	1				
17	.29[c]	.21[c]	.23[c]	.16[c]	-.14[c]	.26[c]	-.05	.20[c]	.24[c]	.21[c]	.22[c]	.20[c]	.12[c]	.12[c]	.20[c]	.17[c]	1			
18	.27[c]	.21[c]	.19[c]	.17[c]	-.16[c]	.30[c]	-.07	.25[c]	.25[c]	.19[c]	.32[c]	.27[c]	.12[b]	.20[c]	.22[c]	.16[c]	.65[c]	1		
19	.25[c]	.19[c]	.19[c]	.16[c]	-.17[c]	.25[c]	-.03	.16[c]	.26[c]	.22[c]	.34[c]	.28[c]	.11[b]	.19[c]	.23[c]	.13[b]	.56[c]	.70[c]	1	
20	.28[c]	.22[c]	.20[c]	.17[c]	-.12[b]	.25[c]	-.07	.13[b]	.21[c]	.20[c]	.31[c]	.28[c]	.11[b]	.15[c]	.24[c]	.14[b]	.53[c]	.67[c]	.72[c]	1

Note: [a] $p < .05$; [b] $p < .01$; [c] $p < .001$.

Table 4

Model Fit Indices of the Bivariate Latent Difference Score Models: Child Behavioral Problems and Maternal Parenting (SECCYD Sample).

	χ^2 (*df*, *p*)	Comparison	$\Delta\chi^2$ (Δdf)	RMSEA	CFI	Observed power
a. Unconstrained model	40.17 (14, .000)		-	.043	.991	-
b. No predictions from child problem behaviors to maternal parenting	62.02 (17, .000)	a vs. b	21.85 (3)***	.051	.985	.99
c. No predictions from maternal parenting to child problem behaviors	42.41 (17, .001)	a vs. c	2.24 (3)	.038	.992	.21

Note: N = 1032; $\Delta\chi^2$ = difference in likelihood ratio test; Δdf = difference in *df*; RMSEA = root mean square error of approximation; CFI = comparative-fit index; best fitting model is in bold face. *** $p < .001$.

Table 5

Model Comparisons between Two-Group Bivariate Latent Difference Score Models: Child Behavioral Problem and Maternal Parenting (SECCYD Sample).

Moderator	Model	χ^2 (*df*, *p*)	$\Delta\chi^2$ (Δdf, *p*)	RMSEA	CFI	N (high, low)	Observed power
Maternal anger	**Unconstrained model**	42.62 (28, .038)	-	.023	.995	(423, 563)	-
	Constrained model	62.02 (31, .003)	14.21 (3)**	.029	.991		.90
Maternal anxiety	Unconstrained model	48.84 (28, .009)	-	.027	.993	(436, 551)	-
	Constrained model	50.64 (31, .014)	1.79 (3)	.025	.993		.20
Maternal traditional belief	Unconstrained model	59.04 (28, .001)	-	.034	.987	(466, 506)	-
	Constrained model	63.46 (31, .001)	4.42 (3)	.033	.987		.39
Maternal progressive belief	Unconstrained model	59.59 (28, .000)	-	.034	.988	(529, 438)	-
	Constrained model	60.22 (31, .001)	.633 (3)	.031	.989		.09

Note: $\Delta\chi^2$ = difference in likelihood ratio test; Δdf = difference in *df*; RMSEA = root mean square error of approximation; CFI = comparative-fit index; best fitting model is in bold face. ** $p < .01$.

Table 6

Descriptive Statistics of the Main Study Variables (WRRP Sample).

	Maternal progressive beliefs	Maternal traditional beliefs	Paternal progressive beliefs	Paternal traditional beliefs	Maternal digit span	Maternal negativity wave1	Maternal negativity wave 2	Maternal negativity wave 3	Paternal negativity wave1	Paternal negativity wave 2	Paternal negativity wave 3	Maternal positivity wave1	Maternal positivity wave2	Maternal positivity wave 3	Paternal positivity wave1	Paternal positivity wave2	Paternal positivity wave3	Child behaviors wave1	Child behaviors wave2	Child behaviors wave3
Twin 1																				
M	3.89	2.48	3.78	2.69	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SD	.38	.42	.38	.43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Skewness	-.07	.40	-.06	.06	.50	.90	.95	.85	.76	.92	.96	2.17	2.01	1.63	1.08	1.12	.76	1.15	.91	1.01
Kurtosis	-.08	1.27	.48	.54	-.02	1.18	.71	.89	.48	.51	.36	10.10	6.53	4.06	1.10	1.21	.50	2.16	.54	.73
Min	2.63	1.29	2.63	1.57	-2.34	-1.73	-1.46	-1.51	-1.55	-1.38	-1.22	-1.24	-1.14	-1.21	-1.35	-1.32	-1.36	-1.72	-1.41	-1.29
Max	4.75	4.14	5.00	4.00	2.91	3.92	3.90	3.73	3.16	3.42	3.09	7.19	5.45	4.98	3.48	3.21	3.42	5.04	3.44	3.69
Twin 2																				
M						.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

SD	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Skewness	.98	.78	.68	1.20	1.49	.87	1.34	1.93	1.58	1.02	1.83	1.25	.98	1.09	1.22
Kurtosis	1.24	.31	-.14	1.83	2.59	.70	2.23	6.19	3.41	.97	5.70	2.23	1.21	1.57	1.84
Min	-1.69	-1.52	-1.46	-1.44	-1.29	-1.28	-1.25	-1.15	-1.23	-1.31	-1.34	-1.23	-1.54	-1.44	-1.31
Max	4.07	3.43	3.46	3.98	4.03	3.44	4.93	5.68	4.83	3.30	5.18	4.12	4.11	3.93	4.70

Table 7

Correlations between the Main Study Variables for Twin 1 (WRRP Sample).

	1 maternal progressive beliefs	2 maternal traditional beliefs	3 paternal progressive beliefs	4 paternal traditional beliefs	5 maternal digit span	6 maternal negativity wave1	7 maternal negativity wave2	8 maternal negativity wave3	9 paternal negativity wave1	10 paternal negativity wave2	11 paternal negativity wave3	12 maternal positivity wave1	13 maternal positivity wave2	14 maternal positivity wave3	15 paternal positivity wave1	16 paternal positivity wave2	17 paternal positivity wave3	18 child behaviors wave1	19 child behaviors wave2
2	-.25[c]																		
3	.21[a]	-.15																	
4	-.04	.34[c]	-.34[c]																
5	.05	-.12	.00	.03															
6	.01	-.02	.16[a]	-.11	-.11														
7	.04	.08	.17	-.01	-.04	.72[c]													
8	.03	.08	.13	.01	-.11	.69[c]	.74[c]												
9	.01	-.05	.07	.00	-.19[a]	.33[c]	.35[c]	.38[c]											
10	-.04	-.10	.04	-.03	-.02	.29[b]	.36[c]	.46[c]	.74[c]										

11	-.17	-.01	.03	.01	-.09	.28[b]	.37[c]	.48[c]	.71[c]	.83[c]									
12	-.12[a]	.02	.07	-.07	-.04	.53[c]	.53[c]	.46[c]	.25[b]	.23[b]	.26[a]								
13	-.10	.04	.04	-.04	.06	.42[c]	.53[c]	.41[c]	.28[b]	.32[c]	.30[b]	.69[c]							
14	-.12	.04	.05	.03	-.01	.45[c]	.46[c]	.62[c]	.34[c]	.44[c]	.52[c]	.62[c]	.66[c]						
15	.00	.03	-.14	.01	-.04	.16	.06	.14	.46[c]	.54[c]	.39[b]	.18[a]	.19[a]	.24[b]					
16	-.07	.06	-.16	.02	-.04	.19[a]	.23[b]	.32[b]	.45[c]	.65[c]	.56[c]	.22[a]	.36[c]	.42[c]	.72[c]				
17	.04	-.12	-.09	.01	-.17	.27[a]	.26[a]	.35[b]	.54[c]	.63[c]	.66[c]	.22[a]	.17	.46[c]	.61[c]	.74[c]			
18	-.03	.06	.03	.13	-.15[a]	.58[c]	.48[c]	.48[c]	.55[c]	.44[c]	.49[c]	.33[c]	.29[c]	.34[c]	.24[b]	.31[c]	.40[c]		
19	-.03	.09	.06	.08	-.09	.48[c]	.56[c]	.51[c]	.46[c]	.57[c]	.54[c]	.31[c]	.29[c]	.37[c]	.23[b]	.37[c]	.48[c]	.74[c]	
20	-.03	.19[b]	.13	.03	-.08	.44[c]	.50[c]	.55[c]	.35[c]	.42[c]	.58[c]	.29[c]	.24[b]	.43[c]	.22[a]	.42[c]	.48[c]	.62[c]	.74[c]

Note: [a] $p < .05$, [b] $p < .01$, [c] $p < .001$.

Table 8

Correlations between the Main Study Variables for Twin 2 (WRRP Sample).

	1 maternal progressive beliefs	2 maternal traditional beliefs	3 paternal progressive beliefs	4 paternal traditional beliefs	5 maternal digit span	6 maternal negativity wave1	7 maternal negativity wave2	8 maternal negativity wave3	9 paternal negativity wave1	10 paternal negativity wave2	11 paternal negativity wave3	12 maternal positivity wave1	13 maternal positivity wave2	14 maternal positivity wave3	15 paternal positivity wave1	16 paternal positivity wave2	17 paternal positivity wave3	18 child behaviors wave1	19 child behaviors wave2
2	-.25[c]																		
3	.21[a]	-.15																	
4	-.04	.34[c]	-.34[c]																
5	.05	-.12	.00	.03															
6	.00	-.02	.21[a]	-.09	-.09														
7	.07	.04	.23[b]	-.06	-.05	.73[c]													
8	.15a	.01	.21[a]	-.07	-.16[a]	.68[c]	.69[c]												
9	.05	-.05	.05	.02	-.06	.41[c]	.36[c]	.43[c]											
10	-.02	-.10	.06	-.05	-.11	.36[c]	.44[c]	.42[c]	.68[c]										

11	-.06	-.07	.05	-.07	-.16	.29[b]	.34[b]	.49[c]	.79[c]	.83[c]									
12	-.13[a]	.06	.03	-.05	-.04	.60[c]	.55[c]	.48[c]	.30[c]	.33[c]	.31[b]								
13	-.06	.01	.09	-.04	.01	.40[c]	.52[c]	.43[c]	.22[a]	.38[c]	.28[b]	.64[c]							
14	-.02	.04	.12	-.08	-.06	.41[b]	.47[c]	.61[c]	.33[c]	.43[c]	.44[c]	.63[c]	.66[c]						
15	.03	.01	-.13	.02	-.04	.22[b]	.19[a]	.20[a]	.52[c]	.50[c]	.40[c]	.36[c]	.30[c]	.26[b]					
16	-.01	-.03	-.12	-.05	-.08	.21[a]	.24[b]	.30[b]	.43[c]	.57[c]	.56[c]	.30[c]	.38[c]	.46[c]	.72[c]				
17	.04	-.15	.01	-.04	-.19	.27[b]	.27[b]	.31[b]	.48[c]	.61[c]	.65[c]	.38[c]	.27[b]	.44[c]	.57[c]	.76[c]			
18	-.07	.12[a]	.13	.13	-.07	.57[c]	.46[c]	.46[c]	.57[c]	.45[c]	.43[c]	.42[c]	.30[c]	.37[c]	.30[c]	.30[c]	.36[c]		
19	.02	.08	.20[a]	.08	-.12	.45[c]	.53[c]	.49[c]	.44[c]	.54[c]	.54[c]	.33[c]	.31[c]	.41[c]	.30[c]	.33[c]	.39[c]	.67[c]	
20	.06	.11	.10	-.03	-.11	.45[c]	.48[c]	.57[c]	.46[c]	.45[c]	.63[c]	.38[c]	.33[c]	.50[c]	.31[b]	.42[c]	.46[c]	.62[c]	.75[c]

Note: w = wave. [a] $p < .05$, [b] $p < .01$, [c] $p < .001$.

Table 9

Cross-twins Correlations between the Main Study Variables for MZ Twins (WRRP Sample).

Twin 2 Twin 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 maternal negativity w1	.78[c]	.60[c]	.48[c]	.33[b]	.41[b]	.17	.43[c]	.25[a]	.40[c]	.21	.40[b]	.24	.44[c]	.29[b]	.30[b]
2 maternal negativity w2	.59[c]	.84[c]	.56[c]	.45[c]	.62[c]	.41[a]	.54[c]	.42[c]	.44[c]	.20	.36[b]	.31[a]	.45[c]	.53[c]	.38[c]
3 maternal negativity w3	.64[c]	.76[c]	.83[c]	.45[b]	.65[c]	.54[c]	.54[c]	.47[c]	.62[c]	.25	.42[c]	.37[b]	.48[c]	.58[c]	.59[c]
4 paternal negativity w1	.45[c]	.32[b]	.36[b]	.87[c]	.77[c]	.77[c]	.25	.31[a]	.34[a]	.43[c]	.57[c]	.50[b]	.52[c]	.32[b]	.28[a]
5 paternal negativity w2	.44[b]	.40[b]	.41[b]	.74[c]	.91[c]	.74[c]	.31[a]	.33[b]	.42[b]	.50[c]	.64[c]	.54[b]	.50[c]	.54[c]	.45[b]
6 paternal negativity w3	.11	.18	.21	.71[c]	.84[c]	.92[c]	.15	.20	.31	.35	.61[c]	.66[c]	.35[a]	.50[b]	.59[c]
7 maternal positivity w1	.44[c]	.52[c]	.37[b]	.23	.34[b]	.06	.78[c]	.60[c]	.64[c]	.31[a]	.37[b]	.21	.22[a]	.23[a]	.23[a]
8 maternal positivity w2	.38[c]	.49[c]	.43[c]	.30[a]	.42[b]	.17	.75[c]	.85[c]	.59[c]	.43[c]	.47[c]	.19	.31[b]	.24[a]	.19
9 maternal positivity w3	.37[b]	.52[c]	.53[c]	.37[b]	.49[c]	.44[b]	.67[c]	.69[c]	.88[c]	.37[b]	.46[c]	.39[a]	.38[c]	.42[c]	.50[c]
10 paternal positivity w1	.14	.00	.08	.47[c]	.39[b]	.37a	.32[b]	.29[a]	.22	.90[c]	.74[c]	.62[c]	.06	.11	.17
11 paternal positivity w2	.35[b]	.30[a]	.32[a]	.57[c]	.63[c]	.53[b]	.47[c]	.44[b]	.46[b]	.71[c]	.90[c]	.77[c]	.38[b]	.41[b]	.53[c]
12 paternal positivity w3	.05	.20	.14	.66[c]	.58[b]	.68[c]	.25	.16	.35[a]	.58[b]	.74[c]	.95[c]	.40[a]	.45[b]	.52[b]

13 child behaviors w1	.37[c]	.37[c]	.27[a]	.41[b]	.38[b]	.31	.21[a]	.23[a]	.30[b]	.11	.31[a]	.16	.71[c]	.56[c]	.48[c]
14 child behaviors w2	.27[b]	.36[c]	.19	.50[c]	.66[c]	.45[b]	.24[a]	.19	.32[b]	.25[a]	.43[c]	.40[a]	.60[c]	.77[c]	.70[c]
15 child behaviors w3	.15	.31[b]	.25[a]	.32[a]	.53[c]	.48[b]	.22	.21	.36[b]	.18	.53[c]	.51[b]	.54[c]	.70[c]	.77[c]

Note: [a] $p < .05$, [b] $p < .01$, [c] $p < .001$.

Table 10

Cross-twins Correlations between the Main Study Variables for DZ Twins (WRRP Sample).

Twin 2 Twin 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 maternal negativity w1	.64[c]	.60[c]	.54[c]	.13	.15	.25	.41[c]	.33[c]	.35[c]	.03	.04	.31[a]	.38[c]	.29[c]	.33[c]
2 maternal negativity w2	.48[c]	.66[c]	.50[c]	.18	.02	..22	.33[c]	.29[c]	.29[b]	-.03	-.01	.10	.35[c]	.26[b]	.35[c]
3 maternal negativity w3	.53[c]	.59[c]	.67[c]	.28[a]	.28[a]	.45[b]	.39[c]	.31[b]	.41[c]	.10	.22	.36[b]	.45[c]	.39[c]	.41[c]
4 paternal negativity w1	.25[a]	.37[b]	.40[b]	.68[c]	.63[c]	.69[c]	.33[b]	.23[a]	.31[a]	.47[c]	.34[a]	.41[b]	.40[c]	.44[c]	.42[c]
5 paternal negativity w2	.16	.22	.24	.47[c]	.74[c]	.74[c]	.24[a]	.31[b]	.37[b]	.49[c]	.50[c]	.56[c]	.36[b]	.43[c]	.29[a]
6 paternal negativity w3	.32[a]	.41[b]	.46[c]	.65[c]	.76[c]	.82[c]	.35[a]	.36[b]	.45[b]	.43[b]	.54[c]	.60[c]	.44[b]	.50[c]	.52[c]
7 maternal positivity w1	.42[c]	.47[c]	.39[c]	.12	.20	.28[a]	.70[c]	.55[c]	.56[c]	.10	.06	.25	.31[c]	.23[b]	.27[b]
8 maternal positivity w2	.28[b]	.37[c]	.28[b]	.15	.10	.17	.52[c]	.69[c]	.53[c]	-.03	.10	.02	.27[b]	.21[a]	.25[b]
9 maternal positivity w3	.33[c]	.38[c]	.42[c]	.23	.39[b]	.46[c]	.52[c]	.57[c]	.73[c]	.16	.37[b]	.48[c]	.36[c]	.33[c]	.37[c]
10 paternal positivity w1	.16	.11	.14	.33[b]	.45[b]	.29	.28[a]	.13	.23	.82[c]	.69[c]	.50[b]	.34[b]	.30[b]	.25[a]
11 paternal positivity w2	.07	.08	.10	.13	.37[b]	.40[b]	.22	.24[a]	.32[a]	.56[c]	.75[c]	.64[c]	.21	.24[a]	.21
12 paternal positivity w3	.34[a]	.29[a]	.37[b]	.37[a]	.57[c]	.54[c]	.35[b]	.29[a]	.40[b]	.53[c]	.67[c]	.83[c]	.30[a]	.26	.30[a]

13 child behaviors w1	.40[c]	.38[c]	.36[c]	.36[b]	.35[b]	.44[b]	.29[c]	.20[a]	.26[b]	.23[a]	.25[a]	.43[b]	.55[c]	.45[c]	.39[c]
14 child behaviors w2	.37[c]	.42[c]	.37[c]	.23	.35[b]	.44[b]	.26[b]	.22[b]	.29[b]	.18	.22	.43[b]	.48[c]	.57[c]	.42[c]
15 child behaviors w3	.35[c]	.44[c]	.37[c]	.22	.30[a]	.47[c]	.29[b]	.24[b]	.27[b]	.22	.33[a]	.47[c]	.44[c]	.49[c]	.55[c]

Note: [a] $p < .05$, [b] $p < .01$, [c] $p < .001$.

Table 11

Model Fit Indices and Parameter Estimates of the Bivariate Cholesky Models between Child Behavioral Problems and Maternal Negativity (WRRP Sample).

		-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	A	C	E	A	C	E	Ra	Rc	Re	Observed power
					Child Behaviors			Maternal Negativity						
Wave 1	**Full model**	2607.44 (1099)	-	409.44	.41*	.33*	.26*	.44*	.39*	.17*	.52*	.70*	.49*	-
	No Ra	2614.52 (1100)	7.08 (1)*	414.52										.76
	No Rc	2615.48 (1100)	8.04 (1)*	415.47										.81
	No Re	2639.21 (1100)	31.77 (1)*	439.21										1.00
Wave2	Full model	2339.25 (1002)	-	335.25	.46*	.33*	.21*	.40*	.45*	.15*	.75*	.43	.35*	-
	No Ra	2357.39 (1003)	18.14 (1)*	351.39										.99
	No Rc	2342.70 (1003)	3.45 (1)	336.70										.46
	No Re	2353.65 (1003)	14.40 (1)*	347.65										.97
Wave3	**Full model**	2022.07 (863)	-	296.07	.49*	.30*	.21*	.33*	.50*	.17*	.63*	.62*	.42*	-
	No Ra	2030.66 (864)	8.59 (1)*	302.66										.83
	No Rc	2028.13 (864)	6.06 (1)*	300.13										.69

No Re	2039.48 (864)	17.41 (1)*	311.45	.99

Note: *-2LL* = -2 times log likelihood. AIC = Akaike information criterion. A = heritability estimate. C = Shared environmental variance. E = Nonshared environment variance. Ra = genetic correlation. Rc = shared environmental correlation. Re = nonshared environmental correlation. Best fitting model is in bold face. * $p < .05$.

Table 12

Model Fit Indices and Parameter Estimates of the Bivariate Cholesky Models between Child Behavioral Problems and Maternal Positivity (WRRP Sample).

		-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	A	C	E	A	C	E	Ra	Rc	Re	Observed power
					Child Behaviors			Maternal Positivity						
Wave 1	**Full model**	2699.06 (1096)	-	507.06	.40*	.36*	.26*	.22*	.59*	.20*	.57*	.36*	.25*	-
	No Ra	2704.05 (1097)	4.99 (1)*	510.05										.61
	No Rc	2703.12 (1097)	4.06 (1)	509.12										.52
	No Re	2706.52 (1097)	7.46 (1)*	512.52										.78
Wave2	Full model	2436.38 (999)	-	438.38	.46*	.33*	.21*	.33*	.52*	.15*	.55*	.18	.11	-
	No Ra	2445.81 (1000)	9.43 (1)*	445.81										.87
	No Rc	2437.26 (1000)	.88 (1)	437.26										.16
	No Re	2437.58 (1000)	1.20 (1)	437.58										.20
Wave3	**Full model**	2033.59 (860)	-	313.59	.48*	.31*	.21*	.26*	.61*	.13*	.71*	.46*	.06	-
	No Ra	2046.06 (861)	12.47 (1)*	324.06										.94
	No Rc	2038.75 (861)	5.16 (1)*	316.75										.62

No Re	2033.90 (861)	.31 (1)	311.90		.09

Note: *-2LL* = -2 times log likelihood. AIC = Akaike information criterion. A = heritability estimate. C = Shared environmental variance. E = Nonshared environment variance. Ra = genetic correlation. Rc = shared environmental correlation. Re = nonshared environmental correlation. Best fitting model is in bold face. $^{*}p < .05$.

Table 13

Model Fit Indices and Parameter Estimates of the Bivariate Cholesky Models between Child Behavioral Problems and Paternal Negativity (WRRP Sample).

		-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	A	C	E	A	C	E	Ra	Rc	Re	Observed power
					Child Behaviors			Paternal Negativity						
Wave 1	**Full model**	2039.56 (848)	-	343.56	.40*	.34*	.26*	.32*	.55*	.13*	.92*	.49*	.30*	-
	No Ra	2053.56 (849)	14.00 (1)*	355.56										.96
	No Rc	2043.70 (849)	4.14 (1)*	345.70										.53
	No Re	2048.20 (849)	8.64 (1)*	350.20										.84
Wave2	Full model	1824.09 (775)	-	274.09	.44*	.34*	.22*	.31*	.59*	.09*	.79*	.61*	.08	-
	No Ra	1835.16 (776)	11.07 (1)*	283.16										.91
	No Rc	1830.16 (776)	6.07 (1)*	278.16										.69
	No Re	1824.43 (776)	.34 (1)	272.43										.09
Wave3	**Full model**	1453.68 (619)	-	215.68	.47*	.32*	.22*	.20*	.72*	.08*	.53	.90*	.39*	-
	No Ra	1456.89 (620)	3.21 (1)	216.89										.43
	No Rc	1467.43 (620)	13.75 (1)*	227.43										.96

No Re	1458.66 (620)	4.98 (1) *	218.66		.61

Note: *-2LL* = -2 times log likelihood. AIC = Akaike information criterion. A = heritability estimate. C = Shared environmental variance. E = Nonshared environment variance. Ra = genetic correlation. Rc = shared environmental correlation. Re = nonshared environmental correlation. Best fitting model is in bold face. * $p < .05$.

Table 14

Model Fit Indices and Parameter Estimates of the Bivariate Cholesky Models between Child Behavioral Problems and Paternal Positivity (WRRP Sample).

		-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	A	C	E	A	C	E	Ra	Rc	Re	Observed power
					Child Behaviors			Paternal Positivity						
Wave 1	**Full model**	2067.50 (849)	-	369.50	.40*	.34*	.26*	.12*	.77*	.11*	.59	.26	.21	-
	No Ra	2070.65 (850)	3.15 (1)	370.65										.43
	No Rc	2069.41 (850)	1.91 (1)	369.41										.28
	No Re	2070.90 (850)	3.40 (1)	370.90										.45
Wave2	Full model	1873.60 (774)	-	325.60	.45*	.34*	.22*	.28*	.62*	.11*	.71*	.31	-.12	-
	No Ra	1880.82 (775)	7.22 (1)*	330.82										.77
	No Rc	1875.17 (775)	1.57 (1)	325.17										.24
	No Re	1874.39 (775)	.79 (1)	324.39										.14
Wave3	**Full model**	1460.10 (619)	-	222.10	.47*	.32*	.22*	.17*	.77*	.06*	.75*	.60*	-.03	-
	No Ra	1467.00 (620)	6.90 (1) *	227.00										.75
	No Rc	1466.90 (620)	6.80 (1) *	226.90										.74

No Re	1460.12 (620)	.02 (1)	220.12		.05

Note: *-2LL* = -2 times log likelihood. AIC = Akaike information criterion. A = heritability estimate. C = Shared environmental variance. E = Nonshared environment variance. Ra = genetic correlation. Rc = shared environmental correlation. Re = nonshared environmental correlation. Best fitting model is in bold face. * $p < .05$.

Table 15

Model Fit Indices of the Bivariate Cholesky Models: Maternal Digit Span as a Moderator (WRRP Sample).

	Wave 1				Wave 2				Wave 3			
	-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power
					Negativity & child behaviors							
Full model	2089.67 (891)	-	307.67	-	1934.27 (836)	-	262.27	-	1734.75 (741)	-	252.75	-
No β_{common}	2091.38 (892)	1.71 (1)	307.38	.26	1934.37 (837)	.11 (1)	260.37	.06	1735.55 (742)	.80 (1)	251.55	.15
No $\beta_{residual}$	2089.87 (892)	.19 (1)	305.87	.07	1935.57 (837)	1.39 (1)	261.57	.21	1737.55 (742)	2.80 (1)	253.55	.39
No $\beta_{common, residual}$	2091.66 (893)	1.99 (2)	305.66	.22	1935.79 (838)	1.53 (2)	259.79	.18	1738.45 (743)	3.70 (2)	252.45	.39
					Positivity & child behaviors							
Full model	2139.68 (889)	-	361.68	-	2032.16 (833)	-	366.16	-	1758.08 (738)	-	282.08	-
No β_{common}	2139.69 (890)	.01 (1)	359.69	.05	2032.25 (834)	.09 (1)	364.25	.06	1760.03 (739)	1.95 (1)	282.03	.29
No $\beta_{residual}$	2142.98 (890)	3.30 (1)	362.98	.44	2033.18 (834)	1.02 (1)	365.18	.17	1758.33 (739)	.25 (1)	280.33	.08
No $\beta_{common, residual}$	2142.99 (891)	3.32 (2)	360.99	.35	2033.22 (835)	1.06 (2)	363.22	.14	1760.07 (740)	1.99 (2)	280.07	.22

Note: *-2LL* = -2 times log likelihood. Δ-*2LL* = difference in -2 times log likelihood. Δ*df* = difference in degrees of freedom. AIC = Akaike information criterion.

Table 16

Model Fit Indices of the Bivariate Cholesky Models: Maternal Traditional Rearing Beliefs as a Moderator (WRRP Sample).

	Wave 1				Wave 2				Wave 3			
	-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power
					Negativity & child behaviors							
Full model	2574.63(1086)	-	402.62	-	2258.65 (959)	-	340.65	-	1939.08 (820)	-	299.08	-
No β_{common}	2574.75(1087)	.12 (1)	400.75	.06	2258.65 (960)	.00 (1)	338.65	.05	1939.18 (821)	.10 (1)	297.18	.06
No $\beta_{residual}$	2577.89 (1087)	3.26 (1)	403.89	.44	2258.78 (960)	.13 (1)	338.78	.06	1939.34 (821)	.27 (1)	297.34	.08
No $\beta_{common, residual}$	2577.92 (1088)	3.29 (2)	401.92	.35	2258.79 (961)	.14 (2)	336.79	.06	1939.52 (822)	.44 (2)	295.52	.08
					Positivity & child behaviors							
Full model	2669.33 (1083)	-	503.33	-	2352.27 (956)	-	440.27	-	1933.67 (817)	-	299.67	-
No β_{common}	2670.86 (1084)	1.52 (1)	502.86	.23	2354.85 (957)	2.57 (1)	440.85	.36	1942.05 (818)	8.38 (1)*	306.05	.83
No $\beta_{residual}$	2669.58 (1084)	.25 (1)	501.58	.08	2352.28 (957)	.01 (1)	438.28	.05	1933.89 (818)	.23 (1)	297.89	.08
No $\beta_{common, residual}$	2671.74 (1085)	2.40 (2)	501.74	.26	2354.87 (958)	2.59 (2)	438.87	.28	1943.40 (819)	9.73 (2)*	305.40	.80

Note: *-2LL* = -2 times log likelihood. Δ-*2LL* = difference in -2 times log likelihood. Δ*df* = difference in degrees of freedom. AIC = Akaike information criterion. * $p < .05$.

Table 17

Model Fit Indices of the Bivariate Cholesky Models: Maternal progressive Rearing Beliefs as a Moderator (WRRP Sample).

	Wave 1				Wave 2				Wave 3			
	-2LL (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power	*-2LL* (*df*)	Δ-*2LL* (Δ*df*)	AIC	Power
					Negativity & child behaviors							
Full model	2580.70 (1086)	-	408.70	-	2255.94 (959)	-	337.94	-	1944.43 (820)	-	304.43	-
No β_{common}	2580.71 (1087)	.01 (1)	406.71	.05	2256.12 (960)	.18 (1)	336.12	.07	1944.51 (821)	.07 (1)	302.51	.06
No $\beta_{residual}$	2581.37 (1087)	.67 (1)	407.37	.13	2260.27 (960)	4.32 (1)*	340.27	.54	1944.78 (821)	.35 (1)	302.78	.09
No $\beta_{common, residual}$	2581.37 (1088)	.67 (2)	405.37	.10	2260.34 (961)	4.40 (2)	338.34	.45	1944.84 (822)	.41 (2)	300.84	.08
					Positivity & child behaviors							
Full model	2667.49 (1083)	-	501.49	-	2353.12 (956)	-	441.12	-	1947.05 (817)	-	313.05	-
No β_{common}	2667.94 (1084)	.45 (1)	499.94	.10	2354.75 (957)	1.63 (1)	440.75	.25	1948.57 (818)	1.52 (1)	312.57	.23
No $\beta_{residual}$	2668.05 (1084)	.57 (1)	500.05	.12	2354.51 (957)	1.40 (1)	440.51	.22	1947.80 (818)	.75 (1)	311.80	.14
No $\beta_{common, residual}$	2668.57 (1085)	1.08 (2)	498.57	.14	2355.49 (958)	2.37 (2)	439.49	.26	1950.80 (819)	3.75 (2)	312.80	.39

Note: *-2LL* = -2 times log likelihood. Δ-*2LL* = difference in -2 times log likelihood. Δ*df* = difference in degrees of freedom. AIC = Akaike information criterion. * $p < .05$.

Table 18

Moderated Bivariate Cholesky Models: Genetic Correlations between Parenting and Child Behavioral Problems (WRRP Sample).

			Genetic correlation estimates				
Variables	Moderator	Best fitting model	-2SD	-1SD	Mean	1SD	2SD
Wave 3 maternal positivity & child behaviors	Traditional belief	No $\beta_{residual}$	.07	.61	.83	.91	.94
Wave 2 maternal negativity & child behaviors	Progressive belief	No β_{common}	1.00	.93	.83	.71	.62

Note: -2SD, -1SD, 1SD, and 2SD: moderator takes the value of 1 or 2 SD below or above the mean of the moderator; mean: moderator takes the value of the mean of moderator.

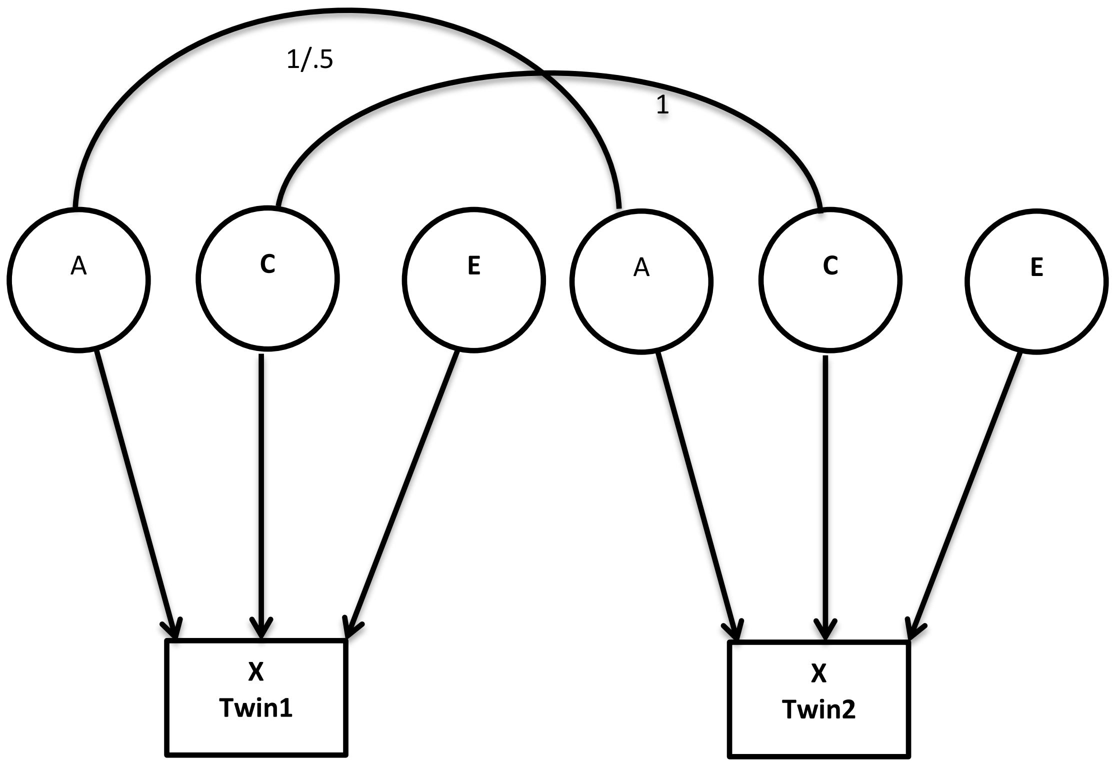

Figure 1. Univariate behavioral genetic model in a twin design (WRRP Sample).

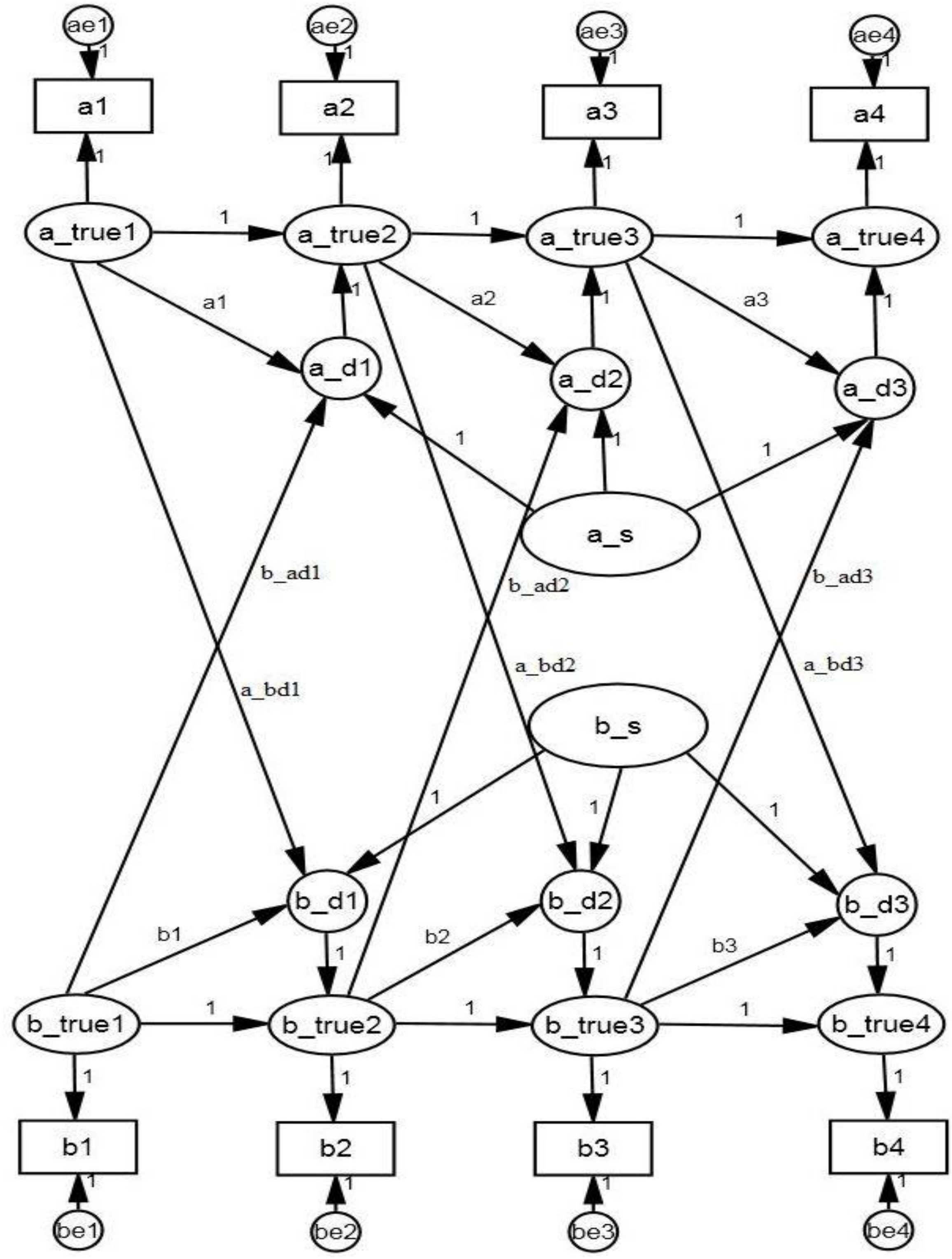

Figure 2. Bivariate latent difference score model (SECCYD Sample).

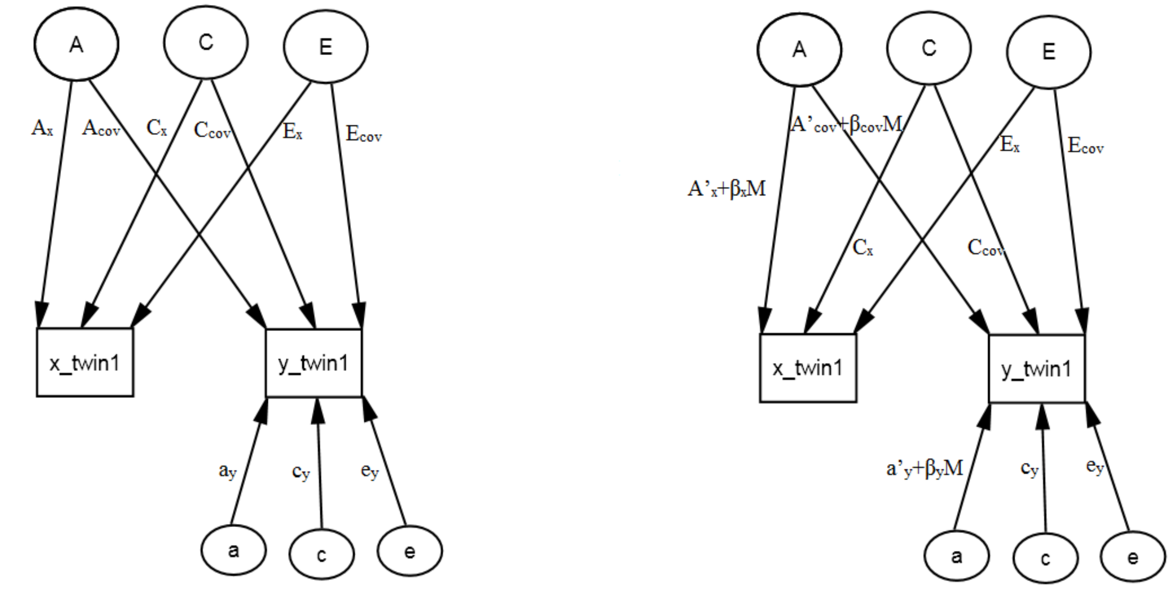

Figure 3. Bivariate Cholesky decomposition model with (right) and without (left) a continuous moderator (WRRP Sample).

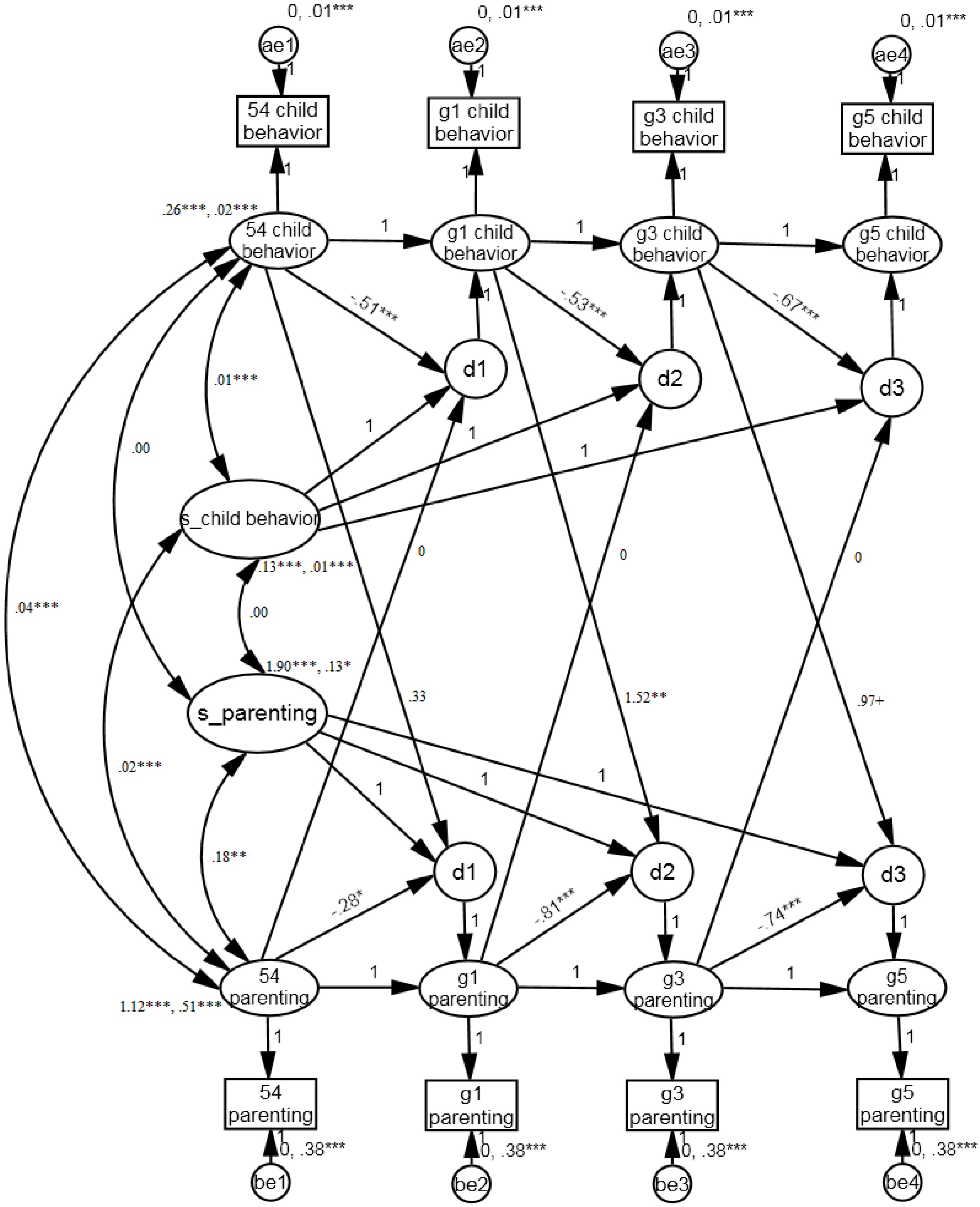

Figure 4. Bivariate latent difference score model. Values given next to the predictive paths are unstandardized coefficients; for the intercepts, slopes, and measurement errors, values given are means and variances. Values given next to the correlational paths are covariances between intercepts and slopes (SECCYD Sample). + *p* < .07; * *p* < .05; ** *p* < .01; *** *p* < .001.