

Shared Environment Moderates the Heritability of Temperament in Childhood

by

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A Thesis Presented in Partial Fulfillment  
of the Requirements for the Degree  
Master of Arts

Approved April 2011 by the  
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May 2011

## ABSTRACT

The interplay of genes and environment on children's development is a complex dynamic process. As behavior geneticists begin to model protective as well as risk factors, and interactive as well as main effect influences, development is elucidated. It was hypothesized that positive parenting, a quality home environment, and high family cohesion would moderate the heritability of three components of temperament: Effortful Control, Negative Affectivity, and Extraversion/Surgency. Participants were drawn from the Wisconsin Twin Project and consisted of 1573 twins (51% boys), 88.5% Caucasian,  $M=7.93$  years ( $SD=0.87$ ). Higher order composites for the parenting and family environment moderators were formed from mother and father reports of Behavior Management Self-Assessment, Child Rearing Practices Report, Family Assessment Device, and Family Conflict Scale. Measures of the home environment (LEOS Living Environment Observation Scale and CHAOS Confusion, Hubbub, and Order Scale) were not composited due to the nature of the variables. Correlational analyses showed a majority of the temperament and environmental measures to be correlated ( $r_s = -.49-.57$ ). For Effortful Control, Negative Affectivity, and Extraversion/Surgency, estimates for the heritability and nonshared environment were 0.60 and 0.40, 0.80 and 0.20, and 0.59 and 0.41, respectively, with no significant main effects of the shared environment. Models incorporating environmental moderation of these estimates yielded parenting as a significant moderator for Negative Affectivity, LEOS for Effortful Control and Extraversion/Surgency, and CHAOS for Effortful Control and

Extraversion/Surgency. Results suggest that the quality of the family environment may act as a permissive or determinative influence on the heritability and expression of temperament. Future analyses include the examination of interactive genetic influences. These findings underscore the importance of shared environment, and support the recent literature on the benefits of positive influences on children's development.

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## **Introduction**

The interplay of genes and environment on children's development is complex and dynamic. Of interest in this study are the effects of positive environments, such as warm and supportive parenting, a clean, structured home, and a cohesive family unit on children's temperament. In the past, developmental literature has associated negative life circumstances with maladaptive child outcomes, such as internalizing and externalizing problem behaviors, deficits in self-regulatory skills, and poor adjustment later in life (e.g., Booth-LaForce & Oxford, 2008; Deater-Deckard & Petrill, 2004; Maccoby & Martin, 1983, Prevatt, 2003). Only recently has research substantially begun to illuminate the benefits of positive influences on children's development, as well as modeling gene by environment interactions (e.g., Lemery-Chalfant, 2010). Thus, the present study serves to advance this movement by examining positive family environments and the heritability of temperament in children using a twin design.

According to Bronfenbrenner's (1979, 1999) bioecological systems theory (see Figure 1), children's development is a function of multiple levels of nested influences that integrate to play a unified role in child development. More specifically, the theory outlines four layers that encompass this environment: microsystem, mesosystem, exosystem, and macrosystem. The present study focuses on key aspects of the microsystem, including parent-child relationships, physical surroundings, and organization and emotional climate within the home. These aspects appear to be implicated in children's development generally and may affect the heritability of some aspects of children's temperament; however,

this is not to say that the other components of the system do not influence the extent to which environments are permissive or determinative and how genetically determined features of temperament are enacted. In using this model, Bronfenbrenner acknowledged that many of these factors are enmeshed, and that children have bidirectional, or transactional, influences on their experiences.

Considering the enmeshed nature of this environmental model, the events and influences in any one sector have a ripple effect unto the rest. As such, some environments may be more permissive or determinative in regards to their influence on children's development. A permissive environment is one in which conditions are sufficient to allow children to develop naturally, such that genes are freely expressed and the environment serves to support the development of competencies and proclivities in accordance with the child's intrinsic characteristics. A determinative environment, on the other hand, either constrains the genetically driven pathways to development or leverages them beyond their normal (e.g., expected) expression (Baumrind, 1993; Bradley, 2006; Novak & Peleaz, 2003; Sroufe, 1997). For example, a chaotic, unstructured home lacks the stability children need in order to develop foundational skills, like self-regulation and self-efficacy, such that the deficit of these skills are associated with poor outcomes and ultimately suppress the true potential of the child (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005).

At the core of this environmental framework is child temperament, commonly defined as "constitutionally based individual differences in reactivity and regulation," which are moderately heritable and relatively stable over time (p.

100, Rothbart & Bates, 2006). Temperament helps direct individuals' interactions with their environment, though it should be noted that temperament marks behavioral tendencies that are stable across contexts rather than specific situational behavioral acts (Derryberry & Reed, 1994; Goldsmith et al., 1987).

While the organized concept of temperament traces back to approximately 200 AD when Galen of Pergamon hypothesized that different balances of the four humours (blood, yellow bile, black bile, and phlegm) were responsible for different human personalities (Sanguine, Choleric, Melancholic, Phlegmatic), decades of research and the use of factor analysis have revealed multiple dimensions of temperament, including fearful distress, irritability, attention span, activity level, and positive affectivity (e.g., Garstein & Rothbart, 2003; Rothbart & Bates, 2006; Shiner, 1998). There are approximately 14-18 dimensions of temperament that have been identified depending on age in infancy and childhood, which inclusively comprise five broader factors—negative affectivity (e.g., fear, frustration), extraversion/surgency (e.g., positive anticipation), high intensity pleasure (e.g., sociability), effortful control/self-regulation (e.g., attentional focusing, inhibitory control), and agreeableness/adaptability (e.g., manageability) (Garstein & Rothbart, 2003; Rothbart & Bates, 2006). Furthermore, temperament becomes increasingly stable after toddlerhood (Lemery, Goldsmith, Klinnert, & Mrazek, 1999), and remains relatively stable throughout the lifespan (Caspi & Roberts, 2005; Durban, Hayden, Klein, & Olino, 2007; Pedlow, Sanson, Prior, & Oberklaid, 1993). Regardless, temperament

continues to be open to change in response to maturation and environmental demands (Goldsmith et al., 1987; Rothbart, 1986).

Temperament has also been commonly described in terms of evolutionary mechanisms, such that different temperament styles may have evolved to increase chances of survival. Studies find, for example, that fearful inhibition helps children avoid fear inducing situations, leading to fewer of these experiences (Akker, Dekovic, Prinzie, & Ascher, 2010). This reaction may serve as a protective factor to avoid potentially dangerous situations. On the other hand, children with easy temperaments are less at risk than children with difficult temperaments for eliciting abusive parenting, having behavior problems, and experiencing sleep difficulties which hinder development (e.g., Goodnight, Bates, Staples, Pettit, & Dodge, 2007; Vitaro, Barker, Boivin, Brendgen, & Tremblay, 2006). These studies exemplify Belsky's (2005) differential susceptibility hypothesis, a newly formed hypothesis that some individuals are more susceptible to their environment for genetic and possibly evolutionary reasons such that they fare poorly in negative environments yet can excel in positive environments. For example, growing up in a supportive environment was extremely beneficial to children high in negative affectivity while effects on other children were less salient (Belsky, 2005; Boyce & Ellis, 2005). More recently, Ellis and Belsky (2011) suggest that the implications for differential susceptibility effects of positive environments on typically deemed risky genetic variants and environments are understudied. In light, Knafo, Israel, and Ebstein (2011) found that susceptible children showed the highest levels of prosocial behavior when

also having highly warm and positive mothers, and lowest levels at low to moderate parental warmth. These results suggest that, given a nurturing, positive environment, some children (those who are environmentally susceptible) will be able to optimally utilize their genetic tendencies to excel.

Tellegen et al. (1988) estimated the heritability, or the proportion of phenotypic variation due to genetic variation, of temperament to be approximately .50 using an adult sample of monozygotic twins reared apart. More specifically, heritability is found to range from .20 to .60 (Saudino, 2005). It is important to note, however, that heritability may differ between samples as it is a group statistic and may fluctuate given environmental circumstances (Lemery-Chalfant, 2010). Theoretically, the remaining .40 to .80 of variability is accounted for by environmental influences, whether shared or non-shared between twins.

Estimates of heritability and environmental effects may also vary by temperament dimensions (Saudino, 2005). For example, activity level is heritable at .76 (Saudino, 1991), .68 for social fear, and .47 for shyness (Goldsmith, Buss, & Lemery, 1997). Based on these examples, temperament seems to be influenced by both genes and environments. It is interesting, then, to consider the context in which heritability is measured in that extremely permissive or determinative environments may act to inhibit or exaggerate genetically driven propensities.

Quantitatively, twin methodology is a useful design commonly used to estimate heritability. The Arizona Twin Project and the Boston University Twin Project are two longitudinal studies of early temperament development. Since monozygotic (MZ) twins share 100% of their genes and their shared environment,

any differences between cotwins can be attributed to the non-shared environment. Dizygotic (DZ), or fraternal twins share 50% of their segregating genes, so differences between DZ cotwins are due to both genes and non-shared environments, since common environment is also shared. Twin studies can also be used to gain more knowledge about the interplay of genes and environment on child development. Statistically, the ACE model (see Figure 2) is used to obtain estimates of heritability (Neale & Cardon, 1992). This model contains three latent factors that account for variance in the trait: A (additive genetics, or heritability), C (common shared environment, which makes twins more similar to each other), and E (non-shared environment, which creates differences between cotwins). Squares represent measured variables of interest and circles represent the latent variables of A, C, and E. Figure 3 illustrates the ACE model with an added environmental moderator (Purcell, 2002), which is represented by a triangle. Here, influences of A, C, and E on a trait (e.g., temperament) may vary depending on the micro-environment (e.g., facets of the positive environment).

Much of previous literature has shown that the C estimate, a linear main effect, in the ACE model almost always drops out due to the lack of power to detect its significance (e.g., Kendler et al., 1996; McCall, 1991; Mullineaux, Deater-Deckard, Petrill, Thompson, & DeThorne, 2009; Plomin, Defries, McClearn, & McGuffin, 2001; Saudino, 2005; Saudino & Cherny, 2001; Slutske et al., 1997), resulting in an AE model. As a result, the importance of the common environment is often limited and is neither discussed conceptually nor statistically. In fact, previous literature has advocated that the shared environment

is unimportant and that genetics instead account for the majority of variance in individual differences. This assertion suggests that parenting and other facets of the shared environment generally have little influence on child development (e.g., Harris, 1998; Rowe, 1994; Scarr, 1992); however, constituents of the common environment – parenting, physical home setting, family cohesion, among others – are often associated with child outcomes when not investigated using genetically-informed models (e.g., Leventhal & Brooks-Gunn, 2000; Pettit, Bates, & Dodge, 1997) making the nonsignificant quantitative genetic findings questionable. Accordingly, this study examined a different pathway in which the common environment may exert influence in the quantitative genetic model – as a nonlinear moderator of the remaining AE model, which results when the C estimate is dropped from the full ACE model. This moderational model allows analysis of potential changes in the heritability of temperament across varying levels of common environmental factors.

Past research has strongly suggested that temperament is involved with numerous child outcomes, including the development of attachment and healthy relationships (e.g., Kochanska, Aksan, Carlson, 2005; Putnam, Sanson, & Rothbart, 2002), social and emotional development (e.g., Sanson, Hemphill, Smart, 2004), resilience (e.g., Rutter, 2002), and psychopathology (e.g., Janson & Mathiesen, 2008; Shannon, Beauchaine, Brenner, Neuhaus, & Gatzke-Kopp, 2007). Child temperament also serves as a buffer in negative environments. More specifically, an easy, outgoing temperament is protective against the

maladaptive effects of low socioeconomic status (Kim-Cohen, Moffitt, Caspi, & Taylor, 2004).

An important consideration in the exploration of how temperament can be impacted by a positive environment is the degree of person-environment fit, or goodness of fit. Goodness of fit was first introduced by Thomas and Chess (1977) and emphasizes how well an individual can function with the demands and opportunities present in the environment. The person-environment fit is important in that dimensions of temperament require appropriate environments for their expression, especially for children whose temperamental proclivities make them more than normally susceptible to environmental influences (e.g., Belsky, 1997, 2005; Boyce & Ellis, 2005; Ellis & Boyce, 2008). Here, positive environments, such as parental warmth and responsiveness, are a universal and optimal fit for all children, regardless of temperament style. A positive environment is conducive to nurturing adaptive expressions of temperament and healthy child development in general.

Last, much of the previous literature has historically focused on infant and early childhood temperament, and little on middle childhood. While temperament is moderately stable throughout the life span, it is still malleable in the face of maturation and environmental influences (Rothbart & Bates, 2006). By definition, maturational processes rely on gene expression, which in turn involves adaptation to the environment. Middle childhood is one such time of adaptation, as it is the beginning of when children begin to play more proactive roles in their environments as they learn to adjust to school, form and maintain peer



relationships, and increasingly become at-risk for mood and behavior problems. Since the heritability of traits may become more evident over time (Matheny, 1983; 1989; Saudino, 2005), it is important to consider its estimates at different time points in life and how facilitative or determinative environments may change those estimates.

### **Empirical Literature Review**

Given that temperament is a function of the interplay between genes and environment, the present study strives to further elucidate many of the issues previously discussed. More specifically, I examined how a positive micro-environment, which is comprised of positive parenting, a physical home which provides positive affordances, and a cohesive, low conflict family environment can influence, by moderation, children's expression of temperament and how heritability may differ in more or less positive environments in middle childhood. Furthermore, this study considers both Bronfenbrenner's (1979) bioecological systems theory as well as Belsky's (1997, 2005) differential susceptibility hypothesis frameworks in its conceptual and quantitative analysis.

### **Positive Parenting and Children's Temperament**

Parenting has long been considered key to child development in general (e.g., Belsky, 1984; Eisenberg et al., 2005; Kochanska, 1993; Morris, Silk, Steinberg, Myers, Robinson, 2007) and positive parenting "appears to be indispensable to healthy caregiving and wholesome parent-child functioning, at least in Western cultures" (Bornstein et al., 2010, p.385; also Bornstein, 2008; Eisenberg, Cumberland, Spinrad, 1998; Rohner, Khaleque, & Cournoyer, 2005).

Parenting has been studied as both a direct (e.g., predictor) and indirect influence (e.g., moderator). Positive parenting and the mechanisms by which it influences child temperament is the focus of this section, although it should be noted that without further examination, the discussion of positive parenting does not necessarily reflect the opposite of negative parenting.

Positive parenting is facilitative, and encourages secure attachments in infants, self-regulation skills, social competence, and well-being overall (e.g., Caspi et al., 2004; Crockenberg, 1981; Harlow, 1958). It not only reduces negative behaviors, such as impulsivity and poor inhibitory control which lead to externalizing and internalizing behaviors (e.g., Bor, Sanders, Markie-Dadds, 2002; Chronis et al., 2007), but encourages positive behaviors. Children with parents who expressed positive emotions were themselves more likely to do the same, even into adulthood (Denham, 1989; Denham & Grout, 1992; Eisenberg et al., 1998; Garner, Robertson, & Smith, 1997). Children with parents high in positive expressivity were also more likely to have higher empathy and social functioning skills (Zhou et al., 2002). In this regard, children who are inclined to show these positive emotions have the avenue to do so by parents who encourage positivity. Conversely, their natural proclivity receives less support for expression and development from parents who tend to manifest negative affect.

Bowlby (1969) proposed that nurturing and warm parent-child interactions are biologically-based behaviors designed to promote children's survival by encouraging the development of healthy regulatory skills. For example, children with parents exhibiting highly positive parenting behaviors at age two showed

increased growth rates of inhibitory control from ages two to four (Moilanen et al., 2010). While the parenting literature has focused largely on the effects of negative parenting, suggesting considerable maladaptive effects on children (e.g., Davidov, 2006; Kaufmann et al., 2000; Morris et al., 2002), more research is now being conducted regarding positive parenting (e.g. Dishion et al., 2008; Eisenberg et al., 2005; Sanders & Cann, 2002). Elements of positive parenting include parental warmth, sensitivity and responsiveness, and parent-child goodness of fit, though the present study focuses on parental warmth and behavior management skills.

The effects of parenting style on children's temperament and development in general has been well researched. Baumrind's (1967) classic parenting styles are often separated into two dimensions: parental emotional support, such as warmth and responsiveness, and parental control (Maccoby & Martin, 1983). Classic literature suggests four styles of parenting: authoritative (balanced warmth and control), permissive (high warmth and little control), authoritarian (little warmth and high control), and uninvolved or neglectful (little warmth and little control) (Baumrind, 1967; Maccoby & Martin, 1983). Each parenting style's unique combination of warmth and control has been shown to uniquely influence child development (e.g., Baumrind, 1991). For example, children of authoritarian parents often have low self-esteem, negative emotionality, and problem behaviors (e.g., Paulussen-Hoogeboom et al., 2007; Rudy & Grusec, 2006; Thompson, Hollis, & Richards, 2003). Specifically, maternal psychological control and hostility have been associated with

internalizing and externalizing problems for children high in irritable distress and poor effortful control, respectively (Morris et al., 2002). On the other extreme, permissive parents tend to rear children who are impulsive, aggressive, struggle academically, and more likely to abuse substances (e.g., Baumrind, 1991; Lamborn et al., 1991). Uninvolved, neglectful, parents provide neither warmth nor control, and are associated with externalizing and internalizing behaviors in children (e.g., Knutson, DeGarmo, & Reid, 2004; Steinberg, Lamborn, Darling, Mounts, & Dornbusch, 1994). Last, the most beneficial parenting style for most children is the authoritative style, which balances warmth and control. This style is typically associated with well-regulated, socially competent children and adolescents (e.g., Baumrind, 1991; Maccoby & Martin, 1983; Steinberg, Elmen, Mounts, 1989).

Furthermore, parenting is composed of many dimensions. For example, parental warmth, especially maternal warmth, has been significantly correlated with children's temperament style (e.g., Bowlby, 1969; Zhou et al., 2002). Recently, Bradley and Corwyn (2008) examined relations between maternal sensitivity, temperament, and problem behaviors. Findings suggest that children with difficult temperaments, who are more reactive to their environments, paired with less sensitive mothers, are more likely to develop behaviors problems. Importantly, these children were also shown to benefit more from positive parenting than children without difficult temperaments. A review of the literature suggests that positive parents, who are high in warmth, nurture children who are high in emotion self regulation and thus less prone to externalizing problems

(Eisenberg et al., 1998). Maternal sensitivity was also found to moderate the relationship between infant wariness at 15 months of age and inhibition at kindergarten age such that children with highly sensitive mothers displayed less inhibition at that time (Early et al., 2002). Findings from Cipriano and Stifter (2010) suggest that children who were categorized as having an exuberant temperament at age two showed greater effortful control at four and a half years of age when mothers displayed positive parenting by use of positive emotional tone when giving commands and prohibitive statements compared to children of mothers who communicated in neutral tones. In another study, mothers' responsiveness at 22 months predicted greater effortful control in their children at 22 and 33 months (Kochanska, Murray, & Harlan, 2000). Last, maternal responsivity was shown to moderate the relation between children's low birth weight and internalizing problems such that children with highly responsive mothers displayed less of these behaviors. This effect was especially true for very low birth weight children, suggesting differential susceptibility effects (Laucht, Esser, & Schmidt, 2001).

From the literature, it is clear that parenting can serve to influence children's development because of its transactional nature; how parents and children act and react to each other help shape their immediate and future interactions (e.g., Collins et al., 1999; Stoolmiller, 2001). To start, children's temperament plays a role in first directing their behaviors (e.g., Komsis, 2008). This behavior influences parents' behavior in turn, which provides feedback to the child on the value and desirability of their initial behavior. Gradually children

modify their behavior to fit the parenting environment. For example, temperament ratings at six months of age predicted maternal sensitivity and then attachment security at 12 months of age (Susman-Stillman, Kalkoske, Egeland, & Waldman, 1996). Bates, Pettit, Dodge, and Ridge (1998) found a temperament by environment interaction where children categorized as having resistant temperament (i.e., impulsivity-unmanageability) with mothers low in control actions had higher externalizing behavior than the children with mothers high in control actions. Moreover, transactional results in middle childhood were found such that maternal inconsistent discipline was predicted by increased child fearfulness and irritability while greater maternal acceptance was predicted by child fearfulness and positive emotionality (Lengua & Kovacs, 2004). Mother perceptions of their children's temperament have been shown to modify parental behavior. For example, children who were perceived as difficult were more likely to be rejected by mothers who were highly conscientious. When considering maternal education, educated mothers who perceived their child as difficult were more likely to assist them by regulating task difficulty and encouraging their efforts than when their children were perceived as having an easy temperament (Neitzel & Stright, 2004).

Last, given that temperament is influenced by both genetics and environment, parenting and temperament relations have been studied using gene by environment interactions (GxE), which examine how individual differences in phenotypes may differ depending on the interaction between genotype and differential environments. Researchers utilize GxE to elucidate genetic and

environmental interplay on outcomes as well as test hypotheses such as Belsky's (1997, 2005) differential susceptibility hypothesis. Sheese (2007), for example, found a significant GxE in terms of allelic variations of the dopamine receptor D4 (DRD4) and parenting quality on temperament. Children carrying the DRD4-7 repeat allele were more sensitive to environmental influences, such as parenting style, than those carrying the 4-repeat allele. The researchers suggest that this allele allows parents more control in shaping their children's temperament, such that low quality parenting increased activity level, impulsivity, and high-intensity pleasure in children with the 7-repeat allele, whereas high quality parenting served as a buffer against these indicators of sensation seeking. Conversely, the same DRD4-7 repeat polymorphism was associated with increased externalizing behavior in children with insensitive mothers (Bakermans-Kranenburg & IJzendoorn, 2006).

Additionally, the influence of maternal anxiety on infant temperament, specifically irritability, was moderated by the serotonin transporter gene, such that children with a short allele were affected while those with the long allele were not (Ivorra et al., 2010). Furthermore, children carrying the short version of the serotonin transporter paired with mothers low in social support were more likely to be behaviorally inhibited during middle childhood than the same children with mothers high in social support (Fox et al., 2005).

### **Positive Home Environment and Children's Temperament**

The home environment is often implicated in child development given that its role is to provide comfort, food, and safety. With Maslow's (1943) hierarchy

of needs theory, there are four needs – physiological needs, safety, love and belonging, and esteem, with self-actualization serving as the capstone. The home environment, which consists of both the concrete, physical setting as well as socio-emotional ambience within the setting (e.g., level of conflict, level of cohesion, degree of structure or organization), provides the foundation for many of these needs. Literature has suggested that a high quality home environment encourages healthy growth by way of association with higher quality care and affordances within that environment (e.g., parenting behavior, availability of learning material) (e.g., Bradley & Corwyn, 2002; Davis-Kean, 2005; Reyno & McGrath, 2006). For example, the home environment has often been found as a mediator between family SES and children’s academic outcomes (Smith et al., 1997). This finding again suggests that some environments are more facilitative while others are determinative.

**Physical home environment.** The physical environment is often measured as a function of the availability of basic necessities, such as electricity or a toilet facility, stimulating materials to encourage learning and growth, the layout and space of the living environment, overall aesthetics, established routines and structure, and the ratio of needs to space and materials available. These elements of the overall socio-emotional ambience have been significantly associated with children’s temperament, outcomes, and development in general (e.g., Bradley, 1993; Evans, 2006; Matheny, Wilson, & Thoben, 1987; Wachs, 1988), and are examined for the purposes of this study. Furthermore, Wachs (1988) suggested that the physical environment plays a role in the expression of



temperament such that the right conditions must be present for the expression of any given dimension of temperament (i.e., enough of the needed conditions, and not too much of the antagonistic conditions). For example, researchers have linked children's development of fine and gross-motor skills with the number of toys in the home (Abbott & Bartlett, 2001). Gabbard, Cacola, Rodrigues (2008) suggest that environmental affordances introduce and enhance learning opportunities. Without them, children have no stimuli to prompt the learning of necessary or new skills. Similarly, studies have examined the association between the availability of natural space as well as outdoor playgrounds and children's activity levels (e.g., Fjortoft, 2001; Kytta, 2004). Thus, children's expression of activity level may be dependent on the affordances of their environment.

An essential element of a healthy home environment includes the enforcement and balance of routines and structure for the child. Chaotic homes, which provide little structure or routine, have been associated with children's poor self-regulatory and cognitive skills, aggression, impulsivity, and mental health issues (e.g., Dumas, Nissley, Nordstrom, Smith, & Levine, 2005; Evans, Wells, & Moch, 2003; Wachs, 2000). Chaotic home environments have also been found to be significantly related to children's externalizing and internalizing problems with both caregiver and teacher reports (Dumas et al., 2005). Additionally, toddlers living in households with high levels of noise, confusion, and disorganization were more likely to show negative emotionality and be more intractable (Matheny et al., 1987). Such environments are often more deterministic toward negative

child outcomes given that children are less able to develop optimally in the face of constant disruptions, confusion, and the inability to self-regulate long enough to learn or accomplish higher order tasks.

One of the earliest studies to examine the relation between physical environment and child temperament found that crowding was positively and significantly correlated with approach and adaptability while the availability of objects and visual stimuli in the home was positively and significantly correlated with activity level (Wachs, 1988). It has also been suggested that a chaotic home increases the likelihood of a difficult temperament (Evans et al., 2005; Wachs, 2000). More recently, Supplee, Unikel, and Shaw (2007) suggested associations between the micro-level (overcrowding and chaos in the home) and macro-level (neighborhood quality) physical environments with children's externalizing behaviors. Results showed that this relation was evident as early as age two for micro-level influences and age three for macro-level influences for predictions of conduct problems at age five. Children in overcrowded homes also receive less parental attention (Liddell & Kruger, 1989) and tend to score high on neuroticism (Murray, 1974). This finding was also later confirmed by Matheny and Phillips (2001).

Additionally, the presence of environmental toxins, such as lead, mercury, and PCBs have been linked to cognitive deficits in children, including poor attentional focus, slower reaction time, and poor visual-motor integration (Chiodo et al., 2004) and increases in impulsivity and aggression (Evans, 2006). Such physical and psychological obstructions may change the developmental trajectory

of a child which may have otherwise been on a more optimal path. For example, the development of attentional focus can be contingent on the environment, such that in the presence of toxins its proper growth is impeded. Poor attentional focus has been strongly linked to the development of problem behaviors (Caspi, Henry, McGee, Moffitt, & Silva, 1995).

Various mechanisms exist as to how the home environment comes to affect the child. For example, parenting behavior is influenced by parents' responses to their environmental influences. More specifically, Coldwell, Pike, and Dunn (2006) found that chaos in the home moderated the relation between positive and negative parenting behaviors and child behavior problems. Thus, the type of parenting may influence the permissiveness or determinative quality of the environment, impacting the extent of temperament expression and resulting behavior problems. Corapci and Wachs (2002) describe three main hypotheses: habituation, fatigue, and diminished control. In habituation, parents cope with an overwhelming environment by habituating a stress response which leads to withdrawal from others. Parents may also respond by physical fatigue, which decreases overall cooperation and increases aggression (Wachs, 1992). Last, diminished control is when parents have low foci of control, thereby reducing parental efficacy (e.g., Bugental & Cortez, 1988; Gondoli & Silverberg, 1997). Indeed, it was found that noise and confusion from environmental chaos was associated with poor parenting (Corapci & Wachs, 2002). Additionally, as previously discussed, children from more chaotic, crowded homes tended to have less responsive parents, which created fewer learning experiences, poor parent-

child relationships, and poor child outcomes (e.g., Coldwell et al., 2004; Liddell & Kruger, 1989; Pachter, Auinger, Palmer, & Weitzman, 2006).

**Family environment.** For the purposes of this study, the family home environment is operationalized as parental emotional availability, communication, and overall family cohesion or conflict. Each of these elements has been linked, whether directly or indirectly, to child temperament and development in general (e.g., Garner & Power, 2008; Kogan & Carter, 1996). A quality family environment can play a powerful role as a facilitator of healthy child development in that it provides good modeling, scaffolding, and a support system.

Possibly the mechanism that is most often implicated with child development, especially concerning emotion regulation skills and expressivity, is parental emotional availability (e.g., Biringen et al., 2000; Eisenberg et al., 2001; Valiente et al., 2004; Volling, McElwain, Notaro, & Herrera, 2002). Even as early as infancy, mother's emotional availability was related to the quality of the infant-mother attachment relationship such that secure infants were likely to have sensitive mothers who encouraged structured play compared to mothers of infants with insecure attachments. Additionally, secure children were more likely to be responsive to their mothers and engage them in play during the Strange Situation (Ziv et al., 2000). In another study, maternal hostility was associated with the infant's difficulty in regulating distress during a task. Children from these dyads also had more difficulty regulating their emotions even after the task was over (Little & Carter, 2005).

Family functioning, such as cohesion or conflict, is also implicated with children's outcomes. Marital conflict and communication is often associated with children's emotional security, emotion regulation skills, and internalizing and externalizing behaviors (e.g., Davies & Cummings, 1994; Katz & Gottman, 1993). The environment provided by family functioning also directly and positively impacted child internalizing behaviors for children with high negative affect (Crawford, Schrock, Woodruff-Borden, 2010). For example, in a study of goodness-of-fit, infant low rhythmicity was associated with parents' difficulty to adapt to the new infant (Sprunger, Boyce, & Gaines, 1985). Prevatt (2003) studied children's adjustment based on family conflict and stress classified as risk factors and family cohesion and social support classified as resilience, or protective, factors. Results suggested that family risk factors and poor parenting accounted for the majority of variance in child externalizing behaviors. Moreover, children with difficult temperament displayed the most internalizing and externalizing problem behaviors when paired with high-conflict families as compared to those with easy temperaments (Tschann et al., 1996).

Last, GxE concerning home environment factors on child temperament are most commonly discussed via Belsky's (1997, 2005) differential susceptibility hypothesis. Caspi et al. (2006) reported that older individuals who were maltreated as children and had low levels of the neurotransmitter-metabolizing enzyme gene monoamine oxidase A (MAOA) were more likely to develop a wide range of problem behaviors, such as conduct disorder and antisocial personality disorder than those with the high MAOA activity gene. Thus, the home

environment, combined with genetic vulnerability, impacted maladaptive development (Belsky, Bakersman-Kranenburg, & IJzendoorn, 2007).

### **Summary**

The empirical literature suggests that while the exact mechanisms are still unclear, there exist genetic and environmental relations, as well as direct and indirect influences of positive environments (parenting, physical home environment, family environment) on child temperament and development. Furthermore, environments can be facilitative or determinative mediums for growth. The present study aimed to elucidate these relations, using both parent report and observer reported measures for greater validity and reliability.

### **Hypotheses**

Based on Bronfenbrenner's (1979) Bioecological systems theory, parenting, home environment, and family environment, are all interrelated in a nested system. The present study focused on the relationships of these elements in the microsystem with temperament and their moderational role on the heritability of temperament. More specifically, *positive parenting* (a composite of parent reported warmth and behavior management), *physical home environment* (observer report of the living environment and mother report of chaos in the home), and *family environment* (a composite of parent reported family conflict and cohesion), were examined with parent reported child *temperament*.

1. Extraversion/Surgency, a positive dimension of temperament, is significantly correlated with positive parenting behaviors, low chaos, and high family cohesion/low conflict.

2. Temperament is both heritable and influenced by shared and non-shared environments (e.g., Saudino, 2005; Tellegan et al., 1988). Specifically, Effortful Control and Negative Affectivity are hypothesized to be more heritable than Extraversion/Surgency in respect to their biological bases.
3. Given that less positive environments are more deterministic in constricting affordances for free temperament expression, it is hypothesized that Negative Affectivity will become less heritable in increasingly positive environments.
4. On the other hand, more positive environments are more facilitative of naturalistic temperament expression, and it is hypothesized that Effortful Control and Extraversion/Surgency become more heritable in positive environments.

## **Method**

### **Participants**

As part of the longitudinal Wisconsin Twin Project (WTP; Lemery-Chalfant, Goldsmith, Schmidt, Arneson, & Van Hulle, 2006), the sample consisted of 1573 individuals, with 51% boys and 49% girls and a mean age of 7.93 years ( $SD=0.87$  years). Families with twin births were identified using Wisconsin state birth records, and were recruited when the twins were infants from 1989 through 2004. Families were sent a recruitment letter and a response card, on which they were asked to indicate interest in participation.

Approximately 95.8% of the original sample was native to Wisconsin. Ethnicities included Caucasian (88.5%), African American (4.1%), Mixed (5.8%), Native American (0.30%), Hmong (0.10%), and Other Race (1.2%). Additionally, parents' levels of education ranged from no formal education to a graduate degree, with a majority of parents having completed some or all of a college degree (*M* mothers = 14.91 years of schooling; *M* fathers = 14.45 years). Family income ranged from unemployed to \$200,000+ a year with the average family making \$51,000-\$70,000.

### **Procedure**

At age eight, children and families were contacted for a follow up assessment. This follow up consisted of phone interviews, questionnaire packets, and a home visit with observational assessment. Families were first contacted for a phone interview to screen for broad dimensions of child problem behaviors and psychopathology, and children were classified into a control group or a risk group. During these phone interviews the primary caregiver was also administered questionnaires which asked about demographics, the twins' temperament and general development, family stress and relationships, parenting behaviors, and chaos in the home. Home visits were five hours long, and included detailed questionnaires on the home environment as well as observer ratings on the quality of the physical home environment.

### **Measures**

**Temperament: Children's Behavior Questionnaire.** Three higher order components of temperament – Effortful Control, Negative Affectivity, and



Extraversion/Surgency – were assessed using mother and father report on the Children’s Behavior Questionnaire (CBQ; Rothbart, et al., 2001). Previous estimates of internal consistency for the CBQ ranged from .67 to .94, averaging .77 across all 15 scales (Ahadi, Rothbart, & Ye, 2003). The CBQ was selected based on its high validity (Rothbart et al., 2001) and respected, extensive use in the literature.

The CBQ consisted of 180 questions scored on a 7-point Likert scale, ranging from “extremely untrue of your child” to “extremely true of your child” over the past six months. Selected scales included Attention Span, Inhibition, Fear, Anger/Frustration, Sadness, Soothability, Activity Level, Shyness, Impulsivity, Smiling and Laughter, and Approach. Sample questions include “My child is full of energy, even in the evening,” “My child will move from one task to another without completing any of them,” and “My child is afraid of loud noises.”

**Positive parenting.** Positive parenting was measured using two mother and father report scales, the Child Rearing Practices Report-Short Form (CRPR; Block, 1965; Dekovic, Janssens, Gerris, 1991) and the Behavior Management Self-Assessment (BMSA; Adapted from the Parental Practices Scale; Strayhorn and Weidman, 1988). Both measures were chosen for their value in measuring parental attitudes and behaviors in regards to child-rearing practices.

***Child Rearing Practices Report Short Form.*** The Child Rearing Practices Report (CRPR) Short Form taps dimensions of parental warmth and control to gauge parental behavior and style and consisted of 35 questions scored

on a 6-point Likert scale which ranged from “strongly disagree” to “strongly agree.” Subscales included Encouraging independence, Open expression of affect, Encouraging openness of expression, and Rational guiding of child. The mean for each scale was computed and scored such that higher scores were associated with higher levels of each dimension. Sample questions include, “I respect my twins’ feelings and opinions and encourage the twins to express them,” “When I am angry with my twins, I let them know it,” “I encourage my twins to be curious, to explore, and to question things,” and “I try to talk it over and reason with my twins when they misbehave.”

***Behavior Management Self-Assessment.*** The Behavior Management Self-Assessment (BMSA), adapted from the Parental Practices Scale (Strayhorn & Weidmann, 1988), taps parenting behavior. Fifteen item-level questions scored on a 5-point Likert scale were averaged to form an overall mean score for mother-report and father-report. Four items were first reverse scored as directed by the scoring manual. Internal consistency has previously been measured at  $\alpha = .81$  (August, Realmuto, Joyce, & Hektner, 1999). The global mean was computed and scored such that higher scores were associated with greater behavioral management. Sample questions include, “I am not consistent in disciplining my child,” “When my child fails to do what I ask, I end up doing it,” “When I have a problem with my child, I set aside some time so that we can talk about our problems together,” and “I try to let my twins make decisions for themselves.”

**Positive home environment.** The positive home environment was measured on two dimensions: the physical home environment and the family

(emotional) home environment. The former uses an observed report of the physical home and a mother rating on the level of chaos. The latter uses mother and father report on levels of family conflict and cohesion.

**Physical home environment.** The Living Environment Observation Scale (LEOS; Adapted from the Home Observation for Measurement of the Environment; Caldwell & Bradley, 1978) was used to assess the physical home environment. The Confusion, Hubbub, and Order Scale (CHAOS; Matheny et al., 1995) was selected for its ability to measure overall environmental confusion (e.g., traffic, noise, overcrowding) and parental behaviors (Matheny et al., 1995).

***Living Environment Observation Scale.*** Adapted from Caldwell and Bradley's (1978) Home Observation for Measurement of the Environment (HOME), this observer report measure was completed during in-home visits. Parents were asked to rate nine dimensions of the home on a scale of one to three, where 1=no/minimal evidence, 2=moderate evidence, and 3=substantial evidence. The global mean was computed such that higher scores equated a higher quality physical environment. The nine dimensions were: structural safety of the home, home décor, child-friendly home, adequate living space for number of individuals in the home, interpersonal space, overall organization, cleanliness, outside play environment, and condition of street where child lives. A sample item (Overall Organization) includes "This item reflects the overall physical organization of the house: (1) Home is cluttered making it difficult to walk around objects, unable to find a clear space to do assessments activities, (2) Home is generally clean though

floors may need to be vacuumed or washed; noticeable dust on furniture, and (3) Home is clean and appears to have been cleaned recently or on a regular basis.”

***Confusion, Hubbub, and Order Scale.*** The Confusion, Hubbub, and Order Scale (CHAOS), a mother report questionnaire, consisted of 15 true/false statements asking participants to think about how each item described their home. Internal consistency has previously been reported at .79 (Matheny et al., 1995). The global mean was computed such that higher scores equated with higher chaos in the home, as is most commonly done with this measure (e.g., Dumas et al., 2005; Coldwell et al., 2006; Evans et al., 2005). Sample questions include, “It’s a real ‘zoo’ at our home,” “Our home is a good place to relax,” “First thing in the day, we have a regular routine at home,” and “We almost always seem to be rushed.”

**Family environment.** Chosen for their assessment of family emotional availability and family conflict/cohesion, the Family Assessment Device (FAD; Epstein, Baldwin, Bishop, 1983) and the Family Conflict Scale (FCS; Porter & O’Leary, 1980) were used to measure the emotional home environment.

***Family Assessment Device.*** The Family Assessment Device (FAD), a mother report and father report questionnaire, consisted of 60 items scored on a 4-point Likert scale, ranging from “Strongly agree” to “Strongly disagree.” The mother-report and father-report were averaged to form mean scores for each selected scale – Problem Solving, Communication, Affective Responses, Affective Involvement, Behavior Control, General Functioning, and Roles. Internal consistency is commonly above  $\alpha = .70$ , though estimates are

subscale dependent (Alderfer et al., 2007). The mean for each subscale was computed and scored such that lower scores are associated with greater family cohesion. Sample questions include, “In times of crisis we can turn to each other for support” (General functioning), “We talk to people directly rather than through go-betweens” (Communication), and “You only get the interest of others when something is important to them” (Affective involvement, reverse scored).

***Family Conflict Survey.*** The Family Conflict Survey (FCS), a mother reported questionnaire, consisted of 10 items answered independently for each twin and is scored as “Never,” “Rarely,” “Occasionally,” “Often,” or “Very often.” All item-level questions were averaged to form an overall mean score. One item was reverse scored as directed by the FCS scoring manual.

The global mean was computed and scored such that higher scores equated higher family conflict. Sample questions include, “How often has Twin A/B heard you and your spouse argue about the wife’s role in the family?” “How often do you and your spouse display affection for each other in front of Twin A/B” (reverse scored), and “Children often go to one parent for money or permission to do something after having been refused by the other parent. How often would you say Twin A/B approaches you or your spouse in this manner with rewarding results?”

### **Data Reduction and Composite Formation**

**Demographics.** A mean socio-economic status (SES) composite was formed from standardized mother education, father education, and total family

income after correlations among the variables were found to be moderate ( $r_s = .45-.55, p < .0001$ ).

**Temperament.** Higher order composites were created from scale-level data drawn from the mother-report and father-report of the CBQ. Preliminary analyses showed that mother-report and father-report CBQ were moderately correlated across each of the 11 temperament scales ( $r_s = .41-.65, p < .0001$ ). Parent composites were then formed by computing mean variables. Based on Rothbart et al. (2001), scales were further composited into three higher order components – Effortful Control, Negative Affectivity, and Extraversion/Surgency. Effortful control is a mean composite of Inhibitory Control and Attentional Focusing ( $r = .72, p < .0001$ ), Negative Affectivity is a mean composite of Fearful Distress, Anger/Frustration, Sadness, and Lack of Soothability ( $r_s = .24-.59, p < .0001$ ), and Extraversion/Surgency is a mean composite of Activity Level, Lack of Shyness, Impulsivity, Smiling/Laughter, and Approach ( $r_s = .15-.66, p < .0001$ ).

**Parenting.** The mother-report and father-report BMSA were found to be moderately correlated ( $r = .28, p < .0001$ ) and were combined to form a mean composite.

Item-level responses from seven subscales of the CRPR were averaged to form mean scores for each subscale. Separate principal components analysis for the mother-report and father-report at the scale level confirmed two distinct components of the CRPR for both reporters, with Encouraging Independence (component loadings; mother = .70, father = .71), Open Expression of Affect (mother = .70, father = .80) Encouraging Open Expression of Affect (mother =

.68, father = .81) and Rational Guiding (mother = .63, father = .78) making up the Warmth component, and Control by Guilt (mother = .45, father = .43), Control by Anxiety (mother = .39, father = .26), and Authoritarian Control (mother = .27, father = .08) making up the Control component. The Warmth composite was formed by forming a mean of the appropriate scales, separately for mother ( $r_s = .25-.43, p < .0001$ ) and father ( $r_s = .36-.48, p < .0001$ ) reports. To further reduce the data, mother and father Warmth were then mean composited ( $r = .26, p < .0001$ ). Since the analyses are focused on positive aspects of parenting, the Control composite was not used.

An overall parenting mean composite was formed from the BMSA parent-composite and CRPR parent-composite ( $r = .41, p < .001$ ). Though parental warmth and behavior management are each individually important and may tap distinct dimensions of parenting (Grusec & Davidov, 2010), they are combined here for the conceptual significance of positive parenting at a global level. More specifically, the coexistence of warm parenting with effective behavior management are used here as construct of positive parenting.

**Home environment.** Although the LEOS and CHAOS were correlated ( $r = -.22, p < .001$ ), they were analyzed separately because they measure fundamentally different aspects of the home environment. The LEOS is designed to measure the physical home environment in terms of affordances such as cleanliness and availability of toys whereas CHAOS is more a measure of the structure of that environment, such as routine.

**Family environment.** Correlations between mother-report and father-report for each scale were moderate ( $r_s = .27-.44$ ,  $p < .0001$ ) and thus parent composites of each scale were created. Since a principal components analysis showed that all of the scales loaded onto one component and the subscales were inter-correlated ( $r_s = .48-.72$ ,  $p < .0001$ ), a single overall mean composite was created by taking a mean of the parent scales.

An overall family environment mean composite was formed from the FAD parent-composite and FCS mother-composite ( $r = .44$ ,  $p < .001$ ). Higher scores on the composite are associated with a more cohesive family environment.

In summary, three covariates – age, SES, and ethnicity –, three higher order temperament composites – Effortful Control, Negative Affectivity, and Extraversion/Surgency –, and four environmental moderators (three moderators, with one having two components) – parenting, LEOS, CHAOS, and family environment – were created for use in correlational analyses, as well as for biometric ACE model fitting.

## **Results**

### **Overview**

The means, standard deviations, and ranges for all study variables can be found in Table 1 and the internal consistency values at the scale level in Table 2. One variable for the home environment (LEOS) was transformed for negative skewness and kurtosis using an inverse transformation (reflected).

Bivariate correlations between study variables can be found in Table 3 ( $r_s = -.44-.57$ ). These analyses were conducted with one randomly selected twin



from each twin pair and any differences when selecting for the other twin and replicating the analysis are noted. Each of the CBQ components was moderately correlated with each other ( $r_s = -.10-.49, p < .001$ ) except for the relation between Negative Affectivity and Extraversion/Surgency with a low correlation ( $r = .08, p < .01$ ). Each of the environmental measures was also moderately to highly correlated with each other ( $r_s = -.31-.57, p < .001$ ).

Each of the temperament dimensions was also correlated to measures of the environment. Effortful Control and Negative Affectivity were correlated to all four measures (respectively,  $r_s = -.36-.49, p < .001$ ;  $r_s = -.26-.28, p < .001$ ). Extraversion/Surgency was positively and significantly correlated to CHAOS ( $r = .23, p < .001$ ) and was negatively and significantly correlated with LEOS (only when selecting for the other twin;  $r = -.15, p < .001$ ), but was not correlated with any other measures of the environment.

To examine whether children's age and SES influenced these correlations, partial correlations were computed and the results can be found in Table 4 ( $r_s = -.35-.57$ ). To examine whether correlations varied significantly from the zero-order correlations given in Table 2, Fisher's Z tests were run. No correlations were found to have a significant difference. From these analyses, covariates did not change the relation between predictors and outcomes and were thus not included in the twin ACE models, below.

Last, independent sample t-tests were run to examine sex or ethnicity differences in means. In terms of differences by sex (Group 1 = girls, Group 2 = boys), when randomly selecting one twin from each pair, girls were higher on

CBQ-Effortful Control, ( $t(785) = 5.40, p < .01$ ;  $M$  girls = 4.78;  $M$  boys = 4.48) and boys were higher in CBQ-Extraversion/Surgency, ( $t(778) = -6.70, p < .01$ ;  $M$  boys = 4.89;  $M$  girls = 4.65) regardless of which twin was selected. In terms of differences by ethnicity (Group 1 = Caucasian, Group 2 = Not Caucasian), Caucasian twins scored lower on the parenting measure ( $t(680) = -3.37, p < .01$ ;  $M$  Caucasian = -.04,  $M$  Not Caucasian = .30), but higher on the LEOS ( $t(582) = -2.79, p < .01$ ;  $M$  Caucasian = 2.86,  $M$  Not Caucasian = 2.72).

### **Twin Biometric ACE Model Fitting**

To find the best fitting model, I adhered to a set of rules. I started with the full ACE model with no moderation, then fit the nested AE, CE and E only models for each of the three dimensions of temperament. Notice that the latent variable E is always included in the model because it includes measurement error. The full results can be found in Table 5. The best fitting reduced model were chosen in regards to  $\Delta\chi^2$  and  $p$ . Models were examined for whether or not the changes in chi-square values were of significant detriment in fit at one and two degrees of freedom (depending on the model). Models that were significantly detrimental were discarded and remaining models were compared similarly until the most reduced model remained. If models did not show a detriment, the most parsimonious model was always chosen, regardless of whether the probability of its fit was lower than another nested model. With this strategy, the AE model was the best fitting reduced model found for each of the three temperament dimensions. For Effortful Control, Negative Affectivity, and Extraversion/Surgency, estimates for the heritability ( $A; h^2$ ) and nonshared

environment ( $E$ ;  $e^2$ ) were 0.60 and 0.40, 0.80 and 0.20, and 0.59 and 0.41, respectively.

Since the AE model fit best, I then tested an AE model with full moderation against only A moderation, only E moderation, and no moderation nested models. For Effortful Control (Table 6), CHAOS was a significant moderator of the E path. Across levels of CHAOS (Table 7), the estimate of E (the moderated path) changed such that it accounted for minimal variance below 1 *SD* of CHAOS ( $E = 31\%$ ), increased to account for more variance between -1 and 1 *SD* ( $E = 57\%$ ), and dropped again at above 1 *SD* ( $E = 42\%$ ) (Figure 4).

For Negative Affectivity (Table 8), Parenting was a significant moderator of the A path and LEOS on the E path. First, across levels of Parenting (Table 7), the estimate of A (the moderated path) consistently accounted for a majority of the variance ( $A = 70\%$ ,  $83\%$ ,  $77\%$ ) (Figure 5), though the estimates dropped slightly at either extreme of scores on parenting. Second, across increasing levels of LEOS (Figure 6; Table 7), the estimate of E steadily decreased, accounting for the highest variance at half one *SD* below ( $E = 26\%$ ,  $18\%$ ,  $16\%$ ). Note that because of lower variance in the LEOS variable there was no data beyond 1 *SD*. Thus, Figure 6 and Figure 7 were charted at half one *SD* increments.

For Extraversion/Surgency (Table 9), both LEOS and CHAOS were found to moderate environmental contributions to temperament through the E path. First, across increasing levels of LEOS (Table 7), estimates of the E path continuously declined ( $E = 55\%$ ,  $44\%$ ,  $32\%$ ) (Figure 7). Second, across levels of CHAOS, the estimate of E (the moderated path) changed such that it accounted

for less variance at both extremes (below -1 SD, E = 40%; above 1 SD, E = 33%) than at the mean (E = 52%) (Figure 8).

## **Discussion**

As behavior geneticists begin to model protective as well as risk factors, and interactive as well as main effect influences, development is elucidated. The primary goal of this novel study was to examine the potential impacts of positive environments on the heritability of temperament in middle childhood. Results suggest that the quality of the environment may act as a facilitative or determinative influence on the heritability and expression of temperament. Specifically, it was hypothesized that positive aspects of parenting, the physical home environment, and the family environment would indirectly influence temperament – Effortful Control, Negative Affectivity, and Extraversion/Surgency – through moderation of the A, C, and/or E estimates. While the developmental literature has largely focused on negative factors on child outcomes, this study provides support for recent studies on positive influences and growth (e.g., Evans, 2006; Seifer, Sameroff, Baldwin, & Baldwin, 1992; Thomas & Zimmer-Gembeck, 2007) and results encourage the field to investigate the myriad of opportunities that a positive environment can provide.

### **Placing the Findings in the Context of the Literature**

An examination of the zero-order correlations between study variables suggested that the first hypothesis – that Extraversion/Surgency is significantly correlated with positive parenting behaviors, low chaos, and high family cohesion/low conflict – was not supported. Extraversion/Surgency was moderately correlated with chaos in the home, but in the opposite direction than expected, such that higher Extraversion/Surgency was correlated with higher

chaos. These results may be due to the consideration that Extraversion/Surgency is a higher order component of temperament which is in part a composite of Activity Level and Impulsivity, subscales of which have previously been positively correlated with chaos and dysregulation in the home (Dumas et al., 2005; Schaughency & Fagot, 1993). Extraversion/Surgency was not significantly correlated with any of the other aspects of the environment.

Estimates of A, C, and E for the three temperament dimensions suggested that the second hypothesis – that Effortful Control and Negative Affectivity are more heritable than Extraversion/Surgency – was partially supported, such that additive genetics accounted for 20% more variance in Negative Affectivity than for Extraversion/Surgency. With high heritability, Negative Affectivity may be less open to environmental influence, with individual differences largely explained by genetic differences among the children. Heritability estimates for both the individual scale composites and the overall higher order composite of Negative Affectivity has been found to range from 56% to 71% (Mullineaux, et al., 2009) The difference in the A estimates between Effortful Control and Extraversion/Surgency were minimal. Previous literature has shown that in a sample of twins three to eight years of age, the heritability of Effortful Control was 43%-58% and another sample (Mullineaux, et al., 2009) suggested 57% for Extraversion, both estimates similar to what was found in this study. With this moderate heritability, Effortful Control and Extraversion/Surgency may be more open to greater environmental influences and the impacts of a positive, facilitative environment than Negative Affectivity.

The third hypothesis – that Negative Affectivity is less heritable in increasingly positive environments – was not supported. Instead, heritability increased with increasing quality of parenting and the home environment (LEOS). It was originally thought that the growing salience of positive environments would constrain and overreach the affordances for negative affect and encourage instead the free expression of more positive behaviors (in a way, this may light positive environments as having a deterministic property of their own). Nevertheless, the high acceptance of such free expression may also be allowing for the embodiment of negative components of temperament, given the child's biological bases are so inclined, thus showing the increase in heritability for Negative Affectivity as the environment comes to allow for it.

Furthermore, negative, risky environments contribute to individual differences, resulting in lower heritability in stressful environments. In this study, the heritability of Negative Affectivity was found to be lower as a function of lower quality home environments and highest in high quality environments. In the broader literature, Kendler, Thornton & Pedersen (2000) give an example of the increasing heritability of a negative trait when given a more permissive environment do so. More specifically, they highlighted that the heritability of smoking in women has steadily increased as the behavior has become more acceptable in our socio-cultural norms, allowing for increased expression of heritable traits (Lemery-Chalfant, 2009; Rutter, Moffitt, & Caspi, 2006). Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask (2011) found that the heritability of cognitive ability, as measured by the Bayley Short Form (adapted from Bayley

Scales of Infant Development, Second Edition; Bayley, 1993), varied across levels of SES. At 10 months of age, heritability estimates were low for both low and high SES families; however, at two years of age, heritability remained low for low SES families but contributed to approximately 50% of the variance in mental ability for high SES families, suggesting that low SES factors allow for more environmental variance and individual differences in cognitive development as children age.

Last, the fourth hypothesis – that Effortful Control and Extraversion/Surgency are more heritable in positive environments – was supported. Results suggested that though the trends of heritability of both temperament dimensions differed by levels of environment, they nonetheless showed that heritability estimates were higher under more positive environments. It is important to note, however, that high heritability does not necessarily mean that the trait is unchangeable, but that it may be less susceptible to environmental influences. In low levels of chaos, genetic expression of Effortful Control was highest, potentially because it is not impeded by unstable environments, allowing the child to develop more naturally and optimally. At average and high levels of chaos, genetic expression is suppressed such that the environment plays a more important role in determining outcomes on this dimension. These results make sense considering Effortful Control is the ability to regulate (e.g., Eisenberg et al., 2004).

A similar trend was found for Extraversion/Surgency at varying levels of chaos. As previously discussed, this higher order component is comprised of



subscales such as Activity Level and Impulsivity, but also Smiling and Laughter and Lack of Shyness. At high levels of chaos, heritability accounted for the most variance in Extraversion/Surgency. At low levels of chaos, genetic expression, though still accounting for a majority of variance, is lower such that the environment then plays a larger role in regulating affordances for impulsive, active components while allowing more positive emotion components of Extraversion/Surgency. Thus, Extraversion/Surgency as a higher order component may interact with chaos uniquely, in that chaos may moderate the different subscales in different directions. In regards to LEOS, Extraversion/Surgency steadily increased as scores on the LEOS increased, which supports the notion that positive environments are facilitative for the expression of heritable traits.

### **Implications of the Findings**

The results of this study are luminary in that they delineate new, interactive pathways of genetic and environmental influence on temperament. Previous literature has reported that the common environment (C estimate) almost always drops out of the overall ACE model due to low power to detect it as a linear main effect (with the AE model then becoming the best fitting, most parsimonious model) (e.g., Plomin et al., 2001); however, the significance of the AE model becomes limited as all variance in the construct of interest is parsed into either additive genetic effects (A) or nonshared environment effects confounded with measurement error (E). Based on these findings, theorists have concluded that the common environment is not important to child development

(Harris, 1998; Rowe, 1994; Scarr, 1992). Working C back into the AE model through nonlinear pathways allows specific measures of the shared environment to be incorporated into these twin models and influence outcomes without the previously discussed power limitations

To further ensure the statistical soundness of the model and results, tests for homoscedasticity, or the notion of constant variance, were run on the data to ensure there were no violations. While this test was nonsignificant for most of the temperament dimensions on the environmental moderators, the variance on the family environment composite in relation to Extraversion/Surgency varied significantly for both cotwins at  $p < 0.001$ ; however, family environment was not found to be a significant moderator.

Present findings thereby suggest that the common environment does not simply drop out of the statistical model or the conceptual framework. Although the AE model was the best fitting main effects model for the three components of temperament examined, nested moderation models indicated that the common environment plays a significant role in the quantitative models, but through nonlinear pathways as moderators. Previous studies (e.g., Purcell, 2002) have suggested similar mechanisms but no known studies have used this model specifically in examination of temperament. For example, a broader study used adversity in the home (environmental risk) as an environmental moderator of the mediated model of biological risk to adolescent aggressive behavior to poor parenting (Riggins-Casper, Cadoret, Knutson, & Langbehn, 2003).

The fact that the heritability of temperament changes at varying levels of the environmental moderators suggests that the environment may play a large role in providing the affordances for temperament expression. More specifically, the results here support that negative environments are more determinative in that they restrict the venues to temperament expression and thereby suppress the influence of genetic variability. Other broader studies have also supported this, such that lower heritabilities of IQ and physical health have been found in adverse environments (Johnson & Krueger, 2005). Further, in this study, the check for homoscedasticity ensured that gene by environment interactions were not forced as a result of this violation of constant variance. As environments become more positive, they also become more permissive, or facilitative, such that they provide the affordances to “let you be you.” This may play a role in explaining why at-risk children more often show maladaptive outcomes, unless given a pathway for resilience and positive growth (e.g., Head Start Program; Love et al., 2005); however, it could also be the case that negative environments, which can be stressful and chaotic, contribute more to individual differences than supportive environments.

### **Limitations of the Study**

The study faced four main limitations. First, it was limited in its generalizability to other populations since the sample was predominantly composed of middle-class Caucasian families. With the introduction of cultural diversity, researchers may find uniquely different parenting styles, parent-child relationships, home environments, and family environments, such that the impact

on child temperament (e.g., Ahadi et al., 1993) may lead to different heritability estimates than what is found in this study. For example, the HOME, which was adapted for use as the LEOS in this study, has suggested cultural differences influencing children's behavior. Brooks-Gunn, Klebanov, and Duncan (1996) found that the home environment was significantly associated with ethnic differences in children's IQ scores. These associations, along with other child outcomes, such as social competence, are often attributed to affordances in the home environment, such as the availability of learning materials, parental responsiveness, and stimulation, as a function of different cultural values and beliefs (e.g., Bradley, 2005; Bradley & Corwyn, 2002).

A second limitation was a methodological issue underlying the use of parent reports. While there are benefits and limitations to this report, ultimately the key lies in whether it assesses the behavior of interest with optimal validity. Historically, parent report has been used in measurement of children's temperament and facets of the home environment (e.g., Children's Behavior Questionnaire; Rothbart, Ahadi, Hershey, & Fisher, 2001; Confusion, Hubbub, & Order Scale; Matheny, Wachs, Ludwig, & Phillips, 1995), as used in this study. Such measures are inexpensive, easy to administer, and allow the researcher to examine several variables at once (Bates, 1994; Rothbart & Bates, 2006). Parents are more knowledgeable and familiar with their children in multiple contexts and situations than other caregivers, such as teachers or relatives; however, parent-report also carries biases. For example, parents have been found to exaggerate similarities or differences when using questionnaires with twins (Saudino, Werz,

Gagne, & Chawla, 2004). Saudino (2005) has also noted that parent-report of temperament is also genetically influenced, which may confound the responses. Thus, while researchers widely use parent report for its many qualities in assessing temperament and family environments, many suggest that these reports should be used as supplemental to observed reports, or as integrative methods (e.g., Kagan & Fox, 2006; Seifer, Sameroff, Barrett, & Krafchuk, 1994).

Third is the limited ability to account for gene-environment correlations, which occur when environment selection is influenced by individual genetic predispositions (Lemery-Chalfant, 2010). Overall, there exist three types of gene-environment correlations – passive, evocative, and active. In this study, a passive correlation would exist if the parenting effects on child temperament are influenced by heritable parent temperament. An evocative correlation would exist if children’s heritable temperament evokes specific parenting behavior. An active gene-environment correlation would exist if children actively seek environments that are conducive to facilitating their temperament, such as aggressive children spending more time with an antisocial father. South and Krueger (2011) recently simultaneously modeled rGE and GxE with twin data. With twin-specific measures of adult income, they tested moderation of the heritability of internalizing problem behaviors, or “social causation,” while rGE represented psychopathology as being correlated with low income, or “social selection.” Findings suggested that GxE was important, even when accounting for rGE. To examine rGE in the present study, follow-ups should consider using South and Krueger’s (2011) combined model while measuring twin-specific parenting

behaviors; however, this method was not available in the current study since parenting was assessed at the family level.

Last, the fourth limitation is that with temperament it is difficult to determine how much variance is due to genetics or the environment without also considering dominant, or nonadditive genetic effects. Dominance is the interaction of two alleles at the same loci. Practically, dominance may be present when MZ twins are more than twice as similar as DZ twins. This is true here since MZ twins share 100% of their additive genetic effects (A) and all of their dominant and interaction effects (D), but DZ twins share only 25% (50% of dominance x 50% of interactions = 25%), making MZ twins actually four times more similar than DZ twins. Considering temperament is heritable, the A estimate may be exaggerated and detract from the E estimate (considering use of the AE model). This impact on the E estimate may then serve to influence the fit or validity of moderation models.

### **Future Directions**

There are several directions future studies may take to advance these findings. First, since the present study examines moderation using higher order components, future studies should consider investigating moderation at scale levels. In addition, testing mediation models versus the moderation models found here may provide more insight into the pathways in which environmental factors influence child temperament (e.g., Paulussen-Hoogeboom, et al., 2008). Second, a model examining sex differences in heritability may also prove useful (Hur, 2009; Purcell, 2002; Purcell & Sham, 2003). Past research has shown mean level

sex differences on temperament dimensions. In the broader literature, a meta-analysis from Else-Quest, Hyde, Goldsmith, and Van Hulle (2006) found, with a sample ranging in age from 3 months to 13 years, moderate mean level differences on Effortful Control (girls higher than boys) and Surgency (boys higher than girls). Similar results have been previously reported (Kochanska, et al. 2000; Rothbart & Bates, 1998; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). These differences may lead to inflated scores on measures such as parent behavior management (higher scores for boys confounding lower scores for girls) and thus should be examined in the context of a model of sex differences. Additionally, few studies consider sex differences directly in terms of heritability. On a broader level, large differences in heritability between boys and girls have been found for ADHD, such that boys have higher heritability of ADHD than girls (Rhee, Waldman, & Levy, 1999; Martel & Nigg, 2006). Third, the use of longitudinal study designs to examine the heritability of temperament at different ages would be valuable, both in consideration that children are more proactive in choosing their environments as they become older and that temperament is malleable at any age.

Another future direction is applying the knowledge of environmental importance to shaping prevention and intervention programs for at-risk children. More specifically, the results of the present study advocate intervention programs that offer at-risk children a more protective and supportive environments because they restrict negative affordances and enhance positive ones. On a theoretical level, the Integrating Environmental Change Theory (Klitzner, 1998) suggests

that by adjusting the norms, availability, and regulations found in the shared environment, that this also adjusts affordances available for shaping children's behavior. It is thereby suggested that more positive environments facilitate the expression of positive behaviors.

As a mechanism, many programs have begun to incorporate the concept of positive parenting to encourage healthy parent-child interactions. One example is the Triple P-Positive Parenting Program, which was developed as a prevention and intervention for children with behavior, mood, and developmental problems (Sanders, Markie-Dadds, Tully, & Bor, 2000). The program encourages positive parent child relationships by retraining parental attribution of child behaviors, teaching behavior management strategies, and anger management. At one year post-test children showed a clinically reliable decrease in problem behaviors. By introducing these changes in parental behaviors, children have fewer negative affordances (e.g., negative parent attribution to behavior) and more positive affordances (e.g., better management, fewer experiences with easily angered parent).

As another pathway, parent training programs have also begun to focus on the concept of mindfulness, or attention to the present and self-awareness. These studies are important in that they allow researchers to show the broader causal role that parenting may have on temperament. Singh et al. (2010) found that caregivers who received mindfulness training had happier interactions with their children than those who did not receive the training. Second, children of these happy parent-child interactions showed a decrease in non-compliance over the



course of the eight week training session and 16 weeks post-training.

Additionally, mindful parents were more likely to display an authoritative parenting style (Williams & Wahler, 2010).

The results of the present study support the findings of the Triple P-Positive Parenting Program and the work of Singh et al. (2010), and give a basic empirical basis to the Integrating Environmental Change Theory.

Future studies should also consider integrating Belsky's (1997) differential susceptibility hypothesis. Some individuals may be more susceptible to their environment due to their individual genotypes, while others remain resilient to environmental influences. For example, a supportive environment was beneficial to children high in negative affectivity over and above average children such that they showed greater reductions in problem behaviors (Belsky, 1997; Boyce & Ellis, 2005). Since the results of the current study suggest heritability varies with the environment and genetic variance is often greatest at extremes, they mirror the differential susceptibility hypothesis in that extreme environments are where the greatest effects are found. As suggested in this study, the heritability of temperament was seen to shift across ranges of the environment, which suggests differential susceptibility since genetic and environmental variance was seen to change as a function of the quality of the environment. Testing Belsky's hypothesis in future studies would be valuable in order to more closely examine the mechanism with which this interplay between genes and the environment works to influence development.

The consideration of the differential susceptibility hypothesis and the use of measured genes in future studies may also prove to be beneficial for the development of genetically-informed interventions. It is important to examine goodness of fit, or whether or not there are different variants of the environment that may be a better fit for optimizing child outcomes. More specifically, previously discussed measured genes, such as DRD4, have different implications for children with regards to whether they possess the 7-repeat or the 4-repeat allele, such that the former is more susceptible to low quality parenting, manifesting in sensation seeking temperament (Sheese, 2007). Thus, as the field of behavior genetics advances, future studies should begin to focus on how environmentally susceptible and resilient children differ, and elucidate components of goodness of fit for children with various genotypes.

Last, future studies may focus on lower order facets of positive parenting and home environment to elucidate the specificity of the effects. For example, parenting warmth and management may be considered separately (Grusec & Davidov, 2010). The family environment may be studied with more emphasis on parental emotional availability and expressivity (e.g., Cassidy, Parke, Butkovsky, & Braungart, 1992) or parental differential sibling treatment, both of which relate to child well-being and temperament (Brody, Stoneman, & Gauger, 1996; McHale, Crouter, McGuire, & Updegraff, 1995).

### **Final Remarks**

The current findings underscore the importance of the shared environment and are valuable to the field of behavior genetics because they illustrate a

mechanism, that has not been previously reported, by which the shared environment influences temperament in childhood. They also demonstrate the need not only for a revised quantitative genetic model, but also for more research on the possible affordances provided by positive environments for child development. As more becomes known about gene-environment interplay and development, researchers may more accurately form effective parenting and educational programs to encourage positive and optimal growth in the youth population.

## References

- Abbott, A., & Bartlett, D. (2001). Infant motor development and equipment use in the home. *Child, Care, and Development*, 27, 295–306. doi: 10.1046/j.1365-2214.2001.00186.x
- Ahadi, S., Rothbart, M. K., & Ye, R. (2003). Children's temperament in the US and China: Similarities and differences. *European Journal of Personality*, 7, 359-377. doi: 10.1002/per.2410070506
- Akker, A., Dekovic, M., Prinzie, P., and Asscher, J. (2010). Toddlers' temperament profiles: Stability and relations to negative and positive parenting. *Journal of Abnormal Child Psychology*, 38, 485-495. doi: 10.1007/s10802-009-9379-0
- Alderfer, M., Fiese, B., Gold, J., Cutuli, J., Holmbeck, G., Goldbeck, L., et al. (2008). Evidence-based Assessment in Pediatric Psychology: Family Measures. *Journal of Pediatric Psychology*, 33, 1046-1061. doi: 10.1093/jpepsy/jsm083
- August, G., Realmuto, G., Joyce, T., & Hektner, J. (1999). Persistence and desistance of Oppositional Defiant Disorder in a community sample of children with ADHD. *Child and Adolescent Psychiatry*, 38, 1262-1270. doi:10.1097/00004583-199910000-00015
- Bakermans-Kranenburg, M., & IJzendoorn, H. (2006). Gene-environment interaction of the dopamine D4 receptor (DRD4) and observed maternal insensitivity predicting externalizing behavior in preschoolers. *Developmental Psychobiology*, 58, 406-409. doi: 10.1002/dev.20152
- Bates, J. (1994). Parents as scientific observers of their children's development. In S. L. Friedman & H. C. Haywood (Eds.), *Developmental follow-up: Concepts, domains, and methods* (pp.197-216). Chichester, England: Wiley.
- Bates, J., Pettit, G., Dodge, K., & Ridge, B. (1998). Interaction of Temperamental Resistance to Control and Restrictive Parenting in the Development of Externalizing Behavior. *Developmental Psychology*, 34, 982-995. doi: 10.1037/0012-1649.34.5.982
- Baumrind, D. (1967). Child care practices anteceding three patterns of preschool behavior. *Genetic Psychology Monographs*, 75(1), 43-88.
- Baumrind, D. (1991). The influence of parenting style on adolescent competence and substance use. *Journal of Early Adolescence*, 11, 56-95. doi: 10.1177/02724316911111004

- Baumrind, D. (1993). The average respectable environment is not good enough: A response to Scarr. *Child Development*, 64, 1299-1317. doi: 10.1111/j.1467-8624.1993.tb02954.x
- Bayley N. *Bayley Scales of Infant Development*. 2nd ed. San Antonio, TX: Psychological Corporation; 1993
- Belsky, J. (1984). The determinants of parenting: A process model. *Child Development*, 55(1), 83-96.
- Belsky J.(1997).Variation in susceptibility to rearing influence: An evolutionary argument. *Psychological Inquiry*, 8(3), 82–186.
- Belsky., J. (2005). Differential susceptibility to rearing influences: An evolutionary hypothesis and some evidence. In B. Ellis & D. Bjorklund (Eds.), *Origins of the social mind: Evolutionary psychology and child development* (pp. 139-163). New York, NY: Guilford Press.
- Belsky, J. & Jaffee, S. (2006). The Multiple Determinants of Parenting. In D. Cicchetti & D. Cohen (Eds.), *Developmental Psychopathology*, 2nd Ed., Vol. 3: Risk, disorder and adaptation (pp. 38-85). NY: Wiley.
- Belsky, J., Bakermans-Kranenburg, M., & van IJzendoorn, M. (2007). For better and for worse. Differential susceptibility to environmental influences. *Current Directions in Psychological Science*, 16, 300-304. doi: 10.1111/j.1467-8721.2007.00525.x
- Bjorklund, D. F, & Kipp, K. (1996). Parental investment theory and sex differences in the evolution of inhibition mechanisms. *Psychological Bulletin*, 120, 163-188. doi: 10.1037/0033-2909.120.2.163
- Block, H. J. (1965). *The child rearing practices report* (Tech. Rep.). Berkeley: Institute of Human Development, University of California.
- Biringen, Z., et al., (2000) The Emotional Availability Scales, 3rd edition, *Attachment and Human Development*, 2, 256-270.
- Booth-LaForce, C., & Oxford, M. (2008). Trajectories of Social withdrawal from grades 1 to 6: Prediction from early parenting, attachment, and temperament. *Developmental Psychology*, 44, 1298-1313. doi: 10.1037/a0012954
- Bor, W., Sanders, M. R., & Markie-Dadds, C. (2002). The effects of the Triple P—Positive Parenting Program on preschool children with co-occurring disruptive behavior and attentional/hyperactive difficulties. *Journal of Abnormal Child Psychology*, 30, 571-587. doi: 10.1023/A:1020807613155

- Bornstein, M. H. (2008) Positive Parenting and Positive Characteristics and Values in Children, in *What Can Parents Do?: New Insights into the Role of Parents in Adolescent Problem Behavior* (eds M. Kerr, H. Stattin and R. C. M. E. Engels), John Wiley & Sons, Ltd, Chichester, UK.
- Bornstein, M. H., Suwalsky, J., Putnick, D., Gini, M., Venuti, P., de Falco, S., et al. (2010). Developmental continuity and stability of emotional availability in the family: Two ages and two genders in child-mother dyads from two regions in three countries. *International Journal of Behavioral Development*, *34*, 385-397. doi: 10.1177/0165025409339080
- Bowlby, J. (1969). *Attachment and loss: Attachment* (Vol. 1). New York: Basic
- Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development & Psychopathology*, *17*, 271–301. doi: 10.1017/S0954579405050145
- Bradley, R.H. (1993). Children's home environments, health, behavior and intervention efforts: A review using the HOME Inventory as a marker measure. *Genetic, Social, & General Psychology Monographs*, *119*, 439-490.
- Bradley, R.H., & Corwyn, R.F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*, 371-399. doi: 10.1146/annurev.psych.53.100901.135233
- Bradley, R.H. (2006). Home environment. In N. Watt, C. Ayoub, R.H. Bradley, J. Puma & W. LaBoeuf (Eds.), *The Crisis in Youth Mental Health, vol. 4: Early intervention programs and policies* (pp. 89-120). Westport, CN: Greenwood Publishing Group.
- Bradley, R. H. & Corwyn, R. F. (2008). Infant temperament, parenting, and externalizing behavior in the first grade: A test of the differential susceptibility hypothesis. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *49*, 124-131. doi: 10.1111/j.1469-7610.2007.01829.x
- Brody, G., Stoneman, Z., & Gauger, K. (1996). Parent-child relationships, family problem-solving behavior, and sibling relationship quality: The moderating role of sibling temperaments. *Child Development*, *67*, 1289-1300. doi: 10.1111/j.1467-8624.1996.tb01796.x
- Bronfenbrenner, U. (1979). *Ecology of human development*. Cambridge, MA: Harvard University Press.

- Bronfenbrenner, U. (1999). Environments in developmental perspective: Theoretical and operational models. In S. L. Friedman & T. D. Wachs (Eds.), *Measuring environment across the life span: Emerging methods and concepts* (pp. 3-28). Washington, D.C.: American Psychological Association.
- Brooks-Gunn, J., Klebanov, P. K., & Duncan, G.J. (1996). Ethnic differences in children's intelligence test scores: Role of economic deprivation, home environment, and maternal characteristics. *Child Development, 67*, 396-408. doi: 10.1111/j.1467-8624.1996.tb01741.x
- Bugental, D. B., & Cortez, V. L. (1988). Perceived control over caregiving outcomes: Implications for child abuse. *Developmental Psychology, 25*, 532-539. doi: 10.1037/0012-1649.25.4.532
- Caldwell, B. M., & Bradley, R. H. (1984). *Home observation for measurement of the environment*. Little Rock: University of Arkansas Press.
- Cassidy, J., Parke, R. D., Butkovsky, L., & Braungart, J. M. (1992). Family-peer connections: The roles of emotional expressiveness within the family and children's understanding of emotions. *Child Development, 63*, 603-618. doi: 10.1111/j.1467-8624.1992.tb01649.x
- Caspi, A., Henry, B., McGee, R., Moffitt, T. E., & Silva, P. A. (1995). Temperamental origins of child and adolescent behavior problems: From age three to age fifteen. *Child Development, 66*, 55-68. doi: 10.1111/j.1467-8624.1995.tb00855.x
- Caspi, A., McClay, J., Moffitt, T., Mill, J., Martin, J., Craig, I...Poutlon, R. (2002). Role of genotype in the cycle of violence in maltreated children. *Science, 297*, 851-854. doi; 10.1126/science.1072290
- Caspi, A., Moffitt, T., Morgan, J., Rutter, M., Taylor, A., Arseneault, L., Tully, L., Jacobs, C., & Kim-Cohen, J., Polo-Tomas, M. (2004). Maternal expressed emotion predicts children's antisocial behavior problems: using monozygotic-twin differences to identify environmental effects on behavioral development. *Developmental Psychology, 40*(2), 149-161.
- Caspi, A., & Roberts, B. W.(2005). Personality development: Stability and change. *Annual Review of Psychology, 56*, 453-484. doi: 10.1146/annurev.psych.55.090902.141913
- Chiodo, L.M., Jacobson, S.W, Jacobson, J.L. (2004). Neurodevelopmental effects of postnatal lead exposure at very low levels. *Neurotoxicology and Teratology, 26*, 359-371. doi:10.1016/j.ntt.2004.01.010

- Chronis, A., Lahey, N., Pelham, W., Williams, S., Baumann, B., Kipp, H., Jones, H., & Rathouz, P. (2007). Maternal depression and early positive parenting predict future conduct problems in young children with attention-deficit/hyperactivity disorder. *Developmental Psychology, 43*, 70–82. doi:10.1037/0012-1649.43.1.70
- Cipriano, E., & Stifter, C. (2010). Predicting preschool effortful control from toddler temperament and parenting behavior. *Journal of Applied Developmental Psychology, 31*, 221-230. doi:10.1016/j.appdev.2010.02.004
- Coldwell, J., Pike, A., & Dunn, J. (2006). Household chaos-links with parenting and child behavior. *Journal of Child Psychology and Psychiatry, 47*(11), 1116-1122. doi: 10.1111/j.1469-7610.2006.01655.x
- Collins, W., Maccoby, E., Steinberg, L., Hetherington, E., & Bornstein, M. (2000). Contemporary research on parenting. The case for nature and nurture. *American Psychologist, 55*(2), 218-232.
- Corapci, F., & Wachs, T. D. (2002). Does parental mood or efficacy mediate the influence of environmental chaos upon parenting behavior? *Merrill-Palmer Quarterly, 48*, 182–201. doi: 10.1037/0003-066X.55.2.218
- Crawford, N., Schrock, M., & Woodruff-Borden, J. (2010). Child Internalizing Symptoms: Contributions of Child Temperament, Maternal Negative Affect, and Family Functioning. *Child Psychiatry & Human Development, 42*, 53-64. doi: 10.1007/s10578-010-0202-5
- Crockenberg, S. (1981). Infant irritability, mother responsiveness, and social support influences on the security of infant-mother attachment. *Child Development, 52*(3), 857-869.
- Davidov, M., & Grusec, J. (2006). Untangling the Links of Parental Responsiveness to Distress and Warmth to Child Outcomes. *Child Development, 77*, 44-58. doi: 10.1111/j.1467-8624.2006.00855.x
- Davies, P., & Cummings, E. (1994). Marital Conflict and Child Adjustment: An Emotional Security Hypothesis. *Psychological Bulletin, 116*, 387-411. doi: 10.1037/0033-2909.116.3.387
- Davis-Kean, P. E. (2005). The Influence of Parent Education and Family Income on Child Achievement: The Indirect Role of Parental Expectations and the Home Environment. *Journal of Family Psychology, 19*, 294-304. doi:10.1037/0893-3200.19.2.294



- Deater-Deckard, K., & Petrill, S. (2004). Parent-child dyadic mutuality and child behavior problems: an investigation of gene-environment processes. *Journal of Child Psychology and Psychiatry*, *45*, 1171-1179. doi: 10.1111/j.1469-7610.2004.00309.x
- Dekovic, M., Janssens, J.M., & Gerris, J.R.M. (1991). Factor structure and construct validity of the Block Child Rearing Practices Report (CRPR). *Psychological Assessment*, *3*(2), 182–187.
- Derryberry, D., & Reed, M. (1994). Temperament and attention: Orienting toward and away from positive and negative signals. *Journal of Personality and Social Psychology*, *66*(6), 1128-1139.
- Dishion, T., Shaw, D., Connell, A., Gardner, F., Weaver, C., & Wilson, M. (2008). The family check-up with high-risk indigent families: Outcomes of positive parenting and problem behavior from ages 2 through 4 years. *Child Development*, *79*(5), 1395-1414.
- Dumas, J., Nissley, J., Nordstrom, A., Smith, E., Prinz, R., & Levine, D. (2005). Home Chaos: Sociodemographic, Parenting, Interactional, and Child Correlates. *Journal of Clinical Child and Adolescent Psychology*, *34*, 93-104. doi: 10.1207/s15374424jccp3401\_9
- Durbin, C. E., Hayden, E. P., Klein, D. N., & Olino, T. M. (2007). Stability of laboratory-assessed temperamental emotionality traits from ages 3 to 7. *Emotion*, *7*, 388-399. doi: 10.1037/1528-3542.7.2.388
- Early, D., Rimm-Kaufmann, S., Cox, M., Saluja, G., Pianta, R., Bradley, R., et al. (2002). Maternal sensitivity and child wariness in the transition to kindergarten. *Parenting: Science and Practice*, *2*, 355–377. doi: 10.1207/S15327922PAR0204\_02
- Eisenberg, N., Cumberland, A., & Spinrad, T. (1998). Parental socialization of emotion. *Psychological Inquiry*, *9*, 241-273. doi:10.1207/s15327965pli0904\_1
- Eisenberg, N., Cumberland, A., Spinrad, T.L., Fabes, R.A., Shepard, S.A., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development*, *72*, 1112–1134.
- Eisenberg, N., Spinrad, T., Fabes, R., Reiser, M., Cumberland, A., Shepard, S., Valiente, C., et al. (2004). The Relations of Effortful Control and Impulsivity to Children's Resiliency and Adjustment. *Child Development*, *75*, 25-46. doi: 10.1111/1467-8624.00337

- Eisenberg, N., Zhou Q., Spinrad, T., Valiente, C., Fabes, R., & Liew, J. (2005). Relations among positive parenting, children's effortful control, and externalizing problems: A three-wave longitudinal study. *Child Development, 76*, 1055-1071. doi: 0.1111/j.1467-8624.2005.00897.x
- Ellis, B. J., & Boyce, W. T. (2008). Biological sensitivity to context. *Current Directions in Psychological Science, 17*, 183-187. doi: 10.1111/j.1467-8721.2008.00571.x
- Ellis, B.J., & Boyce, W.T. (2011). Differential susceptibility to the environment: Toward an understanding of sensitivity to developmental experiences and context. *Development and Psychopathology, 23*, 1-5. doi: 10.1017/S095457941000060X
- Else-Quest, N. M., Hyde, J. S., Goldsmith, H. H., & Van Hulle, C. (2006). Gender differences in temperament: A meta-analysis. *Psychological Bulletin, 132*, 33-72. doi: 10.1037/0033-2909.132.1.33
- Epstein, N., Baldwin, L., Bishop, D. (1983). The McMaster Family Assessment Device. *Journal of Marital & Family Therapy, 9*, 171-180. doi: 10.1111/j.1752-0606.1983.tb01497.x
- Evans, G., Wells, N., & Moch, A. (2003). Housing and mental health: A review of the evidence and a methodological and conceptual critique. *Journal of Social Issues, 59*, 475-500. doi: 10.1111/1540-4560.00074
- Evans, G., Gonnella, C., Marcynyszyn, L., Gentile, L., & Salpekar, N. (2005). The role of chaos in poverty and children's socioemotional adjustment. *Psychological Science, 16*, 560-565. doi: 10.1111/j.0956-7976.2005.01575.x
- Evans, G. (2006). Child development and the physical environment. *Annual Review of Psychology, 57*, 423-451. doi: 10.1146/annurev.psych.57.102904.190057
- Fjortoft, I. (2001). The Natural Environment as a Playground for Children: The Impact of Outdoor Play Activities in Pre-Primary School Children. *Early Childhood Education Journal, 29*, 111-117. doi:10.1023/A:1012576913074
- Fox, N., Nichols, K., Henderson, H., Rubin, K., Schmidt, L., Hamer, D., et al. (2005). Evidence for a Gene-Environment Interaction in Predicting Behavioral Inhibition in Middle Childhood. *Psychological Science, 16*, 921-926. doi: 10.1111/j.1467-9280.2005.01637.x

- Gabbard, C., Caçola, P., & Rodrigues, L. P. (2008). A new inventory for assessing Affordances in the Home environment for Motor Development (AHEMD-SR). *Early Childhood Education Journal*, 36, 5-9. doi: 10.1007/s10643-008-0235-6
- Gagne, J. R., Van Hulle, C. A., Aksan, N., Essex, M. J., & Goldsmith, H. H. (2010). Deriving childhood temperament measures from emotion-eliciting behavioral episodes: Scale construction and initial validation. Invited revision under review, *Psychological Assessment*.
- Garner, P., & Power, T. (1996). Preschoolers' emotional control in the disappointment paradigm and its relation to temperament, emotional knowledge, and family expressiveness. *Child Development*, 67, 1406-1419. doi: 10.1111/j.1467-8624.1996.tb01804.x
- Gartstein, M. A. & Rothbart, M. K. (2003). Studying infant temperament via the revised infant behavior questionnaire. *Infant Behavior and Development*, 26, 64-86. doi:10.1016/S0163-6383(02)00169-8
- Goldsmith, H., & Rothbart, K. (1991). *Contemporary Instruments for Assessing Early Temperament by Questionnaire and in the Laboratory*. In A. Angleitner & J. Strelau (Eds.) Explorations in temperament: International perspectives on theory and measurement. New York: Plenum.
- Goldsmith, H. H., Buss, K. A., & Lemery, K. S. (1997). Toddler and childhood temperament: Expanded content, stronger genetic evidence, new evidence for the importance of environment. *Developmental Psychology*, 33(6), 91-905.
- Goldsmith, H. H., Buss, A. H., Plomin, R., Rothbart, M. K., Thomas, A., Chess, S., et al. (1987). Roundtable: What is temperament? Four approaches. *Child Development*, 58(2), 505-529.
- Gondoli, D. M., & Silverberg, S. B. (1997). Maternal emotional distress and diminished responsiveness: The mediating role of parenting efficacy and parental perspective-taking. *Developmental Psychology*, 33, 861-868. doi: 10.1037/0012-1649.33.5.861
- Goodnight, J., Bates, J., Staples, A., Pettit, G., & Dodge, K. (2007). Temperamental resistance to control increases the association between sleep problems and externalizing behavior development. *Journal of Family Psychology*, 21, 39-48. doi:10.1037/0893-3200.21.1.39
- Grusec, J. & Davidov, M. (2010). Integrating different perspectives on socialization theory and research: A domain-specific approach. *Child Development*, 81, 687-709. doi: 10.1111/j.1467-8624.2010.01426.x

- Harlow, H. (1958). The Nature of Love. *American Psychology*, *13*, 673-685.
- Harris, J. R. (1998). *The nurture assumption*. New York: Free Press.
- Hur, Yoon-Mi. (2009). Genetic and environmental contributions to childhood temperament in South Korean Twins. *Twin Research and Human Genetics*, *12*(6), 549-554. doi: 10.1375/twin.12.6.549
- Ivorra, J., Sanjuan, J., Jover, M., Carot, J., Frutos, R., & Molto, D. (2010). Gene-Environment Interaction of Child Temperament. *Journal of Developmental & Behavioral Pediatrics*, *31*, 545-554. doi: 10.1097/DBP.0b013e3181ee4072
- Janson, H., & Mathiesen, K. S. (2008). Temperament profiles from infancy to middle childhood: development and associations with behavior problems. *Developmental Psychology*, *44*, 1314–1328. doi: 10.1037/a0012713
- Johnson, W. (2007). Genetic and environmental influences on behavior: Capturing all the interplay. *Psychological Review*, *114*, 423-440. doi: 10.1037/0033-295X.114.2.423
- Kagan, J., & Fox, N. (2006). Biology, Culture, and Temperamental Biases. In Damon, W. & Lerner, R. (Eds.), *Handbook of Child Psychology (Vol. 3)* (pp.167-225).
- Katz, L., & Gottman, J. (1993). Patterns of Marital Conflict Predict Children's Internalizing and Externalizing Behaviors. *Developmental Psychology*, *29*, 940-950. doi: 10.1037/0012-1649.29.6.940
- Kaufmann, D., Gesten, E., Santa Lucia, R., Salcedo, O., Redina-Gobioff, G., & Gadd, R. (2000). The relationship between parenting style and children's adjustment: The parent's perspective. *Journal of Child and Family Studies*, *9*, 231-245. doi: 10.1023/A:1009475122883
- Kendler, K. S., Neale, M. C., Prescott, C. A., Kessler, R. C., Heath, A. C., Corey, L. A., & Eaves, L. J. (1996). Childhood parental loss and alcoholism in women: A causal analysis using a twin-family design. *Psychological Medicine*, *26*, 79-95. doi: 10.1017/S0033291700033730
- Kim-Cohen, J., Moffitt, T., Caspi, A., & Taylor, A. (2004). Genetic and environmental processes in young children's resilience and vulnerability to socioeconomic deprivation. *Child Development*, *75*(3), 651-668. doi: 10.1111/j.1467-8624.2004.00699.x
- Klitzner, M. (1998). Integrating environmental change theory into prevention practice. Paper presented at Northeast CAPT Regional Summit: Environmental Strategies to Reduce Youth Substance Abuse. December 2-3, in Providence, RI.

- Knutson, J. F., DeGarmo, D. S., & Reid, J. B. (2004). Social disadvantage and neglectful parenting as precursors to the development of antisocial and aggressive child behavior: Testing a theoretical model. *Aggressive Behavior, 30*, 187-205. doi: 10.1002/ab.20016
- Kochanska, G. (1993). Toward a synthesis of parental socialization and child temperament in early development of conscience. *Child Development, 64*, 325-347. doi: 10.1111/j.1467-8624.1993.tb02913.x
- Kochanska, G., Murray, K.T., & Harlan, E. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36*, 220-232. doi: 10.1037/0012-1649.36.2.220
- Kochanska, G., Aksan, N., & Carlson, J. J. (2005). Temperament, relationships, and young children's receptive cooperation with their parents. *Developmental Psychology, 41*, 648-660. doi:10.1037/0012-1649.41.4.648
- Kogan, N., & Carter, A. (1996). Mother-infant reengagement following the still-face: The role of maternal emotional availability and infant affect regulation. *Infant Behavior and Development, 19*, 359-370. doi:10.1016/S0163-6383(96)90034-X
- Komsi, N., Raikkonen, K., Heinonen, K., Pesonen, A-K., Keskivaara, P., Jarvenpaa, A-L., et al. (2008). Transactional Development of Parent Personality and Child Temperament. *European Journal of Personality, 22*, 553-573. doi: 10.1002/per.690
- Knafo, A., Israel, S., & Ebstein, R. P. (2011). Heritability of children's prosocial behavior and differential susceptibility to parenting by variation in the dopamine receptor D4 gene. *Development and Psychopathology, 23*, 53-67. doi: 10.1017/S0954579410000647
- Kyttä, M. (2004). The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments, *Journal of Environmental Psychology, 24*, 179-198. doi:10.1016/S0272-4944(03)00073-2
- Lamborn, S., Mounts, N., Steinberg, L., & Dornbusch, S. (1991). Patterns of competence and adjustment among adolescents from authoritative, authoritarian, indulgent, and neglectful families. *Child Development, 62*(5), 1049-1065. doi: 10.1111/j.1467-8624.1991.tb01588.x

- Laucht, M., Esser, G., & Schmidt, M. (2001). Differential development of infants at risk for psychopathology: the moderating role of early maternal responsivity. *Developmental Medicine & Child Neurology*, *43*, 292-300. doi: 10.1017/S0012162201000561
- Lemery-Chalfant, K. (2010). How genes and environments work together to promote resilience. In J. Reich, A. J. Zautra, & J. S. Hall (Eds.), *Handbook of adult resilience*. Guilford.
- Lemery, K., Goldsmith, H., Klinnert, M., Mrazek, D. (1999). Developmental models of infant and childhood temperament. *Developmental Psychology*, *35*(1), 189-204.
- Lengua, L. J., & Kovacs, E. A. (2005). Bidirectional Associations between Temperament and Parenting, and the Prediction of Adjustment Problems in Middle Childhood. *Journal of Applied Developmental Psychology*, *26*, 21-38. doi: 10.1016/j.appdev.2004.10.001
- Lemery-Chalfant, K., Goldsmith, H. H., Schmidt, N. L., Arneson, C. L., & Van Hulle, C. A. (2006). Wisconsin Twin Project: Current directions and findings. *Twin Research and Human Genetics*, *9*, 1030-1037.
- Leventhal, T. & Brooks-Gunn, J. (2000). The neighborhoods they live in: The effects of neighborhood residence on child and adolescent outcomes. *Psychological Bulletin*, *126*(2), 309-337.
- Liddell, C. And P. Kruger. (1989). Activity and social behaviour in a crowded South African township nursery—a follow-up study on the effects of crowding at home. *Merrill-Parmer Quarterly-Journal of Developmental Psychology*, *35*, 209-226.
- Little, C., & Carter, A. (2005). Negative emotional reactivity and regulation in 12-month-olds following emotional challenge: Contributions of maternal-infant emotional availability in a low-income sample. *Infant Mental Health Journal*, *26*, 354-368. doi: 10.1002/imhj.20055
- Love, J. M, Kisker, E. E, Ross, C.M., Schochet, P.Z., Brooks-Gunn, J., Paulsell, D, et al. (2002). Final Technical Report. I. Princeton, NJ: Mathematica Policy Research, Inc; 2002. Making a difference in the lives of infants and toddlers and their families: The impacts of Early Head Start. U.S. Department of Health and Human Services Administration for Children and Families.

- Maccoby, E. E., & Martin, J. A. (1983). Socialization in the context of 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* (pp. 1-101). New York: Wiley.
- Martel, M. & Nigg, J. (2006). Child ADHD and personality/temperament traits of reactive and effortful control, resiliency, and emotionality. *Journal of Child Psychology and Psychiatry*, 47, 1175-1183. doi: 10.1111/j.1469-7610.2006.01629.x
- Maslow, H. (1943). A Theory of Human Motivation, *Psychological Review* 50(4), 370-396.
- Matheny Jr, A. P. (1983). A longitudinal twin study of stability of components from Bayley's Infant Behavior Record. *Child Development*, 54, 356-360.
- Matheny Jr, A. P. (1989). Children's behavioral inhibition over age and across situations: Genetic similarity for a trait during change. *Journal of Personality* 57, 215-235.
- Matheny, A., Wilson, R., & Thoben, A. (1987). Home and Mother: Relations with Infant Temperament. *American Psychological Association, Inc.*, 23(3), 23-331.
- Matheny Jr, A. P., Wachs, T. D., Ludwig, J. L., & Phillips, K. (1995). Bringing order out of chaos: Psychometric characteristics of the Confusion, Hubbub, and Order Scale. *Journal of Applied Developmental Psychology*, 16, 429-444. doi: doi:10.1016/0193-3973(95)90028-4
- Matheny, A. P., Jr, Phillips, K. (2001). Temperament and context: Correlates of home environment with temperament continuity and change, newborn to 30 months. In: Wachs TD, Kohnstamm GA, editors. *Temperament in context*. Mahwah, NJ: Erlbaum; pp. 81-101.
- McCall, R. (1991). So many interactions, so little evidence: Why? In T. Wachs & R. Plomin (Eds.), *Conceptualization and measurement of organism environment interaction* (pp. 142-161). Washington, DC: American Psychological Association.
- McHale, S., Crouter, A., McGuire, S., & Updegraff, K. (1995). Congruence between mothers' and fathers' differential treatment of siblings; Links with family relations and children's well-being. *Child Development*, 66, 116-128. doi: 10.1111/j.1467-8624.1995.tb00859.x

- Moilanen, K., Shaw, D., Dishion, T., Gardner, F., & Wilson, M. (2010). Predictors of Longitudinal Growth in Inhibitory Control in Early Childhood. *Social Development, 19*, 326-347. doi: 10.1111/j.1467-9507.2009.00536.x
- Morris, A., Silk, J., Steinberg, L., Sessa, F., Avenevoli, S., Essex, M. (2002). Temperamental vulnerability and negative parenting as interacting predictors of child adjustment. *Journal of Marriage and Family, 64*, 461-471. doi: 10.1111/j.1741-3737.2002.00461.x
- Morris, A., Silk, J., Steinberg, L., Myers, S., & Robinson, L. (2007). The role of family context in the development of emotion regulation. *Social Development, 16*, 361-388. doi: 10.1111/j.1467-9507.2007.00389.x
- Mullineaux, P., Deater-Deckard, K., Petrill, S., Thompson, L., & DeThorne, L. (2009). Temperament in middle childhood: A behavioral genetic analysis of fathers' and mothers' reports. *Journal of Research in Personality, 43*, 737-746. doi:10.1016/j.jrp.2009.04.008
- Murray R. (1974). The influence of crowding on children's behavior. In Canter, D. & Lee, T. (Eds.), *Psychology and the Built Environment* (pp.112–117). London: Wiley
- Neale, M.C., & Cardon L. R. (1992). *Methodology for genetic studies of twins and families*. Dordrecht, the Netherlands: Kluwer Academic.
- Neitzal, C., & Stright, A. (2004). Parenting behaviors during child problem solving: The roles of child temperament, mother education and personality, and the problem-solving context. *International Journal of Behavioral Development, 28*(2), 166-179. doi: 10.1080/01650250344000370
- Novak, G., & Pelaez, M. (2003). *Child and adolescent development: A behavioral systems approach*. Thousand Oaks, CA: Sage.
- O'Connor, T. G., Deater-Deckard, K., Fulker, D., Rutter, M. L., & Plomin, R. (1998). Genotype-environment correlations in late childhood and early adolescence: Antisocial behavioral problems and coercive parenting. *Developmental Psychology, 34*, 970-981. doi: 10.1037/0012-1649.34.5.970
- Olson, S., Sameroff, A., Kerr, D., Lopez, N., & Wellman, H. (2005). Developmental foundations of externalizing problems in young children: The role of effortful control. *Development and Psychopathology, 17*, 25-45. doi: 10.1017/S0954579405050029



- Patrick, C., Curtin, J., & Tellegen, A. (2002). Development and Validation of a Brief Form of the Multidimensional Personality Questionnaire. *Psychological Assessment, 14*, 150-163. doi: 10.1037/1040-3590.14.2.150
- Pachter, L.M., Auinger, P., Palmer, R. & Weitzman, M. (2006). Do parenting and the home environment, maternal depression, neighborhood, and chronic poverty affect child behavioral problems differently in different racial-ethnic groups? *Pediatrics, 117*, 1329-1338. doi: 10.1542/peds.2005-1784
- Paulussen-Hoogeboom, M. C., Stams, G. J. J. M., Hermanns, J. M. A., & Peetsma, T. T. D. (2007). Child negative emotionality and parenting from infancy to preschool: A meta-analytic review. *Developmental Psychology, 43*, 438-453. doi:10.1037/0012-1649.43.2.438
- Pedlow, R., Sanson, A., Prior, M., & Oberklaid, F. (1993). Stability of maternally reported temperament from infancy to 8 years. *Developmental Psychology, 29*(6), 998-1007.
- Pettit, G., Bates, J., & Dodge, K. (1997). Supportive parenting, ecological context, and children's adjustment: A seven-year longitudinal study. *Child Development, 68*, 908-923. doi: 10.1111/j.1467-8624.1997.tb01970.x
- Plomin, R., & Rutter, M. (1998). Child development, molecular genetics, and what to do with genes once they are found. *Child Development, 69*, 1223-1242. doi: 10.1111/j.1467-8624.1998.tb06169.x
- Plomin, R., DeFries, J.C., McClearn, G.E., & McGuffin, P. (2001). Behavioral genetics. New York: Worth.
- Porter, B., & O'Leary, K. D. (1980). Marital discord and childhood behavior problems. *Journal of Abnormal Psychology, 9*, 191-202. doi: 10.1007/BF00916376
- Prevatt, F. (2003). The contribution of parenting practices in a risk and resiliency model of children's adjustment. *British Journal of Developmental Psychology, 21*, 469-480. doi: 10.1348/026151003322535174
- Purcell, S. (2002). Variance Components Models for Gene-Environment Interaction in Twin Analysis. *Twin Research, 5*, 554-571. doi: 10.1375/136905202762342026
- Purcell S, Sham PC (2003), A model-fitting implementation of the DeFries-Fulker model for selected twin data. *Behavior Genetics, 33*, 271-278. doi: 10.1023/A:1023494408079

- Putnam, S. P., Sanson, A., & Rothbart, M. K. (2002). Child temperament and parenting. In M. Bornstein (Ed.), *Handbook of parenting* (2nd ed.) (pp 255–277). Mahwah, NJ: Erlbaum.
- Rhee, S. H., Waldman, D., Hay, D., Levy, F. (1999). Sex differences in genetic and environmental influences on DSM-III-R attention deficit/hyperactivity disorder. *Journal of Abnormal Psychology, 108*, 24-41. doi: 10.1037/0021-843X.108.1.24
- Rende, R., & Plomin, R. (1993). Families at risk for psychopathology: Who becomes affected and why? *Development and Psychopathology, 5*, 529-540. doi: 10.1017/S0954579400006143
- Reyno, S.M., & McGrath, P.J. (2006). Predictors of parent training efficacy for child externalizing behavior problem-a meta-analytic review. *Journal of Child Psychology and Psychiatry, 47*, 99–111. doi: 10.1111/j.1469-7610.2005.01544.x
- Riggins-Caspers, K., Cadoret, R., Knutson, J., & Langbehn, D. (2003). Biology-environment interaction and evocative biology-environment correlation: Contributions of harsh discipline and parental psychopathology to problem adolescent behaviors. *Behavior Genetics, 33*, 205-220. doi: 10.1023/A:1023434206261
- Rohner, R., Khaleque, A., & Cournoyer, D. (2005). Parental acceptance-rejection: Theory, methods, cross-cultural evidence, and implications. *Ethos, 33*, 299-334. doi: 10.1525/eth.2005.33.3.299
- Rothbart, M. K.(1986). Longitudinal observation of infant temperament. *Developmental Psychology, 22*(3), 356-365. doi:10.1037/00121649.22.3.356
- Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional and personality development* (5th ed., pp. 105-176). New York: Wiley. Temperament-Part 1 (pgs. 105-139) & Temperament-Part 2 (pgs. 140-176).
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at 3-7 years: The Children's Behavior Questionnaire. *Child Development, 72*, 1394-1408. doi: 10.1111/1467-8624.00355
- Rothbart, M. K., & Bates, J. E. (2006). Temperament. In N. Eisenberg (Ed.) & W. Damon (Series Ed.), *Handbook of child psychology (6th ed.: Vol 3; pp.99-166)*. Hoboken, NJ: John Wiley & Sons, Inc.

- Rowe, D. (1994). *The limits of family influence. Genes, experience, and behavior.* New York: Guilford Press.
- Rudy, D., & Grusec, J. (2006). Authoritarian parenting in individualist and collectivist groups: Associations with maternal emotion and cognition and child self-esteem. *Journal of Family Psychology, 20*, 68-78. doi: doi:10.1037/0893-3200.20.1.68
- Rutter, M. (2002). The interplay of nature, nurture, and developmental influences: the challenge ahead for mental health. *Archives of General Psychiatry, 59*, 996-1000. doi: 10.1001/archpsyc.59.11.996
- Rutter, M., Moffitt, T. E. & Caspi, A. (2006). Gene–environment interplay and psychopathology: Multiple varieties but real effects. *Journal of Child Psychology and Psychiatry, 47*, 226–261. doi: 10.1111/j.1469-7610.2005.01557.x
- Sanders, M.R., & Cann, W. ( 2002). Promoting positive parenting as an abuse prevention strategy. In K. Browne, H. Hanks, P. Stratton & C. Hamilton (Eds.), *Early prediction and prevention of child abuse: A handbook.* Chichester : J. Wiley & Sons.
- Sanson, A., Hemphill, S., & Smart, D. (2004). Connections between Temperament and Social Development: A Review. *Social Development, 13*, 142–170. doi: 10.1046/j.1467-9507.2004.00261.x
- Saudino, K. (1991). Infant temperament and genetics: An objective twin study of motor activity level. *Child Development, 62*, 1167-1174. doi: 10.1111/j.1467-8624.1991.tb01597.x
- Saudino, K. (2005). Behavior genetics and child temperament. *Journal of developmental and behavioral pediatrics, 26*(3), 214–223.
- Saudino, K. J., & Cherny, S. S. (2001). Parent ratings of temperament in twins. In R. N. Emde & J. K. Hewitt (Eds.) *The transition from infancy to early childhood: Genetic and environmental influences in the MacArthur Longitudinal Twin Study* (pp.73–88). New York: Oxford University Press.
- Saudino, J., Wertz, A., Gagne, J., & Chawla, s. (2004). Night and day: Are siblings as different in temperament as parents say they are? *Journal of personality and Social Psychology, 87*(5), 698-706.
- Scarr, S. (1992). Developmental theories for the 1990s: Development and individual differences. *Child Development, 63*, 1-19. doi: 10.1111/j.1467-8624.1992.tb03591.x

- Schaughency, E. A. & Fagot, B. I. (1993). The prediction of adjustment at age 7 from activity level at age 5. *Journal of Abnormal Child Psychology*, *21*, 29-50. doi: 10.1007/BF00910487
- Seifer, R., Sameroff, A. J., Baldwin, C. P., & Baldwin, A. (1992). Child and family factors that ameliorate risk between 4 and 13 years of age. *Journal of the American Academy of Child and Adolescent Psychiatry*, *31*, 893-903. doi:10.1097/00004583-199209000-00018
- Seifer, R., Sameroff, A., Barrett, L., & Krafchuk, E. (1994). Infant temperament measured by multiple observations and parent report. *Child Development*, *65*, 1478-1490. doi: 10.1111/j.1467-8624.1994.tb00830.x
- Shannon, K. E., Beauchaine, T. P., Brenner, S. L., Neuhaus, E., & Gatzke-Kopp, L. (2007). Familial and temperamental predictors of resilience in children at risk for conduct disorder and depression. *Development and Psychopathology*, *19*, 701-727. doi: 10.1017/S0954579407000351
- Sheese, B., Voelker, P., Rothbart, M., Posner, M. (2007). Parenting quality interacts with genetic variation in dopamine receptor D4 to influence temperament in early childhood. *Development and Psychopathology*, *19*, 1039-1046. doi:10.1017/S0954579407000521
- Shiner, R. (1998). How shall we speak of children's personalities in middle childhood? A preliminary taxonomy. *Psychological Bulletin*, *124*(3), 308-332.
- Singh, N., Lancioni, G., Winton, A., Singh, J., Singh, A., Adkins, A., et al. (2010). Training in Mindful Caregiving Transfers to Parent-Child Interactions. *Journal of Child and Family Studies*, *19*(2), 167-174. doi: 10.1007/s10826-009-9267-9
- Slutske, W. C., Heath, A. C., Dinwiddie, S. H., Madden, P. A. R., Bucholz, K. K., Dunne, M. P., et al. (1997). Modeling genetic and environmental influences in the etiology of conduct disorder: A study of 2,682 adult twin pairs. *Journal of Abnormal Psychology*, *106*, 266-279.
- South, S. C. & Krueger, R. F. (2011). Genetic and environmental influences on internalizing and psychopathology vary as a function of economic status. *Psychological Medicine*, *41*, 107-117. doi: 10.1017/S003329170000279
- Sprunger, L., Boyce, W., Gaines, J. (1985). Family-Infant Congruence: Routines and Rhythmicity in Family Adaptations to a Young Infant. *Child Development*, *56*(3), 564-572. doi: 10.2307/1129746

- Sroufe, L.A. (1997). Psychopathology as an outcome of development, *Development and Psychopathology*, 9, 251-268. doi: 10.1017/S0954579497002046
- Steinberg, L., Elmen, J. D., & Mounts, N. S. (1989). Authoritative parenting, psychosocial maturity, and academic success among adolescents. *Child Development*, 60, 1424-1436. doi: 10.2307/1130932
- Steinberg, L., Lamborn, S. D., Darling, N., Mounts, N. S., & Dornbusch, S. M. (1994). Over-time changes in adjustment and competence among adolescents from authoritative, authoritarian, indulgent, and neglectful families. *Child Development*, 65, 754-770. doi: 10.1111/j.1467-8624.1994.tb00781.x
- Stoolmiller, M. (2001). Synergistic interaction of child manageability problems and parental-discipline tactics in predicting future growth in externalizing behavior for boys. *Developmental Psychology*, 37, 814–825. doi: 10.1037/0012-1649.37.6.814
- Supplee, L., Unikel, E., & Shaw, D. (2007). Physical environmental adversity and the protective role of maternal monitoring in relation to early child conduct problems. *Journal of Applied Developmental Psychology*, 28, 166-183. doi:10.1016/j.appdev.2006.12.001
- Susman-Stillman, A., Kalkoske, M., Egeland, B., & Waldman, I. (1996). Infant temperament and maternal sensitivity as predictors of attachment security. *Infant Behavior and Development*, 19, 33–47. doi:10.1016/S0163-6383(96)90042-9
- Tschann, J., Kaiser, P., Chesney, M., Alkon, A., & Boynce, T. (1996). Resilience and vulnerability among preschool children: Family functioning, temperament, and behavior problems. *Child and Adolescent Psychiatry*, 35, 184-192. doi:10.1097/00004583-199602000-00012
- Tellegen, A., Lykken, D., Bouchard, T., Wilxoc, K., Segal, N., & Rich, S. (1988). Personality similarity in twins reared apart and together. *Journal of Personality and social psychology*, 54(6), 1031-1039.
- Thomas, A., & Chess, S. (1977). *Temperament and development*. New York: Bruner/Mazel.
- Thomas, R., & Zimmer-Gembeck, M. J. (2007). Behavioral outcomes of Parent–Child Interaction Therapy and Triple P-Positive Parenting Program: A review and meta-analysis. *Journal of Abnormal Child Psychology*, 35, 475–495. doi: 10.1007/s10802-007-9104-9

- Thompson, A., Hollis, C., & Richards, D. (2003). Authoritarian parenting attitudes as a risk for conduct problems. Results from a British national cohort study. *European Journal of Child and Adolescent Psychiatry, 12*, 84-91. doi: 10.1007/s00787-003-0324-4
- Tucker-Drob, E., Rhemtulla, M., Harden, P., Turkheimer, E., & Fask, D. (2011). Emergence of gene x socioeconomic status interaction on infant mental ability between 10 months and 2 years. *Psychological Science, 22*, 125-133. doi: 10.1177/0956797610392926
- Valiente, C., Eisenberg, N., Shepard, S.A., Fabes, R.A., Cumberland, A.J., Losoya, S.H., et al. The relations of mothers' negative expressivity to children's experience and expression of negative emotion. *Journal of Applied Developmental Psychology, 25*, 215-235. doi:10.1016/j.appdev.2004.02.006
- Van Hulle, C., Lemery, K., & Goldsmith, H. (2002). Wisconsin Twin Panel. *Twin Research, 5*(5), 502-505.
- Vitaro, F., Barker, E., Boivin, M., Brendgen, M., & Tremblay, R. (2006). Do early difficult temperament and harsh parenting differentially predict reactive and proactive aggression? *Journal of Abnormal Child Psychology, 34*, 681-691. doi: 10.1007/s10802-006-9055-6
- Volling, B. L., McElwain, N. L., Notaro, P. C., & Herrera, C. (2002). Parents' emotional availability and infant emotional competence: Predictors of parent-infant attachment and emerging self-regulation. *Journal of Family Psychology, 16*, 447-465. doi: 10.1037/0893-3200.16.4.447
- Wachs, T. (1988). Relevance of physical environment influences for toddler temperament. *Infant Behavior & Development, 11*, 431-445. doi:10.1016/0163-6383(88)90004-5
- Wachs, T D. (1992). *The nature of nurture*. Newbury Park, CA: Sage.
- Wachs, T.D. (2000). *Necessary but Not Sufficient: The Respective Roles of Single and Multiple Influences on Individual Development*, Washington, DC: American Psychological Association.
- Williams, K., & Wahler, R. (2010). Are Mindful Parents More Authoritative and Less Authoritarian? An Analysis of Clinic-Referred Mothers. *Journal of Child and Family Studies, 19*, 230-235. doi: 10.1007/s10826-009-9309-3.
- Zhou, Q., Eisenberg, N., Losoya, S., Fabes, R., Reiser, M., Guthrie, et al. (2002). The relations of parental warmth and positive expressiveness to children's empathy-related responding and social functioning: A longitudinal study. *Child Development, 73*, 893-915. doi: 10.1111/1467-8624.00446

Ziv, Y., Aviezer, O., Gini, M., Sagi, A., Koren-Karie, N. (2000). Emotional availability in the mother-infant dyad as related to the quality of infant-mother attachment relationship. *Attachment & Human Development*, 2, 149-169. doi: 10.1080/14616730050085536

Table 1

*Means, Standard Deviations, and Ranges for Study Variables*

Variable	<i>N</i>	<i>M</i>	<i>SD</i>	Range
Age (months)	1573	95.20	10.48	65-148
Income*	749	10.34	3.91	1.00-17.00
Mother Education**	796	14.91	2.44	0.00-20.00
Father Education**	778	14.45	2.62	0.00-20.00
Temperament				
CBQ – Effortful Control	1573	4.63	0.77	1.86-6.70
CBQ – Extraversion/Surgency	1573	4.77	0.51	2.63-6.58
CBQ – Negative Affectivity	1573	4.14	0.59	1.62-6.29
Parenting				
Overall Parenting Composite	793	0.00	0.84	-3.34-2.47
Physical Home Environment				
Living Environment Observation Scale (LEOS)***	685	1.64	0.15	1.12-1.75
Confusion, Hubbub, and Order Scale (CHAOS)	774	0.28	0.21	0.00-0.87
Family Environment				
Overall Family Environment Composite	793	3.19	0.88	0-5.46

*Note.* Variables with mean of zero are composite variables. CBQ = Children's Behavior Questionnaire.

\* 1 = \$10,000 or less, 2 = \$10,001 to \$15,000, 3 = 15,001 to \$20,000, 4 = \$20,001 to \$25,000, 5 = \$25,001 to \$30,000, 6 = \$30,001 to \$35,000, 7 = \$35,001 to \$40,000, 8 = \$40,001 to \$45,000, 9 = \$45,001 to \$50,000, 10 = \$50,001 to \$60,000, 11 = \$60,001 to \$70,000, 12 = \$70,001 to \$80,000, 13 = \$80,001 to \$90,000, 14 = \$90,001 to \$100,000, 15 = \$100,001 to \$150,000, 16 = \$150,001 to \$200,000, 17 = over \$200,000

\*\* 0 = no formal education, 6-8 = some grade school, 9-11 some high school, 12 = high school graduate, 13-15 = trade, tech, or some college, 16 = college graduate, 17-19 = graduate training, 20+ = graduate degree (MD, JD, DDS, PhD)

\*\*\* Transformed for skewness and kurtosis using the inverse, reflected



Table 2

*Internal Consistency of Study Scales*

Scale	No. Items	Cronbach's $\alpha$ (Mother, Father)
BMSA	15	0.79, 0.80
CRPR	20	0.75, 0.83
LEOS*	9	0.84
CHAOS**	15	0.80
FAD	60	0.95, 0.95
FCS**	12	0.86

*Note.* BMSA = Behavior Management Self-Assessment; CRPR = Child Rear Practices Report (Warmth); LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale; FAD = Family Assessment Device; FCS = Family Conflict Scale.

\* Observer report only

\*\* Mother report only

Table 3

*Zero-order Correlations between Study Variables*

	1	2	3	4	5	6	7	8	9
1. Age	-								
2. SES	-.05	-							
3. CBQ – Effortful Control	.11 <sup>**a</sup>	.22 <sup>***</sup>	-						
4. CBQ – Negative Affectivity	-.10 <sup>*c</sup>	-.14 <sup>***c</sup>	-.49 <sup>***</sup>	-					
5. CBQ – Extraversion/Surgency	.16 <sup>***b</sup>	-.04	-.44 <sup>***</sup>	.08 <sup>**</sup>	-				
6. Parenting Composite	.01	.13 <sup>***</sup>	.32 <sup>***</sup>	-.28 <sup>***</sup>	.01	-			
7. LEOS	-.06 <sup>+</sup>	.44 <sup>***</sup>	.17 <sup>***</sup>	-.14 <sup>***d</sup>	-.05 <sup>e</sup>	.13 <sup>**</sup>	-		
8. CHAOS	-.07 <sup>*</sup>	-.13 <sup>***</sup>	-.36 <sup>***</sup>	.27 <sup>***</sup>	.23 <sup>***</sup>	-.31 <sup>***</sup>	-.22 <sup>***</sup>	-	
9. Family Environment Composite	.02	.24 <sup>***</sup>	.29 <sup>***</sup>	-.26 <sup>***</sup>	.05	.57 <sup>***</sup>	.16 <sup>***</sup>	-.35 <sup>***</sup>	-

*Note.* SES = Socioeconomic status; CBQ = Children’s Behavior Questionnaire; LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale. Correlations were run on a random subsample of one twin selected from each pair, then replicated in a sample of their cotwins, with differences noted as <sup>a</sup> not significant, <sup>b</sup>  $p < .10$ , <sup>c</sup>  $p < .05$ , <sup>d</sup>  $p < .01$ , <sup>e</sup>  $p < .001$ . <sup>+</sup>  $p < .10$ .

\*  $p < .05$  \*\*  $p < .01$  \*\*\*  $p < .001$ .

Table 4

*Partial Correlations between Study Variables, Accounting for Age and Socioeconomic Status*

	1	2	3	4	5	6	7
1. CBQ – Effortful Control	-						
2. CBQ – Negative Affectivity	-.45 <sup>***</sup>	-					
3. CBQ – Extraversion/Surgency	-.42 <sup>***</sup>	.03 <sup>c</sup>	-				
4. Parenting Composite	.31 <sup>***</sup>	-.27 <sup>***</sup>	.03 <sup>c</sup>	-			
5. LEOS	.07 <sup>+d</sup>	-.08 <sup>*</sup>	-.02 <sup>e</sup>	.07 <sup>+</sup>	-		
6. CHAOS	-.32 <sup>***</sup>	.21 <sup>***</sup>	.21 <sup>***d</sup>	-.27 <sup>***</sup>	-.16 <sup>***</sup>	-	
7. Family Environment Composite	.35 <sup>***</sup>	-.28 <sup>***</sup>	.03	.57 <sup>***</sup>	.15 <sup>**c</sup>	-.35 <sup>***</sup>	-

75

*Note.* CBQ = Children's Behavior Questionnaire; LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale. Correlations were run on a random subsample of one twin selected from each pair, then replicated in a sample of their cotwins, with differences noted as <sup>a</sup> not significant, <sup>b</sup>  $p < .10$ , <sup>c</sup>  $p < .05$ , <sup>d</sup>  $p < .01$ , <sup>e</sup>  $p < .001$ .

<sup>+</sup>  $p < .10$  <sup>\*</sup>  $p < .05$  <sup>\*\*</sup>  $p < .01$  <sup>\*\*\*</sup>  $p < .001$ .

Table 5

*Twin Biometric ACE Model Fit Statistics for Effortful Control, Negative Affectivity, and Extraversion/Surgency*

<i>Temperament Dimension</i>	<i>Model</i>	<i>-2LL</i>	<i>df</i>	<i>AIC</i>	$\Delta df$	$\Delta\chi^2$	<i>p</i>	$h^2$	$c^2$	$e^2$
Effortful Control	ACE	3322.7	1540	242.71	-	-	-	0.60	0	0.40
	<b>AE</b>	<b>1</b>		<b>240.71</b>	<b>1</b>	<b>0.00</b>	<b>0.99</b>	<b>0.60</b>	-	<b>0.40</b>
	CE			319.38	1	78.67	0.00	-	0.17	0.83
	E			347.51	2	108.79	0.00	-	-	1
Negative Affectivity	ACE	2271.4	1540	-808.58	-	-	-	0.80	0	0.20
	<b>AE</b>	<b>2</b>		<b>-810.58</b>	<b>1</b>	<b>0.00</b>	<b>0.99</b>	<b>0.80</b>	-	<b>0.20</b>
	CE			-635.82	1	174.76	0.00	-	0.40	0.60
	E			-433.71	2	378.88	0.00	-	-	1
Extraversion/Surgency	ACE	2191.0	1540	-887.57	-	-	-	0.59	0	0.41
	<b>AE</b>	<b>6</b>		<b>-889.57</b>	<b>1</b>	<b>0.00</b>	<b>.99</b>	<b>0.59</b>	-	<b>0.41</b>
	CE			-806.11	1	83.46	0.00	-	0.13	0.87
	E			-787.59	2	103.98	0.00	-	-	1

*Note.* -2LL = -2 times the log likelihood (fit statistic); df = degrees of freedom; AIC = Akaike's Information Criterion (fit index);  $\Delta df$  = change in degrees of freedom;  $\Delta\chi^2$  = change in chi-square value from the best fitting full model to reduced model; *p* = probability;  $h^2$  = heritability estimate;  $c^2$  = shared environment estimate;  $e^2$  = non-shared, or unique, environment estimate. The best fitting reduced model is in bold.

Table 6

*Twin Biometric AE Models with Moderation for Effortful Control*

<i>Model</i>	<i>-2LL</i>	<i>df</i>	<i>AIC</i>	<i>Δdf</i>	<i>Δχ<sup>2</sup></i>	<i>p</i>
<b>Parenting</b>						
AE full moderation	3286.54	1537	212.54	-	-	-
Only A moderation			215.78	1	5.24	0.02
Only E moderation			212.28	1	1.74	0.19
<b>AE no moderation</b>			<b>213.87</b>	<b>2</b>	<b>5.33</b>	<b>0.07</b>
<b>LEOS</b>						
AE full moderation	2838.48	1317	204.48	-	-	-
Only A moderation			205.73	1	3.24	0.07
Only E moderation			204.47	1	1.98	0.16
<b>AE no moderation</b>			<b>203.90</b>	<b>2</b>	<b>3.42</b>	<b>0.18</b>
<b>CHAOS</b>						
AE full moderation	3165.94	1499	167.94	-	-	-
Only A moderation			176.80	1	10.84	0.001
<b>Only E moderation</b>			<b>166.22</b>	<b>1</b>	<b>0.28</b>	<b>0.60</b>
AE no moderation			187.30	2	23.36	0.00
<b>Family Environment</b>						
AE full moderation	3322.52	1539	383.58	-	-	-
Only A moderation			242.57	1	0.05	0.83
Only E moderation			242.68	1	0.16	0.69
<b>AE no moderation</b>			<b>240.71</b>	<b>2</b>	<b>0.20</b>	<b>0.91</b>

*Note.* LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale; -2LL = -2 times the log likelihood (fit statistic); df = degrees of freedom; AIC = Akaike's Information Criterion (fit index);  $\Delta df$  = change in degrees of freedom;  $\Delta\chi^2$  = change in chi-square value from the best fitting full model to reduced model;  $p$  = probability. The best fitting reduced model is in bold.

Table 7

*Estimates of the Moderated Pathways across Varying Levels of Parenting, LEOS, and CHAOS*

<i>Outcome – Moderator</i>		$h^2$	$c^2$	$e^2$
Effortful Control – CHAOS	Below 1 <i>SD</i>	0.69	0.00	0.31
	Between -1 and 1 <i>SD</i>	0.43	0.00	0.57
	Above 1 <i>SD</i>	0.58	0.00	0.42
Negative Affectivity – Parenting	Below 1 <i>SD</i>	0.70	0.00	0.30
	Between -1 and 1 <i>SD</i>	0.83	0.00	0.17
	Above 1 <i>SD</i>	0.77	0.00	0.23
Negative Affectivity – LEOS	Below 0.5 <i>SD</i>	0.74	0.00	0.26
	Between -0.5 and 0.5 <i>SD</i>	0.82	0.00	0.18
	Above 0.5 <i>SD</i>	0.84	0.00	0.16
Extraversion/Surgency – LEOS	Below 0.5 <i>SD</i>	0.45	0.00	0.55
	Between -0.5 and 0.5 <i>SD</i>	0.56	0.00	0.44
	Above 0.5 <i>SD</i>	0.68	0.00	0.32
Extraversion/Surgency – CHAOS	Below 1 <i>SD</i>	0.60	0.00	0.40
	Between -1 and 1 <i>SD</i>	0.48	0.00	0.52
	Above 1 <i>SD</i>	0.67	0.00	0.33

*Note.* LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale; *SD* = Standard Deviation;  $h^2$  = heritability estimate;  $c^2$  = shared environment estimate;  $e^2$  = non-shared, or unique, environment estimate.

Table 8

*Twin Biometric AE Models with Moderation for Negative Affectivity*

	<i>Model</i>	<i>-2LL</i>	<i>df</i>	<i>AIC</i>	$\Delta df$	$\Delta\chi^2$	<i>p</i>	
79	<b>Parenting</b>							
		AE full moderation	2259.69	1537	-814.31	-	-	-
		<b>Only A moderation</b>			<b>-816.23</b>	<b>1</b>	<b>0.08</b>	<b>0.78</b>
		Only E moderation			-810.04	1	6.27	0.01
		No moderation			-811.73	2	6.58	0.04
	<b>LEOS</b>							
		AE full moderation	1905.95	1317	-728.05	-	-	-
		Only A moderation			-722.77	1	7.28	0.01
		<b>Only E moderation</b>			<b>-730.03</b>	<b>1</b>	<b>0.02</b>	<b>0.89</b>
		AE no moderation			-723.02	2	9.03	0.01
	<b>CHAOS</b>							
		AE full moderation	2191.68	1499	-806.32	-	-	-
	Only A moderation			-807.74	1	0.58	0.45	
	Only E moderation			-808.23	1	0.09	0.77	
	<b>AE no moderation</b>			<b>-809.74</b>	<b>2</b>	<b>0.58</b>	<b>0.75</b>	
<b>Family Environment</b>								
	AE full moderation	2268.79	1539	-809.21	-	-	-	
	Only A moderation			-811.14	1	0.07	0.79	
	Only E moderation			-808.73	1	2.48	0.12	
	<b>AE no moderation</b>			<b>-810.58</b>	<b>2</b>	<b>2.62</b>	<b>0.27</b>	

*Note.* LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale; -2LL = -2 times the log likelihood (fit statistic); df = degrees of freedom; AIC = Akaike's Information Criterion (fit index);  $\Delta df$  = change in degrees of freedom;

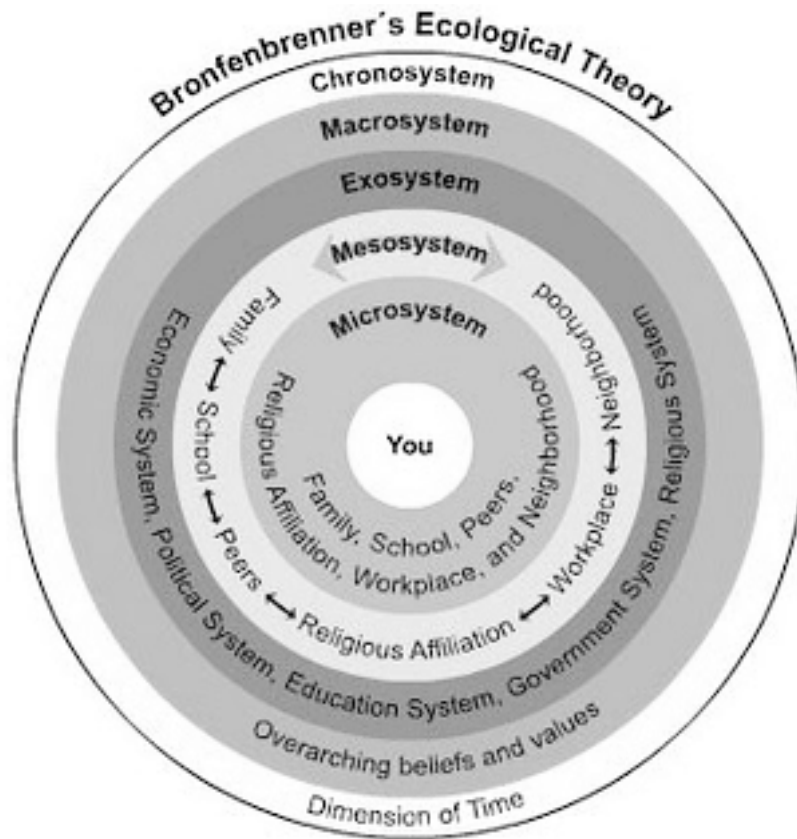
Table 9

*Twin Biometric AE Models with Moderation for Extraversion/Surgency*

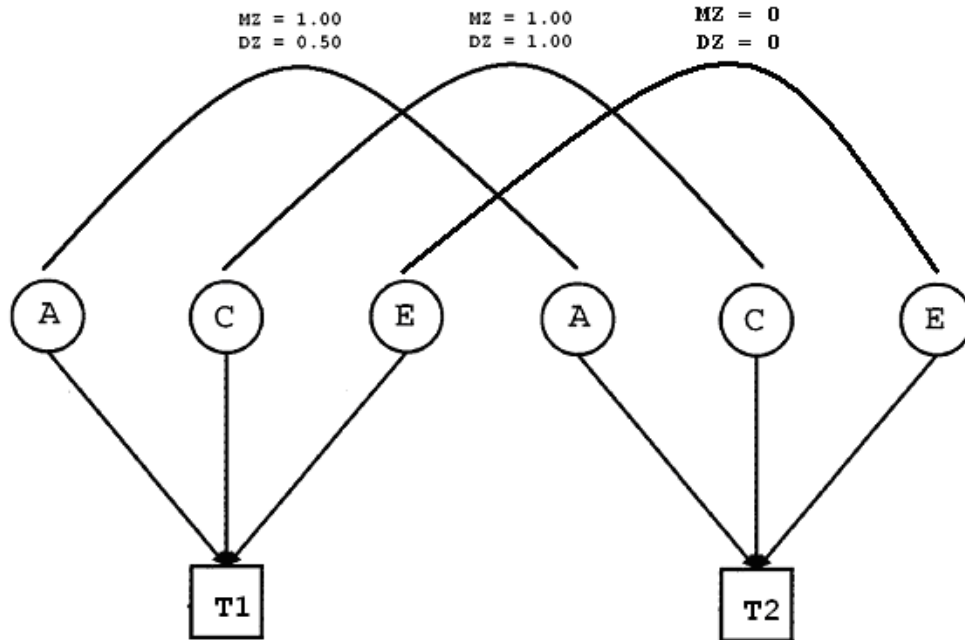
	<i>Model</i>	<i>-2LL</i>	<i>df</i>	<i>AIC</i>	$\Delta df$	$\Delta\chi^2$	<i>p</i>	
8	<b>Parenting</b>							
		AE full moderation	2187.10	1537	-886.91	-	-	-
		Only A moderation			-888.36	1	0.54	0.46
		Only E moderation			-888.90	1	.006	0.94
		<b>AE no moderation</b>			<b>-889.57</b>	<b>2</b>	<b>1.33</b>	<b>0.51</b>
	<b>LEOS</b>							
		AE full moderation	1844.46	1317	-789.54	-	-	-
		Only A moderation			-785.23	1	6.31	0.01
		<b>Only E moderation</b>			<b>-787.87</b>	<b>1</b>	<b>3.67</b>	<b>0.06</b>
		AE no moderation			-787.22	2	6.31	0.04
	<b>CHAOS</b>							
		AE full moderation	2054.12	1499	-943.88	-	-	-
	Only A moderation			-936.89	1	8.99	0.003	
	<b>Only E moderation</b>			<b>-945.80</b>	<b>1</b>	<b>0.08</b>	<b>0.78</b>	
	AE no moderation			-927.08	2	20.80	0.00	
<b>Family Environment</b>								
	AE full moderation	2189.41	1539	-888.59	-	-	-	
	Only A moderation			-890.56	1	0.03	0.86	
	Only E moderation			-890.47	1	0.12	0.73	
	<b>AE no moderation</b>			<b>-890.94</b>	<b>2</b>	<b>1.66</b>	<b>0.44</b>	

*Note.* LEOS = Living Environment Observation Scale; CHAOS = Confusion, Hubbub, and Order Scale; -2LL = -2 times the log likelihood (fit statistic); df = degrees of freedom; AIC = Akaike's Information Criterion (fit index);  $\Delta df$  = change in degrees of freedom;  $\Delta\chi^2$  = change in Chi-square value from the best fitting full model to reduced model; *p* = probability. The best fitting reduced model is in bold.





*Figure 1.* Bronfenbrenner's (1979) bioecological systems model. Note the child of interest is located at the center of the model, most closely influenced by elements in the microsystem, which is largely comprised of family and environment.



*Figure 2.* ACE model example including both cotwins. Squares represent the measured variable of interest (T1 and T2 = Temperament for twin 1 and twin 2). Circles represent the latent variables of A (additive genetic), C (common shared environment), and E (non-shared environment). Note that MZ twins correlate at 1.00, and DZ twins correlate at 0.50 for “A,” or additive genetic effects and 1.00 for “C.” Last, MZ and DZ twins both correlate at 0 for “E,” because it represents anything that creates differences between twins. From Purcell, S. (2002). Variance Components Models for Gene-Environment Interaction in Twin Analysis. *Twin Research*, 5(6), 554-571.

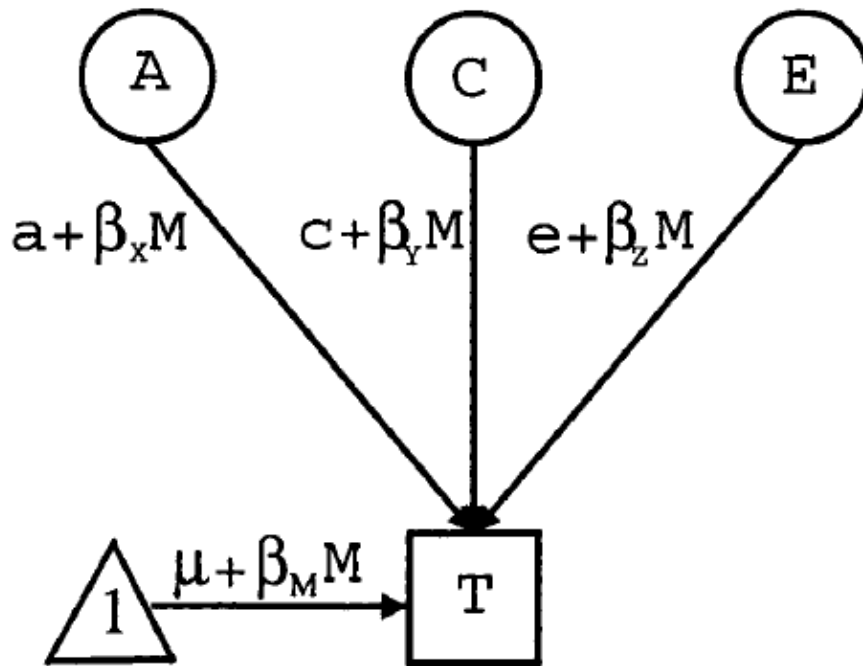
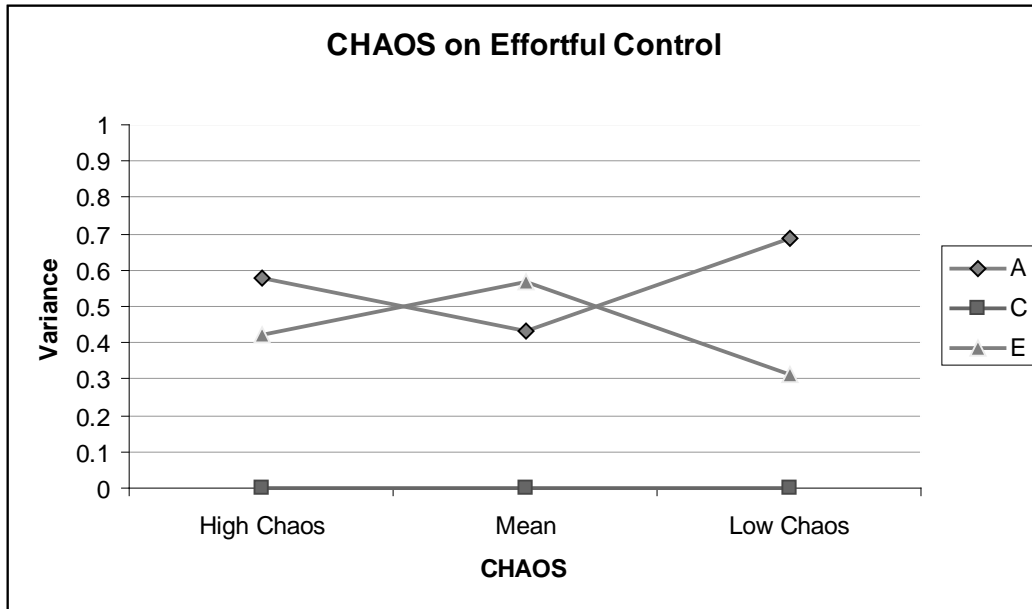
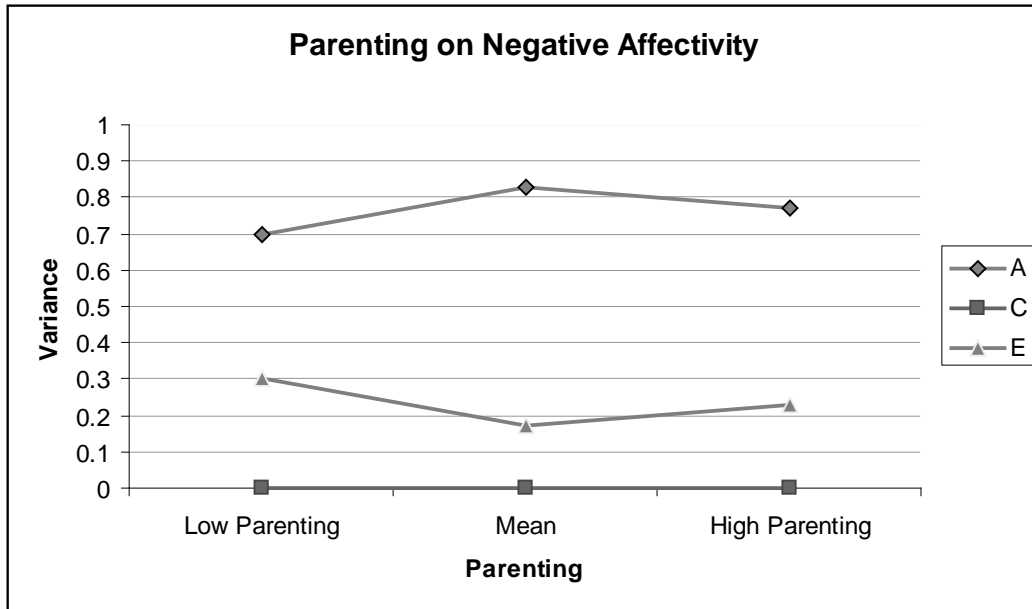


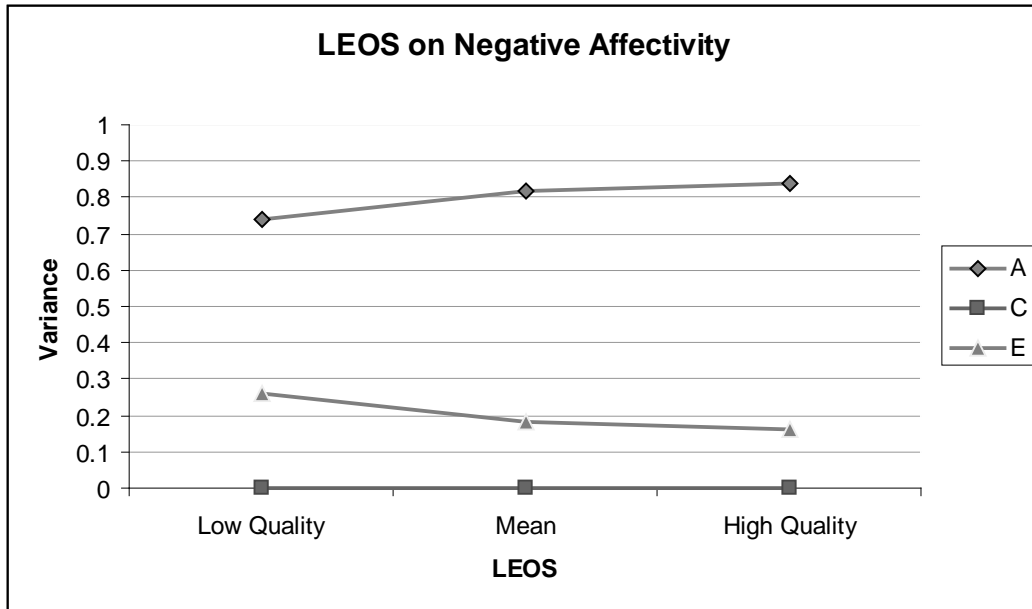
Figure 3. ACE model with moderation example. Only one twin shown to simplify. The square represents the measured variable of interest ( $T =$  temperament), circles represent the latent variables of A (additive genetic), C (common shared environment), and E (non-shared environment), and the triangle represents the moderator (e.g., family environment). Note the equations, which quantify the various sources of influence. They have a generic formula of a constant (e.g.,  $\mu$ ,  $a$ ,  $c$ ,  $e$ ) plus the beta coefficient multiplied by the moderator variable, positive environment (PE). From Purcell, S. (2002). Variance Components Models for Gene-Environment Interaction in Twin Analysis. *Twin Research*, 5(6), 554-571.



*Figure 4.* CHAOS moderates nonshared environment influences on effortful control. Variance in Effortful Control as a function of CHAOS at below one SD, between negative one and one SD, and above one SD. A = additive genetic variance; C = shared environmental variance, E = unique, non-shared, environmental variance.



*Figure 5.* Parenting moderates additive genetic influences on negative affectivity. Variance in Negative Affectivity as a function of parenting at below one SD, between negative one and one SD, and above one SD. A = additive genetic variance; C = shared environmental variance, E = unique, non-shared, environmental variance.



*Figure 6.* LEOS moderates nonshared environment influences on negative affectivity. LEOS = Living Environment Observation Scale. Variance in Negative Affectivity as a function of LEOS at below half one SD, between negative half one SD and half one SD, and above half one SD. A = additive genetic variance; C = shared environmental variance, E = unique, non-shared, environmental variance.

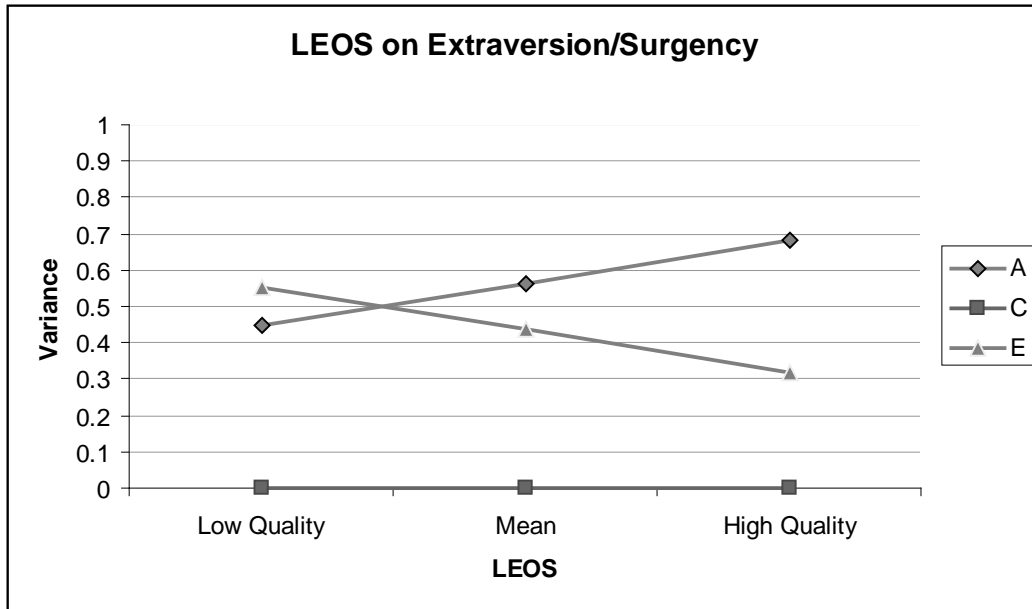
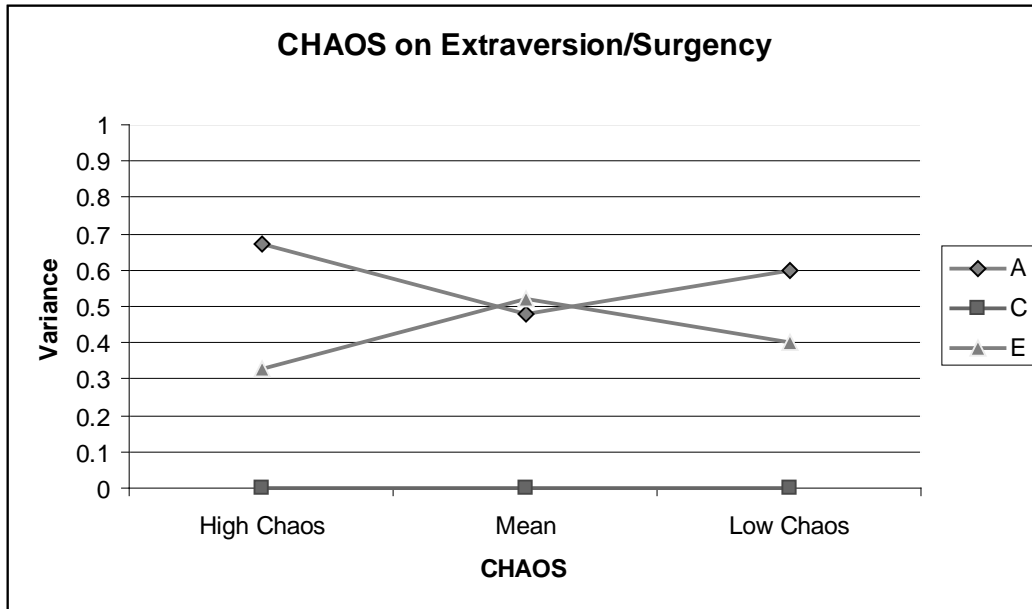


Figure 7. LEOS moderates nonshared environment influences on extraversion/surgency. LEOS = Living Environment Observation Scale. Variance in Extraversion/Surgency as a function of LEOS at below half one SD, between negative half one SD and half one SD, and above half one SD. A = additive genetic variance; C = shared environmental variance, E = unique, non-shared, environmental variance.



*Figure 8.* CHAOS moderates nonshared environment influences on extraversion/surgency. CHAOS = Confusion, Hubbub, and Order Scale. Variance in Extraversion/Surgency as a function of CHAOS at below one SD, between negative one and one SD, and above one SD. A = additive genetic variance; C = shared environmental variance, E = unique, non-shared, environmental variance.



APPENDIX A  
CHILDREN'S BEHAVIOR QUESTIONNAIRE

## Children's Behavior Questionnaire (CBQ)

**Instructions:** Please read carefully before starting:

Today's date:

\_\_\_\_/\_\_\_\_/\_\_\_\_

On the next pages you will see a set of statements that describe children's reactions to a number of situations. We would like you to tell us what your child's reaction is likely to be in those situations. Of course, there are no "correct" ways of reacting; children differ widely in their reactions, and it is these differences we are trying to learn about. We greatly appreciate your patience. Please read each statement and decide how "true" or "untrue" the description is of your child's reaction *within the past six months*. Use the following scale to indicate how well a statement describes your child:

**Circle # if the statement is:**

1-----**extremely untrue of your child**  
2-----**quite untrue of your child**  
3-----**slightly untrue of your child**  
4-----**neither true nor false of your child**  
5-----**slightly true of your child**  
6-----**quite true of your child**  
7-----**extremely true of your child**

If you cannot answer one of the items because you have never seen your child in that situation, for example if the statement is about your child's reaction to your singing and you have never sung to her/him, then circle NA (not applicable).

**Please be sure to circle a number or NA for every item.**

1. Seems always in a big hurry to get from one place to another.
2. Gets angry when told s/he has to go to bed.
3. Her/his feelings are not easily hurt by what parents say.
4. Can lower his/her voice when asked to do so.
5. Is not very bothered by pain.
6. Is hard to get her/his attention when s/he is concentrating on something.
7. Sometimes prefers to watch rather than join other children playing.
8. Likes going down high slides or other adventurous activities.
9. Notices the smoothness or roughness of objects s/he touches.
10. Gets so worked up before an exciting event that s/he has trouble sitting still.
11. Laughs a lot at jokes and silly happenings.
12. Rarely enjoys just being talked to.
13. Usually rushes into an activity without thinking about it.
14. Has a hard time settling down for a nap.
15. Is not afraid of large dogs and/or other animals.
16. When picking up toys or other jobs, usually keeps at the task until it's done.
17. Is comfortable in situations where s/he will be meeting others.
18. Cries sadly when a favorite toy gets lost or broken.
19. Rarely gets irritated when s/he makes a mistake.
20. Is good at games like "Simon Says," "Mother, May I?" and "Red Light, Green Light."
21. Becomes quite uncomfortable when cold and/or wet.
22. Likes to play so wild and recklessly that s/he might get hurt.
23. Seems to be at ease with almost any person.
24. When s/he sees a toy s/he wants, gets very excited about getting it.
25. Tends to run rather than walk from room to room.
26. Sometimes interrupts others when they are speaking.
27. Calms down quickly following an exciting event.
28. Usually doesn't comment on changes in parents' appearance.
29. Can easily shift from one activity to another.
30. Doesn't care for rough and rowdy games.
31. Notices it when parents are wearing new clothing.
32. Has a hard time following instructions.
33. Is afraid of elevators.
34. Has temper tantrums when s/he doesn't get what s/he wants.
35. When s/he wants to do something, s/he talks about little else.
36. Enjoys just sitting quietly in the sunshine.
37. Gets embarrassed when strangers pay a lot of attention to her/him.
38. When practicing an activity, has a hard time keeping her/his mind on it.
39. Tends to feel "down" at the end of an exciting day.
40. Is afraid of burglars or the "boogie man."
41. When outside, often sits quietly.
42. Can be "cheered up" by talking about something s/he is interested in.
43. Enjoys funny stories but usually doesn't laugh at them.

44. Tends to become sad if the family's plans don't work out.
45. Acts very friendly and outgoing with new children.
46. Decides what s/he wants very quickly and goes after it.
47. Will move from one task to another without completing any of them.
48. Moves about actively (runs, climbs, jumps) when playing in the house.
49. Dislikes having nails cut.
50. Is afraid of loud noises.
51. Does not like to take chances for the fun and excitement of it.
52. Seems to listen to even quiet sounds.
53. Has a hard time settling down after an exciting activity.
54. Enjoys taking warm baths.
55. Seems to feel depressed when unable to accomplish some task.
56. Smiles and laughs during play with parents.
57. Joins others quickly, even when they are strangers.
58. Doesn't worry about injections by the doctor.
59. Often rushes into new situations.
60. Doesn't like to go down high slides at the amusement park or playground.
61. Is quite upset by a little cut or bruise.
62. Gets quite frustrated when prevented from doing something s/he wants to do.
63. Prepares for trips and outings by planning things s/he will need.
64. Becomes upset when loved relatives or friends are getting ready to leave following a visit.
65. Comments when a parent has changed his/her appearance.
66. Doesn't enjoy being read to very much.
67. Enjoys activities such as being chased, spun around by the arms, etc.
68. When angry about something, s/he tends to stay upset for ten minutes or longer.
69. Has strong desires for certain kinds of foods.
70. Is not afraid of the dark.
71. Takes a long time in approaching new situations.
72. Does not usually become tearful when tired.
73. Gets mad when even mildly criticized.
74. Is sometimes shy even around people s/he has known a long time.
75. Can wait before entering into new activities if s/he is asked to.
76. Enjoys "snuggling up" next to a parent or babysitter.
77. Enjoys being in crowds of people.
78. Gets angry when s/he can't find something s/he wants to play with.
79. Usually stops and thinks things over before deciding to do something.
80. Is afraid of fire.
81. Her/his feelings are easily hurt by what parents say.
82. Looks forward strongly to the visit of loved relatives.
83. Usually has a serious expression, even during play.
84. Doesn't usually comment on people's facial features, such as size of nose or mouth.
85. Seems to forget a bump or scrape after a couple of minutes.
86. Doesn't care much for quiet games.
87. Is bothered by light or color that is too bright.
88. Sometimes sits quietly for long periods in the house.
89. Sometimes seems nervous when talking to adults s/he has just met.
90. Is slow and unhurried in deciding what to do next.
91. Is very frightened by nightmares.
92. Changes from being upset to feeling much better within a few minutes.
93. Has difficulty waiting in line for something.
94. Becomes tearful when told to do something s/he does not want to do.
95. Has a lot of trouble stopping an activity when called to do something else.
96. Becomes very excited while planning for trips.
97. Finds rough materials uncomfortable, such as wool against his/her skin.
98. Is quickly aware of some new item in the living room.
99. Hardly ever laughs out loud during play with other children.
100. Enjoys exciting and suspenseful TV shows.
101. Is not very upset at minor cuts or bruises.
102. Prefers quiet activities to active games.
103. Falls asleep within ten minutes of going to bed at night.
104. Tends to say the first thing that comes to mind, without stopping to think about it.
105. Usually comments if someone has an unusual voice.
106. Acts shy around new people.
107. Enjoys meeting Santa Claus or other strangers in costumes.
108. Has trouble sitting still when s/he is told to (at movies, church, etc.).
109. Rarely cries when s/he hears a sad story.
110. Sometimes smiles or giggles playing by her/himself.
111. Isn't interested in watching quiet TV shows such as "Mister Rogers."

112. Rarely becomes upset when watching a sad event in a TV show.
113. Enjoys just being talked to.
114. When eager to go outside, sometimes rushes out without putting on the right clothes.
115. Is bothered by bathwater that is too hot or too cold.
116. Is able to resist laughing or smiling when it isn't appropriate.
117. Becomes very excited before an outing (e.g., picnic, party).
118. If upset, cheers up quickly when s/he thinks about something else.
119. Is comfortable asking other children to play.
120. Rarely gets upset when told s/he has to go to bed.
121. Rarely smiles and laughs when playing with pets.
122. Does not seem to notice parents' facial expressions.
123. Rarely runs or moves quickly in the house.
124. Enjoys exploring new places.
125. When drawing or coloring in a book, shows strong concentration.
126. Plays games slowly and deliberately.
127. Sometimes appears downcast for no reason.
128. Becomes easily frustrated when tired.
129. Talks easily to new people.
130. Is afraid of the dark.
131. Is usually pretty calm before going on an outing (e.g., picnic, party).
132. Is likely to cry when even a little bit hurt.
133. Enjoys looking at picture books.
134. Is easy to soothe when s/he is upset.
135. Doesn't often giggle or act "silly."
136. Is good at following instructions.
137. Approaches slowly places where s/he might hurt her/himself.
138. Is rarely frightened by "monsters" seen on TV or at movies.
139. Likes to go high and fast when pushed on a swing.
140. Gets irritable about having to eat food s/he doesn't like.
141. Becomes distressed when hair is combed.
142. Doesn't usually react to different textures of food.
143. Sometimes turns away shyly from new acquaintances.
144. When building or putting something together, becomes very involved in what s/he is doing, and works for long periods.
145. Sits quietly in the bath.
146. Likes being sung to.
147. Approaches places s/he has been told are dangerous slowly and cautiously.
148. Gets very enthusiastic about the things s/he does.
149. Rarely becomes discouraged when s/he has trouble making something work.
150. Is very difficult to soothe when s/he has become upset.
151. Likes the sound of words, such as nursery rhymes.
152. Smiles a lot at people s/he likes.
153. Plays actively outdoors with other children.
154. Notices even little specks of dirt on objects.
155. When s/he sees a toy or game s/he wants, is eager to have it right then.
156. Rarely protests when another child takes his/her toy away.
157. Cries when given an injection.
158. Seems completely at ease with almost any group.
159. Dislikes rough and rowdy games.
160. Has difficulty leaving a project s/he has begun.
161. Is not afraid of heights.
162. Is not very careful and cautious in crossing streets.
163. Often laughs out loud in play with other children.
164. Enjoys gentle rhythmic activities such as rocking or swaying.
165. Rarely laughs aloud while watching TV or movie comedies.
166. Shows great excitement when opening a present.
167. Has a hard time going back to sleep after waking in the night.
168. Can easily stop an activity when s/he is told "no."
169. Is among the last children to try out a new activity.
170. Doesn't usually notice odors such as perfume, smoke, cooking, etc.
171. Is easily distracted when listening to a story.
172. Is full of energy, even in the evening.
173. Easily gets irritated when s/he has trouble with some task (e.g., building, drawing, dressing).
174. Enjoys sitting on parent's lap.
175. Doesn't become very excited about upcoming television programs.
176. Is rarely afraid of sleeping alone in a room.
177. Rarely cries for more than a couple of minutes at a time.
178. Is bothered by loud or scratchy sounds.

179. Smiles at friendly strangers.
180. Has an easy time leaving play to come to dinner.
181. Gets angry when called in from play before s/he is ready to quit.
182. Enjoys riding a tricycle or bicycle fast and recklessly.
183. Is "slow to warm up" to others.
184. Sometimes doesn't seem to hear me when I talk to her/him.
185. Is usually able to resist temptation when told s/he is not supposed to do something.
186. Sometimes becomes absorbed in a picture book and looks at it for a long time.
187. Has difficulty sitting still at dinner.
188. Remains pretty calm about upcoming desserts like ice cream.
189. Gets nervous about going to the dentist.
190. Hardly ever complains when ill with a cold.
191. Looks forward to family outings, but does not get too excited about them.
192. Likes to sit quietly and watch people do things.
193. Gets mad when provoked by other children.
194. Smiles when looking at a picture book.
195. Has a hard time concentrating on an activity when there are distracting noises.

Please check back to make sure you have completed all the pages of the questionnaire. Thank you very much for your help!

APPENDIX B

BEHAVIOR MANAGEMENT SELF-ASSESSMENT

### Behavioral Management Self Assessment (BM)

Please respond to the following statements with the number that best corresponds to how often you engage in the form of discipline described.

- 1-----Never
- 2-----Rarely
- 3-----Sometimes
- 4-----Often
- 5-----Very Often

1. When I ask my twins to do something, I am clear and to the point in my request.
2. During the day, I try to take notice when my twins are being good and let them know I like how they are behaving.
3. When my twins give me a hard time (“whining, yelling”) after I ask them to do something, I give up because its too much of a hassle to continue.
4. I praise my twins for doing something I like or approve of.
5. I am consistent in disciplining my twins.
6. I do a good job of keeping track of my twins’ misbehavior.
7. To change my twins’ undesirable behavior, I try to correct little problems first and gradually work up to what I want her/him to do.
8. When I have had a problem with my twins, I set aside some time so that we can talk about the problem together.
9. I have to nag and/or scold my twins to get them to do something I have asked.
10. When my twins fail to do what I ask, I end up doing it.
- 11..When I punish my twins I do it quickly, and do not let things get out of hand.
- 12..I am firm and consistent in disciplining my twins.
13. I threaten my twins if they do not do what I want.
14. I yell or scream at my twins when they get on my nerves.
15. When I give my twins commands, I do not follow through to see that they obey.

APPENDIX C  
CHILD REARING PRACTICES REPORT



## Child Rearing Practices Report

This first set of questions asks about your attitudes on childrearing and how you plan to raise your twins. Please respond with the number that best reflects your degree of agreement or disagreement to each statement. Refer to Card A for the response choices. The card should read:

(1)	(2)	(3)	(4)	(5)	(6)
STRONGLY DISAGREE	MODERATELY DISAGREE	SLIGHTLY DISAGREE	SLIGHTLY AGREE	MODERATELY AGREE	STRONGLY AGREE

### Encouraging Independence

1. I respect my twins' feelings and opinions and encourage the twins to express them:
2. When my twins get into trouble, I will expect them to handle the problem mostly by themselves:
8. I take into account my twins' preference in making plans for the family:
10. I try to let my twins make many decisions for themselves:
17. I intend to give my twins a good many duties and family responsibilities:
30. I intend to teach my twins that they are responsible for what happens to them:
33. I encourage my twins to be independent of me:

### Open expression of affect

3. I feel children should be given comfort and understanding when they are scared or upset:
6. I express affection by hugging, kissing, and holding my twins:
14. I am easy going and relaxed with my twins:
16. I joke and play with my twins:
18. My twins and I have warm, intimate times together:
27. When I am angry with my twins, I let them know it:

### Encouraging openness of expression

7. I try to encourage my twins to wonder and think about life:
9. I feel children should have time to think, daydream, and even loaf sometimes:
20. I encourage my twins to be curious, to explore, and to question things:
24. I intend to encourage my twins to talk about their troubles:

### Rational guiding of child

15. I try to talk it over and reason with my twins when they misbehave:
22. I believe in praising children when they are good and think it gets better results than punishing them when they are bad:
23. I make sure that my twins know that I appreciate what they try or accomplish:

APPENDIX D

LIVING ENVIRONMENT OBSERVATION SCALE

**LIVING ENVIRONMENT-OBSERVATION SCALE  
(ADAPTED FROM H.O.M.E. – CALDWELL & BRADLEY, 1984)**

This brief observation screen should be completed by parent interviewers during home visits. Ratings can be made from casual observations of the neighborhood and home environments during the assessment process. It is not necessary to ask additional questions of the parent or the child to provide ratings of the environment since the coding is based only on observers' impressions of the neighborhood and home. Ratings should be completed immediately after leaving the visit. A description of each dimension follows, with exemplars to anchor the three points on the coding scale.

Each of the following nine dimensions should be coded using the following scale:

- |          |               |
|----------|---------------|
| evidence | 1=no/minimal  |
| evidence | 2=moderate    |
| evidence | 3=substantial |

**1. Structural Safety of the Home**

This item reflects the home's state of disrepair or neglect and those aspects of the physical environment that could be potentially dangerous to a child.

- Parts of the home appear unsafe; home creates a dangerous environment for the child; plaster coming off ceiling or walls; stairway with boards missing; exposed electrical wiring; kitchen cabinets do not have doors.....1
- Home is neither unsafe nor safe; some obvious safety modifications and repairs to physical environment are needed but the environment does not suggest imminent harm or danger to child; water stains on some ceilings or walls, wallpaper in need or some repair.....2
- No obvious repairs to the home are necessary.....3

**2. Home Décor**

This item reflects attempts to create a "homey" environment. Raters should be careful to avoid making judgements about the attractiveness or style or décor (e.g., do not include personal biases about "tasteful" or "tacky" décor.).

- Home is devoid of decoration (e.g., dark rooms, drapes drawn, or no window treatments, no pictures, nick-nacks or plants; no, or insufficient, furniture in significant living areas such as living room or dining room).....1
- Minimal decoration (e.g., bare walls, one or two table nick-nacks or pictures, bare minimum furniture present such as one couch and one table in the living room .....2
- Reasonable amount of furniture and room decorations such as nick-nacks, pictures, wallhangings, curtains, or windows treatment allow light to enter rooms.....3

**3. Child-Friendly Home**

This item reflects how child-friendly the home environment is by capturing the degree of stimulation available to the child based on the presence of materials for play and leisure and the accessibility of these materials to a young child.

- Absence of toys, games, and books appropriate for use by child this age.....1
- Presence of some toys, games and books for child this age; toys may be broken or inappropriately dirty; toys and games are generally not within easy reach of child .....2
- Many toys, games and books for child this age are in view and could be easily accessed by a child.....3

**4. Adequate Living Space for Number of Individuals in the Home**

This item reflects the relative roominess of the home environment.

- Inadequate living space available, overcrowded living conditions (e.g., a one bedroom home where child sleeps in parents’ bedroom or living room, three or more individuals in one bedroom, child has no other play area than his/her bedroom) .....1
- Living space is adequate though somewhat cramped (e.g., house does not have living space that would be equivalent to at least one 9’ x 12’ room per person) .....2
- It is easy for individuals to have a private space where there are no interruptions from others.....3

**5. Interpersonal Space**

This item captures the “busy-ness” of the home environment—the interpersonal traffic encountered during the home visit.

- There are many people in the home (e.g., 4-5 related or unrelated individuals not including the child and parents) which makes it difficult to find a private place to interview the mother and child .....1
- There are one to three related or unrelated individuals in the home making it difficult to have private time with the mother or the child because of frequent interruptions and disruptions.....2
- It is easy for individuals to have a private space where there are no interruptions from others .....3

**6. Overall Organization**

This item reflects the overall physical organization of the house.

- Home is cluttered making it difficult to walk around objects, unable to find a clear space to do assessments activities.....1
- Home is generally clean though floors may need to be vacuumed or washed; noticeable dust on furniture.....2
- Home is clean and appears to have been cleaned recently or on a regular basis.....3

**7. Cleanliness**

This item reflects how clean the house is upon casual observation.

Home is strewn with trash; kitchen areas have dirty dishes from several meals; floors are Markedly dirty.....	1
Home is generally clean though floors may need to be vacuumed or washed; noticeable dust on furniture.....	2
Home is clean and appears to have been cleaned recently or on a regular basis.....	3

**8. Outside Play Environment**

This item refers to areas outside, but connected to, the home where a young child could play, including any backyard space and the area in front of the home. The rating should include adequacy of space of play areas.

Home has no outside play area or play area is littered with garbage, dangerous objects (e.g., broken glass) or other hazards (e.g., broken toys with sharp edges, large ditches).....	1
This age child could not safely use play area unsupervised (e.g., too close to street, next to “hang-out” for older children and adults); backyard area is too small for a young child’s activities (e.g., 10’ x 10’ enclosed areas).....	2
Safe play area of adequate space with several toys or activity props.....	3

**9. Condition of Street where Child Lives**

This item captures the condition or quality of the environment directly outside the child’s home. Ratings are based on the neighborhood as seen from the front or back of the child’s home (e.g., the block or street on which the child lives).

Presence of abandoned cars, debris in the streets and on the sidewalks, abandoned buildings.....	1
There may be one abandoned car, graffiti on one or two walls in the neighborhood, or on a mailbox yet most homes are well-kept and have generally clean and well-maintained sidewalks.....	2
No evidence of debris or garbage in the streets, houses and yards appear well maintained.....	3

**ADDITIONAL COMMENTS ABOUT HOME OR NEIGHBORHOOD:**

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**ADDITIONAL COMMENTS FOR SUPERVISOR (e.g., PC wants results or is irritated...):**

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APPENDIX E  
CONFUSION, HUBBUB, AND ORDER SCALE

## CHAOS

Thinking about whether or not the statement describes your home, please circle True or False to the following statements.

- |  |      |       |
|--|------|-------|
| 1. There is very little commotion in our home.                           | True | False |
| 2. We can usually find things when we need them.                         | True | False |
| 3. We almost always seem to be rushed.                                   | True | False |
| 4. We are usually able to “stay on top of things”.                       | True | False |
| 5. No matter how hard we try we always seem to be running late.          | True | False |
| 6. It’s a real “zoo” at our home.  | True | False |
| 7. At home we can talk to each other without being interrupted.          | True | False |
| 8. There is often a fuss going on at our home.                           | True | False |
| 9. No matter what our family plans, it usually doesn’t seem to work out. | True | False |
| 10. You can’t hear yourself think in our home.                           | True | False |
| 11. I often get drawn into other people’s arguments at home.             | True | False |
| 12. Our home is a good place to relax.                                   | True | False |
| 13. The telephone takes up a lot of our time at home.                    | True | False |
| 14. The atmosphere in our home is calm.                                  | True | False |
| 15. First thing in the day, we have a regular routine at home.           | True | False |

APPENDIX F  
FAMILY ASSESSMENT DEVICE



### Family Assessment Device

Now I will read a number of statements about families. Please respond with the number that best describes your own family. You should answer according to how you see your family. If you are having trouble with a statement, respond with your first reaction, using the following scale.

1 = Strongly Agree, that is the statement describes your family very accurately.

2 = Agree, the statement describes your family for the most part.

3 = Disagree, the statement does not describe your family for the most part

4 = Strongly Disagree, the statement does not describe your family at all.

1. Planning family activities is difficult because we misunderstand each other.
2. We resolve most everyday problems around the house.
3. When someone is upset the others know why.
4. When you ask someone to do something, you have to check that they did it.
5. If some one is in trouble, the others become too involved.
6. In times of crisis we can turn to each other for support.
7. We don't know what to do when an emergency comes up.
8. We sometimes run out of things that we need.
9. We are reluctant to show our affection for each other.
10. We make sure members meet their family responsibilities.
11. We cannot talk to each other about the sadness we feel.
12. We usually act on our decisions regarding problems.
13. You only get the interest of others when something is important to them.
14. You can't tell how a person is feeling from what they are saying.
15. Family tasks don't get spread around enough.
16. Individuals are accepted for who they are.
17. You can easily get away with breaking the rules.
18. People come right out and say things instead of hinting at them.
19. Some of us just don't respond emotionally.
20. We know what to do in an emergency.
21. We avoid discussing our fears and concerns.
22. It is difficult to talk to each other about tender feelings.
23. We have trouble meeting our bills.
24. After our family tries to solve a problem, we usually discuss whether it worked or not.
25. We are too self-centered.
26. We can express feelings to each other
27. We have no clear expectations about toilet habits.
28. We do not show our love for each other.
29. We talk to people directly rather than through go-betweens.

30. Each of us has particular duties and responsibilities.
31. There are lots of bad feeling in the family.
32. We have rules about hitting people.
33. We get involved with each other only when something interests us.
34. There's little time to explore personal interests.
35. We often don't say what we mean.
36. We feel accepted for what we are.
37. We show interest in each other when we can get something out of it personally.
38. We resolve most emotional upsets that come up.
39. Tenderness takes second place to other things in our family.
40. We discuss who is to do household jobs.
41. Making decisions is a problem for our family.
42. Our family shows interest in each other only when they can get something out of it.
43. We are frank with each other.
44. We don't hold to any rules or standards.
45. If people are asked to do something, they need reminding.
46. We are able to make decisions about how to solve problems.
47. If the rules are broken, we don't know what to expect.
48. Anything goes in our family.
49. We express tenderness.
50. We confront problems involving feelings.
51. We don't get along will together.
52. We don't talk to each other when we are angry.
53. We are generally dissatisfied with the family duties assigned to us.
54. Even though we mean well, we intrude too much into each other's lives.
55. There are rules about dangerous situations.
56. We confide in each other.
57. We cry openly.
58. We don't have reasonable transport.
59. When we don't like what someone has done, we tell them.
60. We try to think of different ways to solve problems.

APPENDIX G  
FAMILY CONFLICT SCALE

## Family Conflict Scale

Please answer all of the following questions to the best of your ability.

Scaling:

Twin A:  
Never \_\_\_\_\_ Rarely \_\_\_\_\_ Occasionally \_\_\_\_\_ Often \_\_\_\_\_ Very Often \_\_\_\_\_

Twin B:  
Never \_\_\_\_\_ Rarely \_\_\_\_\_ Occasionally \_\_\_\_\_ Often \_\_\_\_\_ Very Often \_\_\_\_\_

1. It is difficult in these days of tight budgets to confine financial discussions to specific times and places. How often would you say you and your spouse argue over money in front:
2. Children often go to one parent for money or permission to do something after having been refused by the other parent. How often would you say:
3. Husbands and wives often disagree on the subject of discipline. How often do you and your spouse argue over disciplinary problems in:
4. How often has:

Twin A heard you and your spouse argue about the wife's role in the family? (Housewife, working, etc.)

Twin B heard you and your spouse argue about the wife's role in the family? (Housewife, working, etc.)

5. How often does your spouse complain to you about your personal habits (drinking, nagging, sloppiness, etc.) in front of:
6. How often do you complain to your spouse about his/her personal in front of:
7. In every normal marriage there are arguments. What percentage of the arguments between you and your spouse would you say take place in front of:

Twin A:  
Less than 10% \_\_\_\_\_ 10-25% \_\_\_\_\_ 26-50% \_\_\_\_\_ 51-75% \_\_\_\_\_ More than 75% \_\_\_\_\_

Twin B:

Less than 10% \_\_\_\_\_ 10-25% \_\_\_\_\_ 26-50% \_\_\_\_\_ 51-75% \_\_\_\_\_ More  
than 75% \_\_\_\_\_

8. To varying degrees, we all experience almost irresistible impulses in times of great stress. How often is there physical expression of hostility in front of:
9. How often do you and/or your spouse display verbal hostility in front of:

How often do you and your spouse display affection for each other in front of: