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Maternal Frontal EEG Asymmetry and Chronic Stressors Moderate the Link between Child Conduct Problems and Maternal Negativity

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Abstract

Frontal EEG asymmetry is associated with individual differences in positive/negative emotionality and approach/avoidance tendencies. The current study examined the moderating role of maternal resting frontal EEG asymmetry on the link between child behavior problems and maternal harsh parenting, within the context of differing degrees of chronic family stressors (father unemployment, single parenthood, caring for multiple children, and household chaos). The sample included 121 mother-child pairs. Results showed that stressors and frontal EEG asymmetry together moderated the link. Child problem behaviors were moderately associated with greater maternal negativity for mothers with right frontal asymmetry, or mothers who experienced more stressors. However, no association existed between child behavior problems and maternal negativity for mothers with few stressors and left frontal asymmetry. The findings implicate transactions between household stress and a psychophysiological indicator of maternal emotional reactivity and mothers' approach/avoidance tendencies, in the etiology of parental negativity toward challenging child behaviors.

Keywords

behavior problems; frontal EEG asymmetry; stress; parenting

Harsh maternal negativity and child behavioral problems influence each other over time, and the association tends to be strongest in households with the highest levels of stress (Meunier, Wade, & Jenkins, 2012; Patterson, 1997; Scaramella, Sohr-Preston, Mirabile, Callahan, & Robison, 2008). Although the link between child and maternal behavior is consistently found, the effect size is not substantial and it varies, reflecting in part the individual differences in processes in child and maternal cognitions, emotions and behaviors. Maternal resting frontal electroencephalographic (EEG) asymmetry is one such individual difference factor, and a major emphasis in the current study. The variability in EEG asymmetry reflects the potential for state-related emotional responding to changes in the environment (Coan & Allen, 2004). Our goal in the current study was to examine maternal frontal asymmetry and its pertinence to understanding variance in, and covariance between, maternal perceptions of challenging child behavior problems—defined as aggressive and nonaggressive conduct

problems, hyperactivity, impulsivity, and anger—and self-reports of negative affect and behaviors directed toward the child. In addition, we tested whether the role of maternal frontal asymmetry differed for mothers with high vs. low levels of chronic stress.

Parental Emotional Negativity, Parenting, and Parent-Child Interactions

Past studies have shown that parental emotional negativity is predictive of child behavioral and emotional problems and social incompetence (Eisenberg et al., 1999). As a central component of parenting processes, negative emotional feelings within parents arise when their children fail to meet their expectations, and these emotions can further influence parents' cognitions, motivations and parenting behaviors (Dix, 1991). If not well regulated, parents' emotional negativity can undermine parenting quality and become a major feature of chronically harsh parenting (Scaramella & Leve, 2004). Children's negative emotional reactions can induce parental emotional negativity. This parental emotional negativity can act as a contributor to coercive cycles of interactions between parent and child.

Besides its effects on sustaining coercive relationship dynamics between parents and their children, higher levels of parental emotional negativity can also impair the learning of appropriate emotional regulation skills in children. On the one hand, parental negativity can increase children's emotion arousal, making it harder to effectively regulate negative emotional feelings. On the other hand, children can model their parents to acquire emotion regulation skills and rules of emotion expression (Bariola, Gullone, & Hughes, 2011)—including learning ways to express but not effectively regulate strong negative emotions. Exploring the causes and consequences of parental negative emotionality, and individual differences in this aspect of parenting, are important for achieving a better understanding of parenting processes with findings that lead to suggestions for improving parenting quality.

Frontal EEG Asymmetry and Emotional Reactivity to Negative Stimuli

Examination of psychophysiological components of emotional reactivity and regulation greatly inform this area of research. Previous studies regarding stable individual differences in adults' approach/avoidance and emotional reactivity implicated a distinct lateralization pattern in frontal lobe brain activity that is reflected in frontal asymmetries in the alpha frequency band during the resting state. Within a typical sample of adults, there is wide variation from left to right frontal asymmetry. Usually, a difference score between the activity levels across the left and right frontal lobe is calculated to quantify frontal asymmetry. Left frontal asymmetry indicates that the brain activity in the left frontal lobe is greater than that in the right frontal lobe, whereas the right frontal asymmetry indicates the opposite. More importantly, this variability is stable, with test-retest correlations around .70 with intervals of four weeks or longer between assessments (Allen, Urry, Hiit & Coan, 2004; Debener et al., 2000; Wheeler, Davidson & Tomarken, 1993).

Asymmetry matters, because its magnitude and direction reflect stable individual differences in the functional association between the frontal lobe and the amygdala, a brain network that is involved in processing emotionally salient and relevant information (Davidson, Jackson & Kalin, 2000). Individuals with left resting frontal asymmetry show inhibition of negative

emotional responses to negative information and excitation of positive emotional responses to positive information. In contrast, those with right resting asymmetry show enhanced negative emotional responses to negatively valenced information and inhibition of positive emotional responses to positively valenced information (Davidson, 2000; Jackson et al., 2003).

More generally, left and right frontal asymmetry are thought to reflect neural cortex activity indicative of approach vs. avoidance tendencies (i.e., likelihood of seeking out novel experiences vs. avoiding such experiences; see Davidson et al., 2000) and associated positive/negative emotional feelings (Jones & Fox, 1992; Tomarken, Davidson & Henriques, 1990). Consistent with this pattern, the clinical literature implicates right asymmetry in risk for mood disorders such as depression and anxiety (Field et al., 2000; Wiedemann et al., 1999). Studies regarding the relationship between frontal asymmetry and anger (a negative emotion associated with approach motivation) further suggest that asymmetry is more likely an indicator of motivation of the emotion, rather than the valence of the emotion (Harmon-Jones, 2003). In that literature, trait anger was found to be related with greater left frontal asymmetry and lower right frontal asymmetry (Harmon-Jones & Allen, 1998). Furthermore, induced anger increased left frontal activity (Harmon-Jones & Sigelman, 2001). However, to our knowledge, no study has shown a positive association between induced anger to negative stimuli and resting left frontal asymmetry. Nevertheless, on the whole it is important to consider inferences of emotional valence as well as approach/avoidance tendencies when interpreting frontal asymmetry data.

Resting frontal asymmetry is implicated as an indicator of the brain mechanisms involved in automatic emotion reactivity and regulation in the face of stimuli that elicit negative emotions. For example, Jackson et al.'s (2003) study showed that compared to those with right resting frontal asymmetry, participants with resting left frontal asymmetry had decreased eye startle responses (a physical indication of reduced negative emotional reactivity) after the offset of negative emotional stimuli, indicating the association between left frontal asymmetry and less reactive responses to emotionally aversive stimuli. On the contrary, people with resting right frontal asymmetry showed more negative emotional reactions to aversive stimuli (Davidson, 2000).

What is the relevance of the asymmetry literature to child behavior problems and parenting? Child behavior problems are aversive; not only do they arise as a result of harsh caregiving, they also elicit negative feelings from the caregiver (Calkins, 2002; Nicholson, Fox, & Johnson, 2005). Thus, in households where the child is perceived by the parent as being chronically high in behavior problems, the mother frequently faces negative emotion-laden information arising from the child's behaviors during her interactions with the child. To the extent that this is the norm for the parent-child relationship, parental negative emotional reactivity and poor emotion regulation can become major components of harsh and abusive cognitions and parenting behaviors (Deater-Deckard, Wang, Chen & Bell, 2012; Milner, 1993). Frontal EEG asymmetry pattern, which corresponds with different emotional reactivity to negative stimuli, will probably moderate parenting in response to child behavior problems.

Though past studies have investigated the role of frontal asymmetry in parent-child interaction and child development, most of them focused on the effect of child frontal asymmetry. For example, in a study done by Davidson and Fox (1989), infants with resting right frontal asymmetry showed more crying to maternal separation. In the same vein, children who were shy or fearful showed more baseline right frontal activity (Fox et al., 1995). To our knowledge, the only study that has extended this approach to examining parental emotional reactions to negative stimuli is Killeen and Teti's (2012) study. They found no association between frontal asymmetry and mothers' emotional responses to infants' emotion cues.

It could be that frontal asymmetry is not important in the parenting role. However, it is also plausible that asymmetry may matter for parental negative emotionality primarily when the child's behavior is sufficiently aversive. Therefore, in the current study we focused on child challenging behavior problems as the key variable, incorporating indicators of aggressive and nonaggressive conduct problems, impulsivity, hyperactivity, and anger. These sorts of behavior problems were some of the most consistent and largest correlates of maternal distress and negativity in the family processes literature (Calkins, 2002; Deater-Deckard, 2004). Thus our first aim was to explore the potential additive and interactive effects of child behavior problems and maternal frontal asymmetry in the statistical prediction of maternal harsh negativity toward the child. Based on the literature, our first hypothesis was for a two-way interaction between child behavior problems and maternal asymmetry. Specifically, we anticipated that the statistical prediction of maternal negativity from child behavior problems would be strongest for mothers with right frontal asymmetry and weakest for mothers with left frontal asymmetry.

Chronic Stressors

Maternal frontal asymmetry and its correspondence with maternal emotion and motivation tendencies may well be important in the link between child behavior problems and maternal negativity, but environmental stressors also play an important role (Conger & Donnellan, 2007; Dumas et al., 2005; McLoyd, Jayaratne, Ceballo, & Borquez, 1994). Living with chronic stressors such as single parenthood (Zalewski et al., 2012), unemployment and income insecurity (Conger & Donnellan, 2007; McLoyd et al., 1994), having multiple children (Nye, Carlson, & Garrett, 1970), and high levels of household chaos (e.g., noise pollution, lack of routines; Evans, Lepore, Shejwal, & Palsane, 1998; Pike, Iervolino, Eley, Price, & Plomin, 2006) enhances risk for child behavior problems, in part through its impact on higher levels of harsh maternal negativity. Furthermore, living with more of these chronic stressors impairs mothers' cognitive self-regulation capacity—the very competencies needed for dampening emotional outbursts toward challenging child behavior problems (Deater-Deckard, Chen, Wang, & Bell, 2012; Valiente, Lemery-Chalfant, & Reiser, 2007).

From a physiological perspective, chronic exposure to environmental stressors is closely related to activation of the autonomic nervous system (ANS) through excitation of the hypothalamic-pituitary-adrenal axis (HPA), the “stress response” that is reflected in part in heightened emotional intensity and release of cortisol (De Souza, 1995; Kalin, Shelton, & Davidson, 2000). Over long periods of time, exposure to high levels of cortisol in the brain

may alter emotion-related brain circuitry and cause atrophy in the hypothalamus, a brain structure involved in appropriate emotional responding to affectively-laden information or stimuli (Davidson et al., 2000). Given the potential importance of chronic stress, we examined a “multiple stressor index” representing the absence vs. presence of various stressors that have been implicated in the etiology of harsh parenting. These included unemployment of the child’s biological father, single parenthood, high levels of household chaos, and having three or more children. Past studies have shown that these factors contribute to higher levels of parenting stress (Conger & Donnellan, 2007; McLoyd et al., 1994; Nye et al., 1970; Wachs & Camli, 1991).

We anticipated that having more stressors would be associated with mothers’ greater negative emotional reactivity to child behavior problems. Furthermore, we anticipated that the level of stressors would statistically interact with child problem behavior and maternal frontal asymmetry in the prediction of maternal negativity, given the importance of chronic stress as a context for individual and dyadic stress reactivity and regulation processes. Therefore, our second aim and hypothesis was to test for a three-way interaction between stressors, asymmetry, and child behavior problems (i.e., study hypothesis 2).

There are two likely, yet competing, processes that could be operating. On the one hand, having more chronic stressors could *minimize* any potential moderating effect of individual difference attributes—in this case, maternal frontal asymmetry—on the link between child behavior problems and maternal negativity. This hypothesis is based on theory and empirical research on the etiology of parenting stress that proposes a robust and ubiquitous effect of chronic stressors on deterioration in parental adaptive functioning and caregiving (Crnic, Gaze, & Hoffman, 2005; Deater-Deckard, 2004; Dix, 1991)—above and beyond any individual difference attributes pertaining to stress reactivity and regulation. Accordingly, the current data would show that frontal asymmetry operates as a moderator of the link between child behavior problems and maternal negativity only under low-stress conditions and not under high-stress conditions, as shown hypothetically in Figure 1a.

The competing hypothesis is that the moderating role of frontal asymmetry will be *maximized* in stressful conditions. This is based on the diathesis stress model that stipulates that individual differences attributes (including emotional and physiological reactivity) play their most important role as protective or risk factors under stressful conditions (Monroe & Simons, 1991; Zuckerman, 1999). Thus, mothers with the strongest physiological reactivity and negative emotionality would be most susceptible to stressors such as challenging child behavior problems when functioning under chronically stressful conditions. Accordingly, the current data would show that frontal asymmetry does not operate as a moderator of the link between child behavior problems and maternal negativity under low-stress conditions, but does so only under high-stress conditions; this is shown hypothetically in Figure 1b.

Method

Participants

The sample included 121 mother-child pairs and was recruited through community agencies, organizations and advertisements (e.g., flyers distributed to parents through publicly funded

preschools and schools; flyers put up in common areas throughout the community; through the university website and email announcements). Participants received an honorarium for participation. Mothers' average age was 32.45 years ($SD = 6.3$), and children were 56.71 months old on average ($SD = 14.23$, range = 3–7 years old) with half the sample being female. We were particularly interested in studying the parenting of children in early childhood because parenting is the major socialization agent, and the regulatory aspects of child temperament are developing most rapidly in this developmental period (Rothbart & Bates, 2006). Parenting at this time may be especially important for the development of children's emotion and behavior regulation skills, and this is also a time when stable relationship and interaction dynamics are becoming firmly established.

In the current study, mother age was included as a covariate in analyses whereas child age was not controlled as the correlational analysis showed no association between child age and maternal negativity. Two-thirds of mothers completed a laboratory visit at a downtown office in a small city, and the other third attended a laboratory session on a nearby rural university campus. Nearly all of the mothers who attended at the university site were participating in a different longitudinal study. Mothers recruited from the rural sites tended to be higher in SES. Site was coded as 0 = urban, 1 = rural and was also included as a covariate. Maternal general aptitude measured by Peabody Picture Vocabulary Test (PPVT) was included as a covariate in the analysis. Self-reported race was: seventy-four percent Caucasian, twelve percent African American, one percent Asian, eight percent multiple races, one percent other, and four percent unspecified. Seventy percent were married or cohabiting with the child's biological father, six percent of the mothers were divorced or separated, and twenty-four percent of the mothers were single parents. For educational attainment of the parents (mothers/fathers), twenty-two/thirty-one percent had a high school diploma, GED or less; twenty-eight/twenty-nine percent had some college or associate degree; thirty/nineteen percent held a four-year degree; and twenty/twenty-first percent held a post-graduate degree. Regarding housing conditions, fourteen percent lived in an apartment, twelve percent lived in a duplex, townhouse or mobile home, and seventy-four percent lived in a detached single house. Overall, the sample was socioeconomically diverse and representative of the region's population (based on 2005–2007 US Community Survey data, retrieved at <http://www.census.gov-acs>).

Measures

Maternal Negativity—Maternal harsh parenting was measured by self-report on the negativity scale ($\alpha = .90$, $M = 2.51$, $SD = .91$, range = 1 to 4.38 on a 5-point Likert scale) from the Parent Feelings Questionnaire (Deater-Deckard, 2000). Sample items for this scale included “Sometimes I raise my voice with my child, especially after I've had a bad day”, “Sometimes my child's behavior makes me so angry I can barely stand it” and “My child and I fight or argue more than I would like to”. The average of the item scores was used to represent mothers' negativity toward the children.

Maternal Resting Frontal EEG Asymmetry—Mothers' resting frontal asymmetry was used to measure mothers' tendency for emotional reactivity (Coan & Allen, 2004). The resting period included 60 seconds of eyes open and 60 seconds of eyes closed. The two

conditions were averaged to get the most reliable assessment of resting frontal asymmetry. Mothers' brain electrical activity was recorded with an Electro-Cap (Eaton, OH) from sixteen left and right scalp sites: frontal pole (F1, F2); medial frontal (F3, F4); lateral frontal (F7, F8); central (C3, C4); temporal (T7, T8); parietal (P3, P4, P7, P8); and occipital (O1, O2). The recording reference was Cz. Electrode impedance was measured and kept below 10K ohms. The electrical signals of each site were amplified using separate SA Instrumentation Bioamps (San Diego, CA) and passed from 1 to 100 Hz. EEG Analysis System software (James Long Company; Caroga Lake, NY) was used to examine and analyze the EEG data. EEG data that reflected eye movement and gross motor were artifact scored and removed from all subsequent analyses. The artifact-free epochs were converted to 1 second Hamming windows with 50% overlap and subjected to a discrete Fourier transform. Power was computed for the 8–13 Hz frequency band (alpha band), expressed as mean square microvolts, and transformed using the natural log to achieve a normal distribution.

We were particularly interested in the asymmetry of brain activity in F3/F4 sites, as past studies showed the alpha asymmetry between these two sites indexed a general response tendency of approach vs. inhibition (Coan & Allen, 2004) and positive vs. negative emotionality (Jones & Fox, 1992). The asymmetry score was computed by subtracting the natural log of alpha power at the left hemisphere F3 site from the natural log of alpha power at the right hemisphere F4 site. In the EEG literature, brain activation is indicated by lower EEG power values in the alpha frequency band (Coan & Allen, 2004; Lindsley, 1936). Thus, greater relative left than right frontal activation is indicated by a positive asymmetry score, and greater relative right than left frontal activation is indicated by a negative asymmetry score. The difference score was then standardized, and was used as predictor and to create interaction terms in analyses. Standardization centers the variables and eliminates artificial collinearity between the additive and interactive terms (Aiken & West, 1991). Also, as the mean of the original difference score was close to 0, as was the mean for the standardized difference score, this permitted the same interpretation of positive and negative difference score values for the standardized asymmetry score and the unstandardized difference scores.

Child Behavior Problems—Each mother reported on her child's tendency to be physically active, impulsive, and angry/frustrated, by completing the Child Behavior Questionnaire Short Form (CBQ-SF, Putnam & Rothbart, 2006). The CBQ-SF scales approach normal distributions, providing the full range of variance in these indicators of behavior problems: activity level ($\alpha = .71$, $M = 5.08$, $SD = .90$, $range = 2.86$ to 7 on a 7-point scale; example item: “seems always in a hurry to get from one place to another”); impulsivity ($\alpha = .72$, $M = 4.54$, $SD = 1.00$, $range = 2.33$ to 7 ; example item: “tends to say the first thing that comes to mind without stopping to think about it”); anger/frustration ($\alpha = .80$, $M = 4.40$, $SD = 1.21$, $range = 1.67$ to 7 on a 7-point scale; example item: “has temper tantrums when s/he doesn't get what s/he wants”). We also wanted to include an indicator of aggressive and nonaggressive conduct problems, so we also incorporated the conduct problems subscale from the Strengths and Difficulties Questionnaire (SDQ, Goodman, 1997; $\alpha = .63$, $M = 1.55$, $SD = .80$, $range = 1$ to 5 on a 5-point scale, example item: “Often fights with other children or bullies them”). The first principal component of these scales explained

53% of the variance with loadings ranging from .65 to .80. We computed a composite score representing child behavior problems by standardizing the four scale scores, averaging them, and standardizing the final composite to yield an overall z-score.

Multiple Chronic Stressors—To represent the chronic stress level in the household, we computed a multiple chronic stressors index that includes four indicators of chronic stress. These included: father's unemployment status (0 = employed vs. 1 = unemployed; 17% of sample), and mother's marital status (0 = two parent household vs. 1 = single parent, divorced or separated; 30% of sample), home chaos levels (measured by the abbreviated Chaos, Hubbub and Order Scale; Matheny, Wachs, Ludwig & Phillips, 1995; 0 = below the median score for the sample vs. 1 = above the median score for the sample; 50% of sample), and number of children (0 = one or two children vs. 1 = three or more children; 31% of sample). These four indicators of chronic stressors were summed to produce a composite of multiple chronic stressors present in the household, ranging from 0 to 4 stressors.

Results

Descriptive Statistics and Correlations

Correlational analyses were conducted and the results are shown in Table 1. Mothers who visited the rural university site had less exposure to chronic stressors, higher verbal ability, and younger children. Older mothers tended to experience fewer stressors and showed greater negativity toward their children. Mothers with higher verbal ability were older, had younger children, and reported fewer chronic stressors and more negativity toward the child. In households with higher levels of stressors, mothers reported more behavioral problems of the children. Mothers with greater relative left frontal asymmetry reported fewer child behavior problems. Finally, reports of child problem behavior and negativity toward the child were positively correlated.

Statistical Prediction of Maternal Negativity

To test for the hypothesized interactions, we used a hierarchical regression approach to examine the main effects and statistical interactions between maternal resting frontal asymmetry, child behavior problems and exposure to multiple chronic stressors in the prediction of maternal negativity. In the first step of the equation, we included covariates to control for their effects on the outcome: research site, PPVT standard score, and mother's age. In the second step, the first-order terms of standardized maternal resting frontal asymmetry, child behavior problems and multiple chronic stressors were entered into the equation to test for main effects. In the third step, the two-way interactions between frontal asymmetry, multiple chronic stressors, and child behavior problems were included in the analysis. In the fourth and final step, the three-way interaction term was entered.

Results are shown in Table 2. The overall model was significant, accounting for 31% of the total variance (adjusted R^2) in maternal negativity. As expected based on prior studies, higher levels of child behavior problems were associated with greater maternal negativity. In our test of the first hypothesis—that there would be a significant two-way interaction

between child behavior problems and maternal frontal asymmetry—we could not reject the null hypothesis; none of the two-way interactions was significant.

For our test of the second hypothesis—that there would be a three-way interaction between child behavior problems, EEG asymmetry, and level of chronic stressors—the null hypothesis was rejected. The three-way interaction was statistically significant. We used analysis of simple slopes to probe the three-way interaction (e.g., Dawson & Richter, 2006) by estimating the association between child behavior problems and maternal negativity at different levels of maternal frontal asymmetry and chronic stressors, and testing the significance of those different effect size estimates. To do this, we estimated associations between child behavior problems and maternal negativity based on scores that were one standard deviation above and below the sample means for multiple chronic stressors and EEG asymmetry. This resulted in four estimates of the association (presented as correlations and as slopes) representing the statistical prediction of maternal negativity from child behavior problems for: 1) mothers with left frontal asymmetry living households with high level of stress; 2) mothers with right frontal asymmetry living in household with low level of stress; 3) mothers with left frontal asymmetry in less stressed homes; and 4) mothers with right frontal asymmetry in stressed homes.

Results are shown in Figure 2. This analysis showed that the positive association between child problem behaviors and greater maternal negativity—a well-established correlation in the research literature—was statistically significant and moderate-to-substantial in magnitude for most of the mothers (β s from .51 to .66). But there was one noteworthy exception: the association was non-significant and close to zero for mothers with left frontal EEG asymmetry who also had the fewest stressors. The test of difference of slopes (Dawson & Richter, 2006) revealed that the only significant difference found was between the low stress/left frontal asymmetry condition, compared to the other three conditions: low stress/left frontal asymmetry vs. low stress/right frontal asymmetry, $t = -2.13$, $p < .05$; low stress/left frontal asymmetry vs. high stress/left frontal asymmetry, $t = -2.63$, $p < .05$; and low stress/left frontal asymmetry vs. high stress/right frontal asymmetry, $t = -2.24$, $p < .05$.

Discussion

Harsh parenting is closely related to the development and maintenance of children's behavioral and emotional problems and poor social competence (Chang, Schwartz, Dodge, & McBride-Chang, 2003). Child behavioral problems are challenging for parents to manage, yet parents vary widely in their negative emotional reactions to these behaviors due in part to parents' own characteristics and in part to the broader family environmental context (Deater-Deckard, Wang, Chen, & Bell, 2012; Dix, 1991; Meunier et al., 2012). These individual and contextual factors interact to contribute to variability in parental negativity and harsh caregiving behaviors. With a diverse sample, the current study examined a specific set of mechanisms involving resting frontal EEG asymmetry and family stressors, in helping to explain the wide range of maternal negative emotionality in the face of challenging child behavior problems.

Frontal Asymmetry and Maternal Negativity

Resting frontal EEG asymmetry reflects a distinct pattern of lateralized cortical activity that is associated with stable individual differences in emotional reactivity to positively and negatively valenced stimuli in the environment (Davidson, 2000) and approach vs. avoidance motivational tendencies (Harmon-Jones, 2003). In previous research, Coan and Allen (2003) found that resting frontal EEG asymmetry moderated emotional responses to posed emotional facial expressions. In their study, relatively greater left frontal activity was linked with more positive emotional experiences such as joy, but not withdrawal-related emotions such as sadness and fear. In another study, Jackson et al. (2003) found that those with relatively greater left frontal activity had weaker startle responses to negative stimuli. However, to our knowledge, there is little prior research that has examined this in relation to harsh maternal caregiving among caregivers of children with challenging behavior problems.

Given the literature on the association between frontal asymmetry and dispositional emotional reactivity to negative and positive stimuli, our first hypothesis was that the link between child behavior problems and maternal negativity toward the child would be weakest for mothers with left frontal asymmetry, and strongest for mothers with right frontal asymmetry. However, there was no evidence for this hypothesized effect. It is noteworthy that a similar study, albeit focused on mothers' emotional responses to infants' emotion cues, also showed no such hypothesized moderating effect of frontal EEG asymmetry (Killeen & Teti, 2012). We know of no other studies that have tested this hypothesis with mothers and children. Therefore, it is not clear whether the lack of the effect in the current study and Killeen and Teti (2012) is due to something specific with regard to the parenting role and mother-child interactions and relationships, or if there are other differences between family studies like these and the experimental laboratory-based studies that form the foundation of the EEG asymmetry literature (e.g., carefully controlled environmental cues and stimuli, constrained protocols, volunteer/convenience samples of young adults) on which this hypothesis was based.

Chronic Stressors

Our second hypothesis was that the anticipated moderating effect of frontal asymmetry would depend on the level of chronic socioeconomic and parenting role stressors in the household, given the potential importance of stressful contextual factors in emotion reactivity and regulation processes. More specifically, we tested for two competing mechanisms in this regard that have been theorized in the parenting and emotion dysregulation/psychopathology literatures (summarized in Figure 1). Living with high levels of chronic stress might subsume or minimize (Figure 1a) the role of individual attributes such as frontal asymmetry as moderators of the link between child behavior problems and maternal negativity, given theory and evidence of substantial and consistent effects of chronic stressors on difficulties in parenting and parent-child relationships above and beyond the effects of parents' own attributes (Crnic et al., 2005; Deater-Deckard, 2004; Dix, 1991). In contrast, living with high levels of chronic stress may enhance or maximize (Figure 1b) the role of individual attributes such as EEG asymmetry as moderators, given theory and evidence of diathesis-stress whereby individuals' risk and protective factors are most

important to prediction of emotional difficulties and psychopathology under stressful conditions (Monroe & Simons, 1991; Zuckerman, 1999).

The findings showed a significant three-way interaction, indicating an important moderating role of level of chronic stress. Post-hoc probing of the interaction showed a pattern that was very consistent with the “minimization” mechanism (see Figure 2). Under the condition of high chronic stress, child behavior problems and maternal negativity were moderately positively correlated *regardless of maternal frontal EEG asymmetry*. In contrast, when the stress level is low, the link between child problem behavior and maternal negativity was moderated by maternal frontal asymmetry, as proposed in our first hypothesis. Under the low stress condition, there was no link between child behavior problems and maternal negativity for mothers with greater left frontal activity, but this link was substantial for mothers with right frontal asymmetry.

Why would the moderating effect of frontal asymmetry be minimized for mothers with more stressors? The dependency of the moderating effect of frontal asymmetry on the level of chronic stressors corresponds with a point raised by Davidson and colleagues (2000)—that emotion-related brain circuitry can be altered by contextual cues such as prolonged exposure to stressors that contribute to chronic hyper-activation of the HPA axis. Empirical evidence indicates an effect of stress on lateral frontal activity, with acute cortisol (a stress-related hormone) administration linked to increased right frontal activity in healthy adults (Tops et al., 2005). In regard to caregiving, parents’ emotional and behavioral reactions to their children’s challenging behaviors may vary systematically for those facing multiple chronic stressors. Chronic stressors arising from the lack of socioeconomic resources and poor social relationships are known to increase risk of parenting stress, depression, and harsh parenting behaviors (Coyl, Roggman & Newland, 2002). This effect may be accounted for in part by hyperactivation of the HPA axis evidenced by elevated cortisol levels (Mills-Koonce et al., 2009). The current study specifies a potential role for chronic stressors in parent-child interaction, showing that stress exposure may modify the mechanisms connecting child challenging and aversive behaviors, maternal emotional reactivity and motivational stance, and harsh parenting.

Another potential clue may lie in the strong tie between maternal self-regulation and household regulation among women with multiple socioeconomic stressors. In a previous paper based on the current sample, we reported a correlation of around $-.80$ between lower levels of maternal executive function (an aspect of the cognitive regulation of emotions, thoughts and behaviors) and higher levels of household chaos among mothers with the lowest socioeconomic status (Deater-Deckard, Chen, Wang, & Bell, 2012). The combination of household chaos, socioeconomic risks, and related childrearing stressors like those we examined may represent stress that essentially overwhelms mothers’ effective emotion reactivity and regulation processes that are reflected, in part, in left frontal asymmetry. If chronic, this stress process could induce changes in the brain structures and circuits that are involved in emotional reactivity and regulation in ways that lead to maladaptive affective responding to stressors (Davidson et al., 2000; Madsen et al., 2012). Consistent with this are studies showing associations between high levels of cortisol following stressful situations and heightened emotional reactivity and poorer emotion regulation (De Souza, 1995; Kalin,

Shelton, & Davidson, 2000). These alterations in functioning over time may interfere with the emotion reactivity and motivational approach/avoidance processes that otherwise are indexed by left vs. right frontal EEG asymmetry under less stressful conditions.

Yet another potential explanation is that chronic stressors may alter the frontal asymmetry pattern, whereby those who typically show left frontal asymmetry may show right asymmetry when immersed in stressful environments. Various studies have shown a positive correlation between higher cortisol levels—a biomarker of stress reactivity—and relative right frontal EEG activity (Buss et al., 2003; Hewig et al., 2008; Tops et al., 2005). More specifically, in one study examining stress on young adult students' endocrine functioning, brain activity and health, the frontal asymmetry pattern was found to shift from relative left frontal activity in a low-stress examination session to relatively greater right frontal activity in a high-stress examination session (Lewis, Weekes, & Wang, 2007). Future studies that examine individual frontal asymmetry pattern changes across situations that vary in levels of stress would clarify the underlying processes.

Limitations, Conclusions, and Future Directions

Emotional exchange in parent-child interactions is important for the effectiveness of parental discipline, child socialization and adjustment (Bariola et al., 2011; Dix, 1991; Scaramella & Leve, 2004). Harsh and negative parenting impairs parent-child bonds, leads to child over-arousal, and promotes use of inappropriate coping strategies in emotional challenging situations (e.g. aggression). The current study extends previous research of emotional processes in parenting by examining the effects of individual differences in a psychophysiological indicator of emotion reactivity and approach/avoidance tendencies (i.e., frontal EEG asymmetry) and chronic stressors in families. The current study points out the importance of considering individual differences in parental physiological emotional processes as well as environmental stressors, when studying negativity and coercive relationship dynamics in parenting. Research on physiological processes in parenting is quite rare, and future studies that incorporate physiological indicators of parental emotion, such as patterns in EEG and ECG activity and hormone changes—considered within the context of broader levels of chronic stressors in the family environment—will further our understanding of the role of harsh parenting in the etiology of growth in child problem behaviors. Most interesting would be studies incorporating frontal EEG asymmetry measures during ecologically valid parenting tasks and interactions with the child, while also examining perceived emotion and stressors along with other physiological indicators of stress response and emotion regulation (e.g., cortisol) in the midst of “actual” parenting.

There are several limitations to consider when interpreting the current findings. First, the study used a cross-sectional correlational design, limiting our capacity to detect potential temporal patterns of leading and lagged effects over time, or from making inferences about directionality of parent and child effects on each other's behaviors. Second, we relied on a baseline resting state measure of frontal asymmetry. Although considered adequate as a simple indicator, this variable does not provide any information about how frontal cortical activity changes in the face of emotionally evocative cues from the environment. As measured in the current study, the variance may not generalize as a broad indicator of the

mother's emotional reactivity or her capacity for emotion regulation in the midst of actual emotionally laden interactions with her child. Third, although investigation of multiple stressors as a contextual factor is a strength of the study, we used global static indicators to capture this variance. A more rigorous approach would involve induction of stress as well as emotional states in an experimental design, in order to see how asymmetry and stress response interact as a potentially more precise measure of individual differences in emotion reactivity—a goal for future research.

Fourth, the current study relied on maternal reports of child behavior problems and maternal negativity. Parent reports are accurate and detailed sources of information for child characteristics and parenting (Rothbart & Bates, 2006); the parent provides ratings that are quite specific to the emotions and behaviors actually occurring in the parent-child interaction in the family setting. This is important, because studies have shown that child behaviors and emotional expression varies across situations (Scaramella & Leve, 2004). In this regard, we believe the findings of the current study are informative of the on-going parent-child interaction process in families. Nevertheless, the reliance on mother reports is a limitation because it introduces informant bias, which may inflate the effect sizes overall. Future studies that incorporate multi-methods in the measurement of child behavior problems and parenting (e.g. observation, ratings by other informers) are recommended to provide cross-validated evidence for these findings.

Caveats aside, the current study advances the literature by showing that when examining the connections between frontal asymmetry and caregiving behaviors, researchers should not limit their investigations to estimation of direct effects. Frontal asymmetry and the potential for emotional reactivity that it may represent interact with levels of chronic stressors, as well as child problem behaviors, in explaining variation in harsh maternal negativity. Overall, these results point to the critical importance of considering broad contextual factors, such as socioeconomic and caregiving stress, when testing for potential causal links between maternal emotional reactivity and self-regulation processes and supportive versus harsh caregiving. Ultimately, advancements made in this field of research will inform prevention and intervention efforts that are striving to minimize risk for child maltreatment and reduce levels of child behavior problems.

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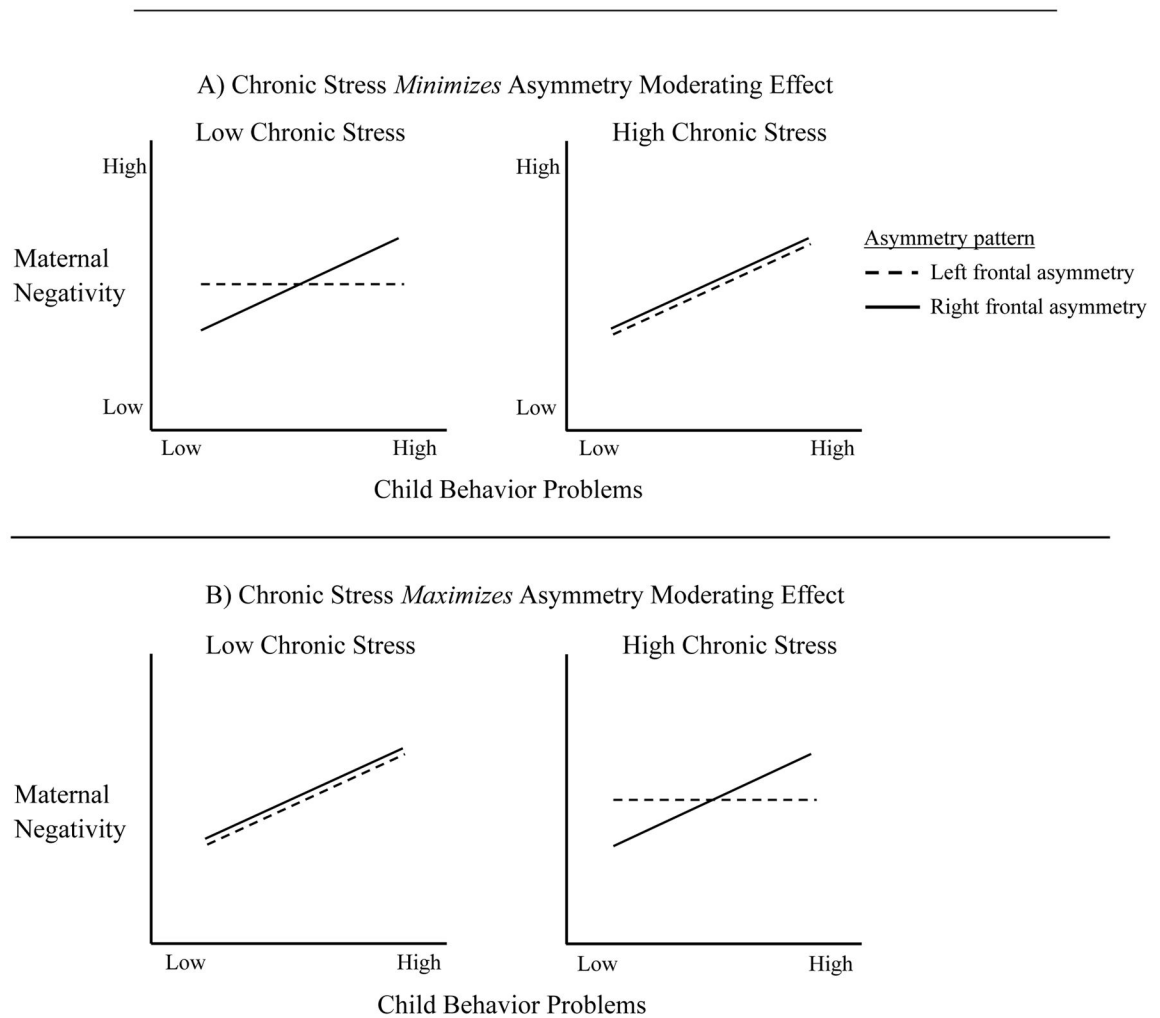


Figure 1.

Hypothetical data representing simple slopes for three-way interaction between chronic stressors, maternal frontal EEG asymmetry, and child behavior problems in the statistical prediction of maternal negativity toward child. Chronic stress may subsume or minimize the moderating role of EEG asymmetry (top half of figure), or may enhance or maximize the moderating role of asymmetry (bottom half of figure).

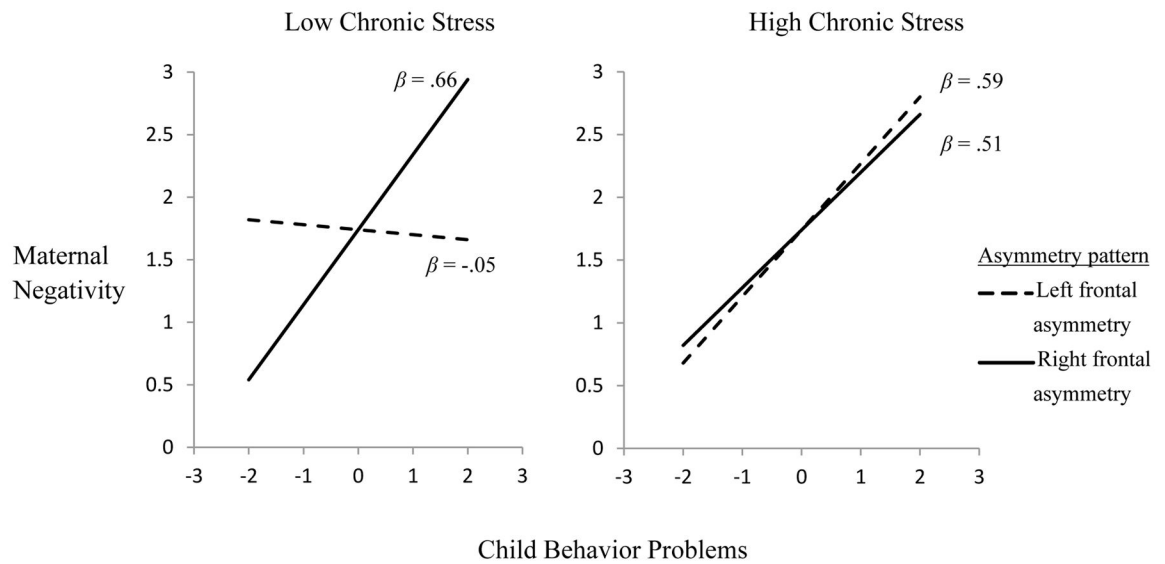


Figure 2. Simple slopes for the association between child conduct problems and maternal negativity, with maternal frontal asymmetry and chronic stressors as moderators (“high” = one standard deviation above mean, “low” = one standard deviation below the mean). The data are consistent with chronic stressors subsuming or minimizing the EEG asymmetry moderating effect on the link between child behavior problems and maternal negativity toward child.

Table 1

Descriptive Statistics and Correlations

	1	2	3	4	5	6	7	8
1. Site (0 urban, 1 rural)	1							
2. PPVT	.32***	1						
3. Mother age (years)	.02	.33***	1					
4. Child age (months)	-.77***	-.18*	.12	1				
5. Stressors	-.19*	-.39***	-.22*	.11	1			
6. EEG asymmetry (z)	.06	.05	.04	-.05	-.01	1		
7. Behavior probs (z)	.04	-.13	-.03	-.07	.22*	-.23*	1	
8. Mother harsh neg	.05	.25***	.23**	-.09	-.04	-.02	.39***	1
Mean	.48	101.45	32.68	56.71	.98	0	0	2.51
Standard Deviation	.50	14.78	6.30	14.23	1.01	1	1	.91

* $p < .05$,** $p < .01$,*** $p < .001$ (two-tailed)

Table 2

Hierarchical Regression Results for the Prediction of Maternal Negativity

	Step 1: Covariates	Step 2: Main effect	Step 3: Two-way	Step 4: Three-way
	β	β	β	β
Step 1: Site	-.02	-.05	-.03	-.12
PPVT	.22*	.33***	.29**	.27**
Mother age	.18	.17*	.13	.16
Step 2:				
EEG Asymmetry (A)		.07	.01	.08
Behavior Problems (BP)		.44***	.43***	.40***
Stressors (S)		.09	.04	.17
Step 3: A×BP			-.04	-.16
A×S			.19	.18
BP×S			.12	.15
Step 4: A×BP×S				.24*
R ²	.10	.20	.03	.03

*
 $p < .05$,**
 $p < .01$,***
 $p < .001$ (two-tailed)