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Child Temperament Moderates Effects of Parent–Child Mutuality on Self-Regulation: A Relationship-Based Path for Emotionally Negative Infants

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This study examined infants' negative emotionality as moderating the effect of parent–child mutually responsive orientation (MRO) on children's self-regulation (n = 102). Negative emotionality was observed in anger-eliciting episodes and in interactions with parents at 7 months. MRO was coded in naturalistic interactions at 15 months. Self-regulation was measured at 25 months in effortful control battery and as self-regulated compliance to parental requests and prohibitions. Negative emotionality moderated the effects of mother–child, but not father–child, MRO. Highly negative infants were less self-regulated when they were in unresponsive relationships (low MRO), but more self-regulated when in responsive relationships (high MRO). For infants not prone to negative emotionality, there was no link between MRO and self-regulation. The ''regions of significance'' analysis supported the differential susceptibility model not the diathesis–stress model.

Self-regulation, broadly considered one of the most important and ubiquitous psychological phenomena, has been studied in virtually every domain of human life (Baumeister & Vohs, 2004; Hoyle, 2010). The focus on self-regulatory processes has also permeated almost all areas of developmental inquiry (Eisenberg, 2006). Developmental research on self-regulation encompasses a broad range of processes, including physiological regulation, emotion regulation, effortful control, self-control, inhibitory control, executive ability, or volitional control (Calkins & Fox, 2002; Eisenberg & Spinrad, 2004). The capacity for the deliberate modulation of one's behavior and emotion develops particularly rapidly in the 2nd year, and it is considered a key developmental milestone that markedly transforms the child's ability to function in the social environment (Kochanska, Coy, & Murray, 2001; Kopp, 1982; Maccoby, 2007).

Self-regulation is also an important aspect of early personality and one that has crucial implications for future development (Caspi & Shiner, 2006; Rothbart & Bates, 2006; Rothbart, Ellis, & Posner, 2004). Early individual differences in self-regulation have been implicated in developmental cascades leading to a vast range of short- and long-term outcomes. Those outcomes include adjustment, behavior problems, mental health, substance use, competencies, school readiness, academic achievement, peer relations, conscience, and health behaviors (Baumeister & Vohs, 2004; Blair & Razza, 2007; Calkins & Fox, 2002; Calkins & Keane, 2009; Kochanska & Knaack, 2003; Kochanska, Murray, & Harlan, 2000; Nigg, 2006; Rothbart & Bates, 2006; Shoda, Mischel, & Peake, 1990; Wills, Ainette, Stoolmiller, Gibbons, & Shinar, 2008).

Children's early relationships with parents have significant implications for emerging self-regulation. Positive, warm, and responsive parenting supports and promotes children's self-regulatory capacities, whereas negative, harsh, and insensitive parenting has detrimental effects (Calkins, Smith, Gill, & Johnson, 1998; Eisenberg et al., 2005; Kochanska et al., 2000; Lengua, Honorado, & Bush, 2007; Power & Chapieski, 1986). Mutually responsive, positive, harmonious, synchronous early parent–child dyadic relationships have particularly beneficial effects. Those effects include a range of outcomes, for example, attachment security, adaptive emotion regulation, or social competence (Calkins & Keane, 2009; Hofer, 1994; Lindsey, Cremeens, & Caldera, 2010; Lindsey, Cremeens, Colwell, & Caldera, 2009; Schore,

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2001; Sroufe, 1996; Thompson, Lewis, & Calkins, 2008). We have repeatedly found that a dyadic construct—parent–child mutually responsive orientation (MRO; Kochanska, 2002), a positive, connected, close, mutually binding relationship—promotes a variety of children's internally regulated behaviors (Kochanska, 1997; Kochanska, Aksan, Prisco, & Adams, 2008).

Research has also shown that children's biologically based temperaments and their environments are inextricably interwoven, and both must be considered in their interplay as contributors to developmental outcomes (e.g., Bates & Pettit, 2007; Bates, Pettit, Dodge, & Ridge, 1998; Belsky, Hsieh, & Crnic, 1998; Lerner, Nitz, Talwar, & Lerner, 1989; Rothbart & Bates, 2006; Thomas & Chess, 1977). That research has often focused on early ''difficult temperament'' (Bates, 1980), following the tradition of clinicians like Thomas and Chess (1977). Typically, early negative emotionality—intense and frequent expressions of negative emotions across a variety of contexts—is the key component of difficult temperament.

Early negative emotionality is sometimes seen as a ''diathesis'' or ''vulnerability'' factor that confers increased risks for future behavior problems, including deficient self-regulation (Bates et al., 1998; Gilliom & Shaw, 2004; Guerin, Gottfried, & Thomas, 1997; Lahey et al., 2008; Rothbart & Bates, 2006; Sanson, Hemphill, & Smart, 2004). Poor modulation of negative arousal in infancy undermines the development of self-regulated compliance at toddler age (Stifter, Spinrad, & Braungart-Rieker, 1999). A combination of early negative emotionality and a poor, negative, adversarial early parent–child relationship has been seen as posing an especially strong risk for future behavior problems, including regulatory deficits (Belsky et al., 1998; Campbell, Shaw, & Gilliom, 2000; Crockenberg, Leerkes, & Barrig Jo, 2008; Feldman, Greenbaum, & Yirmiya, 1999; Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002).

Several scholars have argued, however, that such an approach, extrapolating the ''diathesis–stress'' model, does not capture another important form of interaction between child individuality and environment: ''differential susceptibility'' to context or environment (Belsky, 1997; Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007; Belsky & Pluess, 2009; Belsky et al., 1998; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2011). In the latter view, children are seen as differing in *plasticity* or *malleability* rather than in vulnerability. Children with certain biologically based qualities, including negative emotionality, are more malleable or susceptible than others to *both* negative *and* positive environmental influences. In adverse environments, highly emotionally negative children have poorer outcomes than children not prone to negative emotion. But in supportive environments, emotionally negative children may indeed do *better* than others. Growing evidence has shown that effects of positive early relationships can go beyond ''buffering'' risks for emotionally negative children and that such relationships can even lead to superior developmental outcomes for those children (Belsky & Pluess, 2009; Kochanska, Kim, Barry, & Philibert, 2011). Sensitive parenting and mutually responsive parent–child relationship support child regulation (Sroufe, 1996), and thus, they may be especially consequential for emotionally negative children. Indeed, several studies appear to support such a model.

Spinrad and Stifter (2006) found that infants who were anger prone showed less prosocial behavior than infants who were not anger prone when their mothers were unresponsive, but those same anger-prone infants showed more prosocial behavior if their mothers were highly responsive. van Zeijl et al. (2007) found that toddlers with difficult temperaments were more susceptible to maternal negative discipline (they showed more externalizing problems), as well as more susceptible to positive discipline (they showed fewer externalizing problems and less physical aggression), compared to easy children. However, all measures were concurrent.

Several authors concluded that their studies support differential susceptibility because they showed stronger effects of parenting for difficult than for easy infants (although they did not always examine both forms of effects: better outcomes due to positive parenting and worse outcomes due to poor parenting). Feldman et al. (1999) found that infant–mother observed affective synchrony at 9 months predicted children's self-regulation at age 2 (a composite of child observed self-regulated compliance with maternal requests in a toy cleanup and in a delay task) more strongly for infants with difficult temperaments than for those with easy temperaments. But that study had a small sample (n = 33 at age 2), and the significant interaction between infant temperament and mother–child synchrony was not formally probed beyond the correlations. Mesman et al. (2009) found that observed sensitive parenting predicted a decrease in externalizing, undercontrolled problems from ages 2 to 5, but that relation was true only for children who had ''difficult temperaments.'' Sensitivity had no such beneficial effect for children who had ''easy temperaments.''

In sum, although evidence for Parenting × Child Temperament interactions continues to accumulate, the extant studies have often been subject to limitations. In particular, temperament has been typically assessed using mothers' ratings. Furthermore, another important limitation of most studies on parenting and temperament has been the sole focus on mothers, with the exclusion of fathers.

The role of fathers in development, compared to mothers, remains less understood in general in socialization research. Moreover, the extant findings are complex. Mothers and fathers are thought to take on different roles, with fathers more likely to engage in play and mothers—in routine care giving (Parke & Buriel, 2006). Father–child play and shared positive affect are considered important factors for children's future self-regulatory competence (Lindsey & Mize, 2000; Lindsey et al., 2009; MacDonald & Parke, 1984; McDowell & Parke, 2009). Data, however, are limited. Even less is known about early difficult Temperament × Environment interactions with respect to father–child relationships. Belsky et al. (1998) found that fathers' parenting predicted future inhibition, but only for infants high in negativity. Kochanska, Aksan, and Carlson (2005) found that a combination of negativity and insecurity with fathers was associated with poor outcomes in the 1st year. Lindsey et al. (2010) assessed children's difficult temperament when examining the effect of father–child mutuality on children's social competence, but they considered it as a covariate and not a moderator.

In this longitudinal investigation, we examined the links between the parent–child MRO and children's emerging self-regulation at toddler age for infants differing in negative emotionality. We included both mothers and fathers. All measures (infants' negative emotionality, parent–child MRO, child self-regulation) were observed, either at home or in the laboratory. Consistent with the extant research on Temperament × Parenting interactions, we expected that for highly negative infants, variations in MRO would significantly impact future self-regulation, but for infants who were not prone to negative emotions, those variations would be less consequential.

We were especially interested in exploring, whether, when predicting self-regulatory capacities, those interaction effects conform to the diathesis–stress model or to the differential susceptibility model. To do so, we performed the ''regions of significance'' analysis to identify the *specific levels of the child's negative emotionality* above which the simple slopes of MRO on self-regulation were significant (Kochanska et al., 2011; Preacher, Curran, & Bauer, 2006). This analysis formally elucidated whether highly emotionally negative infants, when in positive early parent–child relationships, do as well as—but not better than—low-negative-emotionality infants (diathesis–stress), or whether those highly negative infants can indeed surpass infants who are not prone to negative emotions (differential susceptibility). The use of the regions of significance has been increasingly accepted and encouraged as a formal method of testing diathesis–stress versus differential susceptibility hypotheses (Belsky & Pluess, 2012).

We aimed for a comprehensive assessment of children's self-regulation. Toward that aim, we included measures of effortful control, observed in a battery of tasks administered by an experimenter, and measures of self-regulated compliance with each parent's requests and prohibitions. Effortful control—the capacity to suppress a dominant response and perform a subdominant response—has been extensively studied, using standardized tasks that call for deliberate delaying, slowing down movements, lowering voice, Stroop-like attention tasks, and stopping and initiating response to signals (Kochanska & Knaack, 2003; Kochanska et al., 2000; Rothbart & Bates, 2006). But many researchers have also studied children's self-regulation in naturalistic parent–child contexts that call for deliberate, active modulation of conduct, or compliance, and have found that effortful control and self-regulated compliance are related (e.g., Calkins & Howse, 2004; Kopp, 1982; Olson, Bates, & Bayles, 1990; Vaughn, Kopp, & Krakow, 1984). As the child's self-regulatory capacities emerge in the beginning of the 2nd year and mature thereafter, parents increasingly expect self-regulated compliance (Kopp, 1982). Note, however, that compliance in parent–child contexts involves a relational component that is absent in nonsocial effortful control tasks presented as challenging ''games'' by an unfamiliar experimenter. Consequently, when predicting effortful control, we examined MRO with both parents (and its interactions with child negative emotionality), but when predicting self-regulated compliance, we focused on the child's earlier history of the relationship (MRO) with the given parent (and its interaction with negative emotionality).

In sum, this longitudinal study examined the links between children's negative emotionality in infancy, their mutually responsive relationships (MRO) with both parents at the beginning of the 2nd year, and their self-regulation at toddler age. Negative emotionality was expected to moderate the effects of MRO on self-regulation, such that those effects were hypothesized to be particularly pronounced for highly emotionally negative infants. We also examined the specific form of Negative Emotionality × MRO interactions (diathesis–stress vs. differential susceptibility).

Method

Participants

Two-parent families of normally developing infants volunteered for the study advertised in Midwestern communities (a college town, a small city, and rural areas). In terms of race, 91% of mothers were White, 3% Hispanic, 1% each African American, Asian, Pacific Islander, and 3% Other non-White. Among fathers, 83% were White, 8% Hispanic, 3% African American, 3% Asian, and 3% Other. In 20% of families, one or both parents were non-White.

Approximately 30% of the parents had a high school education, and 20% had a postgraduate education, 25% had an annual income of $40,000 or less, and 34% had an income of $70,000 or more.

Overview

We focus on the data from three assessments. When children were 7 months (n = 102, 51 girls), we measured their negative emotionality; at 15 months (n = 101, 51 girls), we assessed parent–child MRO, and at 25 months (n = 100, 50 girls), we measured children's self-regulation. At each time, there were two 2- to 3-hr sessions, on 2 different days, one with each parent (at home at 7 months, in the laboratory at 15 and 25 months), conducted by female experimenters (Es). At 7 months, the mother session was first and the father session second, and at 15 and 25 months, the order was randomized. The measures were all coded from videotapes by multiple teams. Reliability was typically established on 20%–25% of cases, followed by realignments to prevent coders' drift. Data were aggregated across trials, episodes, contexts, and so on, to assure robust final constructs.

Assessments and Measures

Assessment of Proneness to Anger, 7 Months

Observed episodes. Proneness to anger was observed in three episodes adapted from the Laboratory Temperament Assessment Battery (Lab-Tab; Goldsmith & Rothbart, 1999), spaced throughout both sessions (for details, see Kochanska, Coy, Tjebkes, & Husarek, 1998). In Arm Restraint, the baby's forearms were pressed gently to his or her sides as the baby was engaged with a toy (2 trials, up to 30 s); in Toy Retraction, an attractive toy was taken away when the baby was playing with it and held briefly out of reach (3 trials, up to 15 s); and in Car Seat, the baby was buckled tightly in a car seat for 60 s. An episode was terminated if the child became very upset.

Coding. The coders rated discrete facial, vocal, and bodily anger expressions, using brief segments (5–6 s), latency to the first anger expression, and intensity. Intensity for facial anger ranged from 0 (*none*) to 3 (*strong, in all three facial regions*); for vocal anger, from 0 (*none*) to 5 (*full intensity cry or scream*); for bodily anger, from 0 (*none*) to 4 (*high intensity, continuous struggle*). Reliabilities for discrete anger expressions during Arm Restraint, Toy Retraction, and Car Seat, average kappas were, respectively, .78, .74, and .67, and, average alphas for latency and intensity ratings were .93, .93, and .85.

Data aggregation. Latencies were reversed and all codes were standardized and then aggregated within each episode to produce a composite score for each episode. Cronbach's alphas for the three episodes were, respectively, .75, .69, and .79. The three composite scores were combined into one overall score of proneness to anger at 7 months (M = 0.00, SD = 0.42, range = −0.84–1.32).

Assessment of Negative Emotion Expression in Naturalistic Interaction, 7 Months

Observed contexts. The infant was observed in multiple scripted, but naturalistic contexts (the total time approximately 45–50 min with each parent). The contexts included: parent busy with a kitchen chore (7 min; parent could choose a chore, which was typically snack preparation), snack (6 min; feeding the baby, cleaning after the snack), play with no toys (5 min), play with toys (5 min), prohibition (5 min; parent kept the baby away from a plastic plant placed on the floor), free play (3 min; E emptied a basket of toys on a blanket), caregiving (12 min; parent gave the baby a bath, toweled him or her off, dressed, brushed hair, changed a diaper), and gift (2 min; E gave the parent and child a gift that they opened together).

Coding. The infant's affect was coded every 30 s across all the contexts. In this study, we focused on negative affect expressions only: neutral negative (not a ''full-blown'' negative affect, but signs of fatigue, subtle discomfort, a minor whimper, negatively ''tinged'' affect, etc.) and discrete negative affect expression (''full-blown'' distress, cry, fussiness, anger, etc.). Particularly intense or pervasive (15 s or more) expressions were marked. The average kappa across several pairs of coders was .81.

Data aggregation. We weighed the tallied instances of the infant's intense or pervasive negative affect by 3, their discrete negative affect by 2, and their neutral negative mood by 1. These figures were then added and divided by the number of coded segments to create a score of the infant's negative emotion expression in naturalistic interactions, separately with each parent (with mother, $M = 0.38$, $SD = 0.34$, range = 0.00–1.63; with father, $M = 0.40$, $SD = 0.41$, range = 0.00–2.85).

Infants' Negative Emotionality Composite

The infant's proneness to anger correlated with negative emotion expression with the mother, $r(102) = .19$, $p < .06$, and with the father, $r(102) = .41$, $p < .001$, and negative emotion expression correlated across both parents, $r(102) = .20$, $p < .05$. As the last step, we aggregated those three scores (having standardized the latter two) into the negative emotionality composite ($M = 0.00$, $SD = 0.59$, range = −0.81–2.17). There were no gender differences in negative emotionality.

Assessment of Mother–Child and Father–Child MRO, 15 Months

Observed contexts. Each mother–child and father–child dyad was observed for approximately 45 min, in scripted, naturalistic, interactive contexts in the laboratory session. The contexts included the introduction to the laboratory (5 min; E brought in the parent and the child to the laboratory ''living room,'' pointed out snacks and toys, introduced the prohibition regarding the off-limits toys on the low shelf, etc.), snack (10 min; parent and child chose a snack from the food shelf), parent busy with questionnaires (7 min), play (5 min; E spilled toys from a basket on the floor and invited parent and child to play), putting toys away after play (10 min), and opening gifts for the parent and child (5 min; at the end of the session, E handed the parent and the child each a gift as tokens of appreciation, and allowed time to open and enjoy them).

Coding. Having watched all the contexts for each dyad, the coders made one overall judgment regarding MRO, from 1 = *very untrue of the dyad* to 5 = *very true of the dyad*. Coder reliability for MRO, average kappa, was .76. That overall judgment represented the coder's impression of the parent–child dyadic functioning across five domains: (a) smooth, synchronous, coordinated routine; (b) mutual cooperation and receptivity; (c) connectedness; (d) harmonious communication; and (e) emotional ambiance (Kochanska et al., 2008). For mother–child dyads, the mean was 3.23 ($SD = 1.25$, range = 1–5), and for father–child dyads, the mean was 3.34 ($SD = 0.99$, range = 1–5); those means were not significantly different, $t(100) < 1$. Mothers and daughters had higher scores ($M = 3.47$, $SD = 1.27$) than mothers and sons ($M = 2.98$, $SD = 1.19$), $t(99) = 2.00$, $p < .05$. There were no gender differences in father–child MRO. The MRO scores were standardized for the following analyses.

Assessment of Children's Effortful Control, 25 Months

Observed tasks. The children performed five tasks developed to assess the child's ability to suppress a dominant response and perform a subdominant response (Kochanska et al., 2000). Three tasks targeted the ability to delay. In Snack Delay (administered in both the mother and father sessions), the child waited to reach for an M&M placed under a transparent cup until E rang the bell that she lifted mid-way through the delay but did not ring until the end (four trials, with delays of 10, 20, 30, and 15 s). In Wrapped Gift, the child first waited, with his or her back to E and without peeking, for E to wrap a gift (60 s), and then waited, without touching or leaving seat, until E returned with a bow (3 min). Gift in Bag was very similar to Wrapped Gift, but it did not involve the wrapping phase (the gift was placed in the bag). The Tower task (two trials) targeted the capacity to suppress or initiate activity to signal. The child and E took turns adding blocks (up to 13 total) to the block tower. The child was asked to wait to put the next block until after E had placed her block.

Coding. In each task, a higher score denoted better effortful control. In Snack Delay, the scores ranged from 0 (*eats snack before E lifts the bell*) to 4 (*waits until bell is rung*). In Wrapped Gift, the peeking score (during the wrapping phase) ranged from 1 (*turns body fully around to see*) to 5 (*does not peek*). The touch score (during the waiting-for-the-bow phase) ranged from 1 (*opens gift*) to 4 (*never touches*), and the seat score ranged from 1 (*remains in seat for < 30 s*) to 4 (*in seat for more than 2 min*). The latencies to peek, turn body, touch, lift, or open gift, and to leave seat were also coded in seconds. The Gift in Bag was coded in a very similar manner, except it did not include the wrapping phase codes. In

Tower, the total number of blocks comprising the final tower was multiplied by 10, and that figure was divided by the number of blocks placed by the child; additionally, 5 points were added if the child gently removed any blocks, and 5 points were subtracted if the child intentionally knocked down the tower during the task.

The reliabilities for specific behavioral codes for the tasks, in kappas, ranged from .77 to 1.00. Alphas for latency scores (e.g., latency to peek) ranged from .88 to 1.00.

Data aggregation. All codes were first standardized. The scores in Snack Delay were averaged across four trials (αs = .84 and .84, in each session). In the Wrapped Gift, the wrapping phase codes were averaged (peeking score, latencies to peek, turn body; α = .85) and the waiting-for-bow codes were averaged (touch score, seat score, and latencies to touch, lift, open gift, and leave seat; α = .82). In the Gift in Bag, all codes were averaged (α = .89). In Tower, the scores were averaged across the two trials (r = .28, $p < .05$). Because the effortful control tasks' composites cohered (Cronbach's alpha = .71), they were aggregated into one overall effortful control score (M = −0.01, SD = 0.66, range = −1.90–1.36). Girls had higher effortful control scores than boys (M = 0.13, SD = 0.66; M = −0.14, SD = 0.65, respectively), $t(98)$ = 2.00, $p < .05$.

Assessment of Children's Self-Regulated Compliance to Parental Requests and Prohibitions, 25 Months

Observed contexts. Parents and children were observed in naturalistic, scripted discipline contexts: toy cleanup when the parent asked the child to pick up toys after play (10 min with each parent), and prohibition when the parent asked the child not to touch very attractive, easily accessible toys, designated at the outset as off limits (37 min with each parent).

Coding. The child's behavior was coded for every 30-s segment. In the present study, we focused on self-regulated (committed) compliance, coded when the child appeared fully internally regulated and did not require parental control to sustain the requested behavior or refrain from prohibited behavior (see Kochanska et al., 2001, for the details of coding). Reliabilities, kappas, were .88 for the cleanups, and .80 for the prohibition.

Data aggregation. All instances of self-regulated compliance in the cleanup and prohibition contexts were tallied and divided by the number of the coding segments. For children with mothers, in the cleanup context, the mean was 0.16 (SD = 0.22, range = 0–0.95), and in the prohibition context, the mean was 0.63 (SD = 0.31, range = 0–1.00); for children with fathers, the means were 0.13 (SD = 0.20, range = 0–0.82) and 0.67 (SD = 0.27, range = 0.11–1.00), respectively. For each child (with each parent), we standardized the committed compliance scores and averaged across the toy cleanup and prohibition contexts, to represent his or her self-regulated response to each parent's discipline; the mean with mothers was 0.00 (SD = 0.73, range = −1.37–2.33), and with fathers was 0.00 (SD = 0.73, range = −1.34–1.98). Girls showed more self-regulated compliance with mothers (M = 0.16, SD = 0.68) than boys (M = −0.16, SD = 0.75), $t(98)$ = 2.25, $p < .05$, and with fathers (girls, M = 0.28, SD = 0.67; boys, M = −0.28, SD = 0.68), $t(98)$ = 4.18, $p < .0001$.

Results

Preliminary Analyses

We first examined the correlations among the studied constructs. The child's MRO scores with the mother and father were significantly correlated, r = .35, $p < .001$. Infants' negative emotionality was modestly negatively correlated with mother–child MRO, r = −.20, $p < .05$, and with one outcome: self-regulated compliance to paternal control, r = −.20, $p < .05$. Mother–child (but not father–child) MRO was positively correlated with one outcome: effortful control, r = .41, $p < .001$. The outcomes (effortful control, self-regulated compliance to the mother and the father) were moderately positively intercorrelated, rs = .28–.51, ps < .01, all dfs = 100–101.

Negative Emotionality, MRO, and Their Interactions Predicting Effortful Control

Multiple Regression Analysis

We first conducted a hierarchical multiple regression to examine the main effects of children's negative emotionality, mother–child and father–child MRO, and the interactions (MRO With Each Parent × Negative Emotionality) on effortful control (note that all variables had been standardized). Due to several gender differences, gender was covaried in Step 1 (F_{ch} = 4.01, $p < .05$), followed by child negative emotionality in Step 2 (F_{ch} = 2.64, *ns*), mother–child and father–child MRO in Step 3 (F_{ch} = 7.43, $p < .001$), and the interactions of mother–child and father–child MRO with negative emotionality in Step 4 (F_{ch} = 4.77, $p < .025$). The findings can be found in Table 1. In the final equation, with all the

Table 1
Infants' Negative Emotionality, Mother–Child and Father–Child MRO, and Their Interactions as Predictors of Children's Self-Regulation

	Children's self-regulation outcomes at 25 mo					
	Effortful control		Self-regulated compliance to M		Self-regulated compliance to F	
Predictors	*F*	β	*F*	β	*F*	β
C Gender	1.72	−.12	4.10*	−.20	17.25***	−.38
C Negative Emotionality, 7 mo	< 1	.01	< 1	.04	1.76	−.13
M–C MRO, 15 mo	13.10***	.36	1.42	.12	—	—
F–C MRO, 15 mo	< 1	.07	—	—	3.82†	.18
M–C MRO × C Negative Emotionality	5.06*	.23	3.99*	.20	—	—
F–C MRO × C Negative Emotionality	1.18	.11	—	—	1.07	.10

Note. MRO = mutually responsive orientation; M = mother; F = father; C = child; mo = months. The values are from the final equations, with all the predictors entered. For effortful control: Step 1, C Gender; Step 2, C Negative Emotionality; Step 3, M–C MRO and F–C MRO; Step 4; M–C MRO × C Negative Emotionality and F–C MRO × C Negative Emotionality. For self-regulated compliance to M: Step 1, C Gender; Step 2, C Negative Emotionality; Step 3, M–C MRO; Step 4; M–C MRO × C Negative Emotionality. For self-regulated compliance to F Step 1, C Gender; Step 2, C Negative Emotionality; Step 3, F–C MRO; Step 4; F–C MRO × C Negative Emotionality.
†$p < .10$. *$p < .05$. ***$p < .001$.

predictors entered, there was a main effect of mother–child MRO, with higher scores predicting higher effortful control. That effect, however, was qualified by a significant interaction of mother–child MRO and child negative emotionality. There were no significant effects for father–child MRO. The overall R^2 was .27, $F(6, 93) = 5.63$, $p < .0001$.

Simple Slopes Analysis

To probe the interaction effect of Infant Negative Emotionality × Mother–Child MRO, we estimated the simple slopes for the infants who were low on negative emotionality (−1 *SD* below the mean) and those who were high (+1 *SD* above the mean; Aiken & West, 1991). As depicted in Figure 1, the simple slope for infants who were high on negative emotionality was significant, $b = .36$, $SE = 0.08$, $p < .001$, but for infants who were low, it was not significant, $b = .11$, $SE = 0.09$, *ns*. For highly emotionally negative infants, variation in mother–child MRO was significantly associated with effortful control, but there was no such association for low-negative infants.

''Regions of Significance'' Analysis

In the simple slope analysis, +1 *SD* above the mean and −1 *SD* below the mean of a moderator are conventionally designated as high and low levels, respectively. Although widely used, the ±1 *SD* values are arbitrary. Imagine, for example, a situation when a simple slope is significant at the level of the moderator that is either slightly above +1 *SD* or slightly below −1 *SD*. Then, the significance of the simple slope may not be detected. By contrast, the ''regions of significance'' analysis computes and graphically represents the specific upper and lower bounds of a moderator variable (in this case, infants' negative emotionality; (Aiken & West, 1991; Hayes & Matthes, 2009; Preacher et al., 2006, http://www.quantpsy.org/interact/mlr2.htm). Consequently, this approach allows for much greater precision in identifying the moderating effects than the conventional representation of the slopes (±1 *SD*, as in Figure 1). The regions of significance indicate the exact ranges of the moderator variable where the simple slopes are significantly different from zero. Thus, above the upper bound of infants' negative emotionality, the simple slope is significantly positive. Below the lower bound, the simple slope is significantly negative.

This additional computation produced the upper and lower bounds of the regions of significance: −0.39 and −9.81, respectively. When infants' negative emotionality was greater than −0.39, the increase in mother–child MRO score significantly predicted the increase in child effortful control score.

Note, however, that the observed range of infants' negative emotionality in this sample was between −0.81 and 2.17, and thus, the value of the lower bound of the region of significance (−9.81) was well beyond that range. Consequently, although calculable, it was not practically interpretable, and thus it is not depicted.

Figure 2 depicts three simple slopes and the region of significance. The red line indicates the

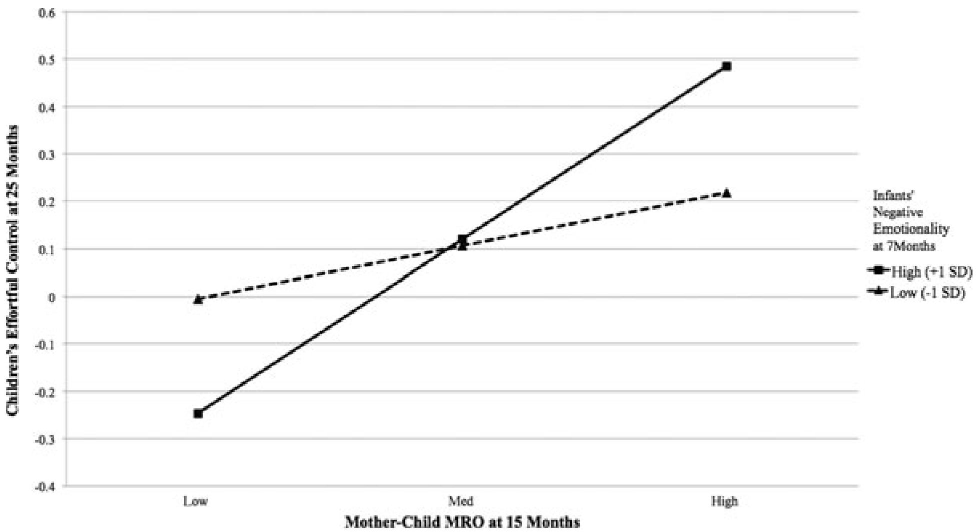

Figure 1. Infants' negative emotionality at 7 months moderates the effect of mother–child mutually responsive orientation (MRO) at 15 months on children's effortful control at 25 months (conventional simple slopes analysis).
Note. Solid line represents a significant simple slope (+1 *SD*); dashed line represents a nonsignificant simple slope (−1 *SD*).

simple slope of the maximum observed negative emotionality (2.17), and the blue line indicates the simple slope of the minimum observed negative emotionality (−0.81). The black compound line indicates the simple slope of the upper bound (−0.39) of the regions of significance. The shaded areas between the simple slopes of the upper bound and the maximum observed score (red line) represent the region of significance. Note that Figure 2 clearly supports the differential susceptibility model. In positive mother–child relationships (high MRO), infants with relatively high negative emotionality developed significantly better effortful control than infants with low negative emotionality. However, in negative mother–child relationships (low MRO), infants with high or even average negative emotionality developed significantly poorer effortful control than infants low in negative emotionality.

Negative Emotionality, MRO, and Their Interaction Predicting Self-Regulated Compliance With Mothers

Multiple Regression Analysis

We examined the main effects of children's negative emotionality, mother–child MRO, and their interaction on children's self-regulated compliance with mothers. The equation was analogous to the one described earlier, except that in Step 3, only mother–child MRO was entered, and in Step 4, only the interaction of Mother–Child MRO × Child Negative Emotionality was entered. F_{ch} values were: after Step 1, 5.08, $p < .05$; after Step 2, < 1; after Step 3, 1.35, *ns*; after Step 4, 3.99, $p < .05$. The findings are presented in Table 1. The effect of gender remained significant. There was also a significant interaction of mother–child MRO and child negative emotionality. The overall R^2 was .10, $F(4, 95) = 2.69$, $p < .05$.

Simple Slopes Analysis

Again, we probed the interaction of infant negative emotionality and mother–child MRO using the conventional simple slopes approach. As depicted in Figure 3, the simple slope for highly negative infants was significant, $b = .21$, $SE = 0.10$, $p < .05$, but for less negative infants, it was not significant, $b = -.04$, $SE = 0.10$, *ns*. For highly negative infants, variation in mother–child MRO was significantly associated with self-regulated compliance, but there was no such association for infants who were low on negative emotionality.

''Regions of Significance'' Analysis

Again, we computed and graphically represented the ''regions of significance'' with the upper and lower bounds of infants' negative emotionality. The upper and lower bounds of the regions of significance were 0.37 and −59.97, respectively. Consequently, when infants' negative emotionality was > 0.37, the simple slope was significantly positive. In other words, in those dyads where the infant's negative emotionality score was > 0.37, the increase in mother–child MRO score significantly predicted

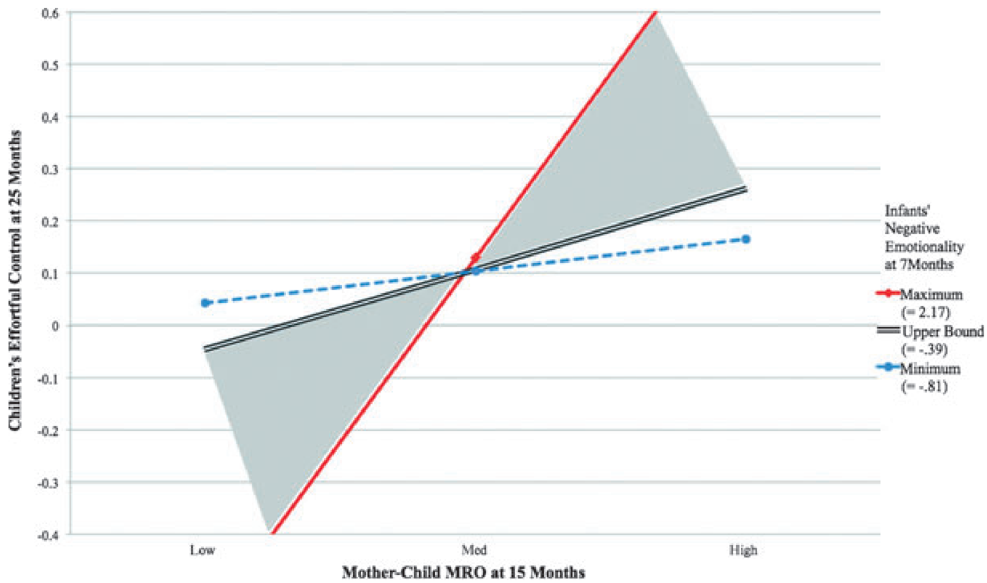

Figure 2. Infants' negative emotionality at 7 months moderates the effect of mother–child mutually responsive orientation (MRO) at 15 months on children's effortful control at 25 months (regions of significance analysis).
Note. Red solid line represents the significant simple slope of the maximum observed negative emotionality score. Blue dashed line represents the nonsignificant simple slope of the minimum observed negative emotionality score. Black compound line represents the upper bound of the region of significance, and the shaded area represents the region of significance.

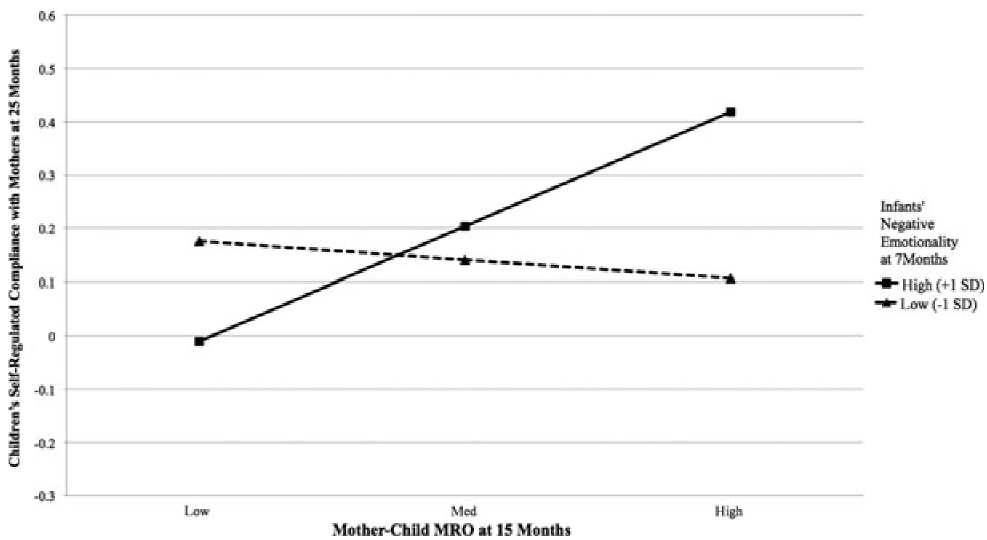

Figure 3. Infants' negative emotionality at 7 months moderates the effect of mother–child mutually responsive orientation (MRO) at 15 months on children's self-regulated compliance with mothers at 25 months (conventional simple slopes analysis).
Note. Solid line represents a significant simple slope (+1 *SD*); dashed line represents a nonsignificant simple slope (−1 *SD*).

the increase in the child's self-regulated compliance score.

Recall that the observed range of infants' negative emotionality in this sample was between −0.81 and 2.17. Consequently, the value of the lower bound of the region of significance (−59.97) was well beyond that range. Thus, although calculable, it was not practically interpretable, and is not depicted.

Figure 4 depicts three simple slopes and the region of significance. Just as in Figure 2, the red line represents the simple slope of the maximum observed negative emotionality and the blue line represents the simple slope of the minimum nega-

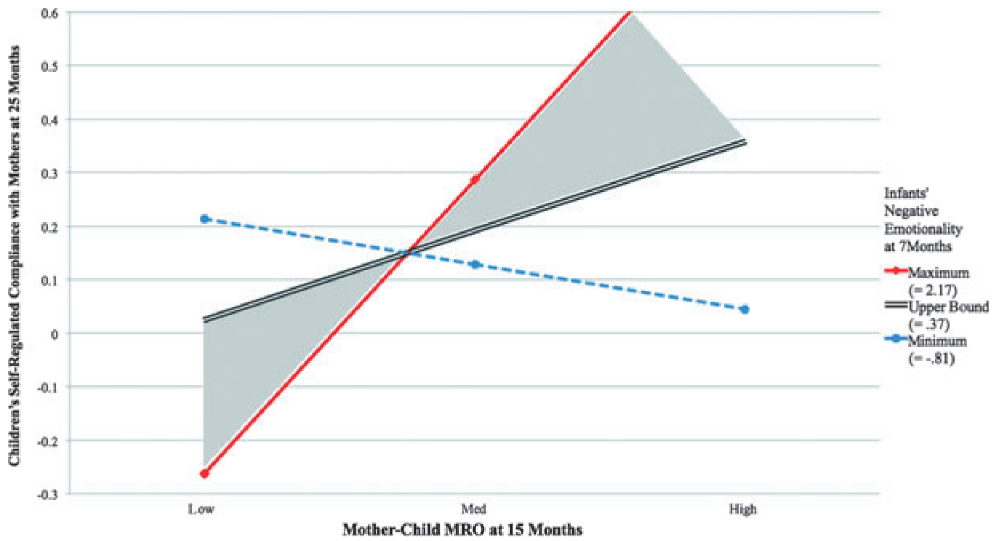

Figure 4. Infants' negative emotionality at 7 months moderates the effect of mother–child MRO at 15 months on children's self-regulated compliance with mothers at 25 months (regions of significance analysis).
Note. Red solid line represents the significant simple slope of the maximum observed negative emotionality score. Blue dashed line represents the nonsignificant simple slope of the minimum observed negative emotionality score. Black compound line represents the upper bound of the region of significance, and the shaded area represents the region of significance.

tive emotionality. The black compound line indicates the simple slope of the upper bound (0.37) of the regions of significance. The shaded areas represent the region of significance. Note that Figure 4 again clearly supports the differential susceptibility model. In positive mother–child relationships (high MRO), infants with high negative emotionality developed significantly better self-regulated compliance than infants with low negative emotionality. In negative mother–child relationships (low MRO), infants with high negative emotionality developed significantly poorer self-regulated compliance than infants low in negative emotionality.

Negative Emotionality, MRO, and Their Interaction Predicting Self-Regulated Compliance With Fathers

Regression Analysis

We examined the main effects of children's negative emotionality, father–child MRO, and their interaction on children's self-regulated compliance with fathers (see Table 1). The equation was analogous to the one that predicted self-regulated compliance with mothers (with mother–child MRO replaced by father–child MRO). F_{ch} values were: after Step 1, 17.45, $p < .001$; after Step 2, 3.78, $p < .10$; after Step 3, 3.62, $p < .10$; after Step 4, 1.07, *ns*. The effect of gender remained significant, and the main effect of father–child MRO was marginal, $p < .06$. There was no significant interaction. The overall R^2 was .22, $F(4, 95) = 6.75$, $p < .0001$. Consequently, we did not conduct the simple slopes or ''regions of significance'' analyses.

Discussion

This longitudinal study adds to the growing body of research on interactions between child temperament and environment in the context of different trajectories in the emerging early self-regulation. Infants' early negative emotionality moderated the effects of the history of mother–child MRO on self-regulation. The relationship history was particularly significant for infants who were prone to negative emotionality. These infants were especially susceptible to the quality of maternal care, or sensitive to context: They did very poorly when in negative, nonsupportive early relationship, but very well when in a mutually responsive one. This was true for both effortful control and self-regulated compliance with the mother. In mutually positive, reciprocal mother–infant dyads, remarkably, highly emotionally negative infants *outperformed* those who were less negative.

The strengths of this study include reliance on observational measures, data on both mother–child and father–child dyads, and a relatively comprehensive assessment of self-regulation.

Another contribution of this study was to provide the formal testing of Negative Emotionality × MRO interactions to elucidate the exact form of the effects, beyond the conventional ''eyeballing,'' and thus to inform the ongoing discussion of the issues of diathesis–stress versus differential susceptibility to the environment in development. Our data clearly supported the model of differential susceptibility to the environment. They also highlighted the particular importance of the quality of the mother–child relationship at the end of the 1st year. Early negative emotionality, as assessed in this study, was not a ''vulnerability factor.'' When considered with the other predictors, it did not explain any significant unique variance in self-regulation. It did, however, clearly serve as a ''plasticity,'' ''malleability,'' or ''sensitivity-to-context'' factor.

These findings are consistent with our earlier findings of children with traditionally considered ''high-risk'' genotypes (a short allele, 5-HTTLPR) who, if they had highly responsive mothers, became *more* prosocial than their peers with traditionally ''low-risk'' genotypes (Kochanska et al., 2011). They are also consistent with other evidence. For example, Spinrad and Stifter (2006) found that, compared to not-anger-prone toddlers, highly anger-prone toddlers of responsive mothers were *more* prosocial, but highly anger-prone toddlers of unresponsive mothers were *less* prosocial. The findings are also consistent with the studies that have examined Temperament × Parenting interactions for global measures of behavior problems, typically assessed by ratings (e.g., Bates et al., 1998; Mesman et al., 2009; van Zeijl et al., 2007). The current study expands the earlier findings by demonstrating the moderating effects of early child temperament on children's self-regulation, with all constructs observed in especially designed multiple tasks and behavioral scripted contexts, at home and laboratory, and in interactions with both parents.

What may account for our findings? Responsive and affectively positive mothers may be particularly attuned to and concerned about their highly negative infants' emotional cues and consequently, they may deploy especially helpful attention management strategies that support infants' regulatory skills (Crockenberg et al., 2008). Early positive mutuality has been stressed as critical for the child's ability for self-regulation—from modulating emotional arousal to complex executive capacities (Hofer, 1994; Schore, 2001; Sroufe, 1996; Thompson et al., 2008). For infants who have difficulty in modulating emotional arousal, early relationships that promote self-regulatory capacity are particularly consequential. But for children who have more effective physiological regulation capacities, relationship-based supports may be less important. More research is needed to understand mechanisms of the potent impact of early mother–child mutuality for highly emotionally negative infants.

As well, more research is needed to understand how the father–child relationship, alone or in interaction with child temperament, contributes to self-regulation. The levels of mother–child and father–child MRO were similar and modestly correlated. Nevertheless, for highly emotionally negative infants, only mother–child MRO had implications for future self-regulation. Perhaps the low-key, comforting, intimate style of maternal interactions with infants—especially with those who are prone to negative emotions—provides more support for psychological regulation, arousal modulation, and future behavioral regulation than the high-intensity, playful style typically adopted by fathers (Maccoby, 1990; Parke & Buriel, 2006). Perhaps compared to fathers, mothers become more attuned to their infants and more supportive of them when they perceive them as difficult, as suggested by recent findings that mothers hold more child-oriented beliefs about their infants' crying than do fathers (Leerkes, Parade, & Burney, 2010).

Our score of MRO as an overall construct, as used in this study, may not have been sensitive enough to detect subtle differences in aspects of mutuality between mothers and fathers and their possible varying outcomes. For example, Lindsey et al. (2009) examined two components of mutuality—mutual compliance and shared positive affect in mother–child and father–child dyads. The findings indicated possible differences in their associations with future self-control in the context of the two relationships. Future studies should also examine more aspects of parent–child relationships, beyond mutuality, including positive and negative discipline (van Zeijl et al., 2007).

The main advantage of the testing of interaction effects using the ''regions of significance,'' compared to the conventional simple slopes strategy, was that it allowed us to identify the exact level of the early negative emotionality above which MRO had a significant effect (slope) on self-regulation. Although this advantage of the ''regions of significance'' analysis was already discussed by Aiken and West (1991), it has not been widely used until Preacher et al. (2006) offered a simple statistical method of implementing it. We can now answer, with much more precision than typically possible, questions about interaction effects. In this study, we can specify in what range of early child negative emotionality MRO has a beneficial effect on self-regulation. For example, when effortful control was considered, a positive mother–child relationship had significant implications for all children who were above −0.39 on negative emotionality, 69% of whom were in this range. This is consistent with the strong effect mother–child MRO had on effortful control in general. However, for self-regulated compliance, MRO had significant implications for only 20% of children whose negative emotionality was above 0.37. Perhaps other aspects of the relationship, such as maternal style of discipline, maternal mood, attachment organization, or the type of demands directed at the child, alone or in interaction with child temperament, also come into play as predictors of compliance. Note that the conventional simple slopes approach would not reveal such nuanced differences.

The ability to describe Temperament × Environment interactions with greater precision is particularly useful in the context of the recent interest in understanding whether such interactions conform to the diathesis–stress or differential susceptibility models. In most studies to date, such inferences are based on simple visual impressions of the shape of the slopes (Belsky & Pluess, 2009). However, the strategy based on the regions of significance illustrates precisely whether the specific significant interaction consists *only* of the combination of an adverse environment and a characteristic of the child's individuality (diathesis–stress), or whether it incorporates *also* the combination of a beneficial environment and the child's characteristic. When *both* effects are part of the interaction, then that interaction represents differential susceptibility (as in Figures 2 and 4). Differential susceptibility implies that the child's individual quality (here, negative emotionality) is not as much a vulnerability factor, as it is a plasticity factor.

A better understanding of such effects has also significant implications for translational research on early prevention. For example, based on our results, infants who are prone to anger and frustration and who express frequent negative affect in daily interactions, and their mothers, should be considered primary candidates for early parenting interventions that increase maternal sensitivity, mutuality, and affective synchrony. In fact, growing evidence supports a view that difficult, highly negative infants benefit most from such interventions (van den Boom, 1994; Ellis et al., 2011). Consequently, infant individuality should be routinely examined as a moderator of the effectiveness of randomized parenting interventions that target mother–child mutuality (Brody, Beach, Philibert, Chen, & Murry, 2009; Cassidy, Woodhouse, Sherman, Stupica, & Lejuez, 2011).

This study had several limitations. The sample was relatively homogeneous, and relatively low in terms of risk. We studied typical, well-functioning, two-parent community families, where parent–child relationships were, by and large, quite adaptive and of good quality. The ethnic diversity was modest. More high-risk and more diverse samples would likely allow for additional insights about the impact of the environment on children's self-regulation. The importance of broad variation in the measures of both child individuality and the environment has been particularly emphasized in the context of the formal testing of the differential susceptibility hypothesis (Ellis et al., 2011; Kochanska et al., 2011), when we examine interaction effects for children very high and very low on certain individual characteristics and across the spectrum of maternal care, from very poor and unsupportive to very positive and responsive. Furthermore, the study was correlational in design. Randomized experiments (e.g., Brody et al., 2009) can provide a stronger test for Temperament × Environment interactions. Despite these limitations, this longitudinal study employing behavioral measures of temperament, environment, and developmental outcomes, yielded promising data on divergent trajectories for children with similar temperament but differing experiences. These data add to the extant body of research and have a potential to inform prevention and intervention efforts.

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