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Preschool Children's Cardiac Reactivity Moderates Relations Between Exposure to Family Violence and Emotional Adjustment

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Abstract

This study examined relations between cardiac reactivity, family violence exposure (i.e., child maltreatment [CM] and inter-partner violence [IPV]), and preschool children's emotional adjustment. A sample of 92 mother–preschooler dyads was drawn from predominantly low-income, rural communities. Dyads participated in a laboratory session in which children's Electrocardiograph (ECG) monitoring occurred during a resting baseline, joint-challenge, and individual emotional and cognitive tasks. Mothers consented to review of Children & Youth Services (CYS) records for CM and completed an IPV measure. Mothers rated children's emotional adjustment, and observers rated children on their frustration and positive affect. Children's vagal suppression was shown to moderate relations between family violence exposure and emotional adjustment. Findings indicated that children greater in vagal suppression showed better emotional adjustment when from families low in violence. However, regardless of children's level of vagal suppression, all children showed poorer emotional adjustment when from families high in violence.

Keywords

child maltreatment; exposure to violence; physiological processes; preschoolers

Child Maltreatment (CM) and domestic violence are critical public health problems in the United States with approximately 1.25 million American children experiencing maltreatment (National Center on Child Abuse and Neglect, 2007) and an estimated 3.3–10 million children witnessing domestic violence each year (Lawrence, 2002). When children are exposed to family violence, they are at greater risk for profound short and long-term consequences associated with psychopathology, including antisocial behavior, aggression, anxiety, and depression (Kolko, 2002; Mulvihill, 2005; Shonkoff & Phillips, 2000). Additionally, children exposed to family violence show neurobiological deficits including reductions in brain mass (e.g., De Bellis & Keshavan, 2003; Teicher et al., 1997), altered neural activation in response to anger expression (e.g., Pollak, Cicchetti, Klorman, &

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Brumaghim, 1997), and changes in physiological stress reactivity (e.g., Gunnar, Fisher, et al., 2006; Saltzman, Holdern, & Holahan, 2005).

Research indicates that children exposed to family violence either directly through CM or indirectly through IPV, are significantly more likely to evidence problems regulating emotionality and thus are at risk of developing poor emotional competence over time (e.g., Cicchetti & Toth, 2005; Cummings, Iannotti, & Zahn-Waxler, 1985; Davies & Cummings, 1994; Gaensbauer, Mrazek, & Harmon, 1981; Gordis, Margolin, & John, 1997; Shields & Cicchetti, 1998; Trickett, 1998). Ineffective emotional regulation often persists beyond the experience of CM and thus contributes to the increased rates of lifetime psychopathology in victims of family violence (Hussey, Chang, & Kotch, 2006; Kolko, 2002; National Institute of Mental Health [NIMH], 2000). Despite the negative impact of family violence on children, not all develop subsequent problems in their emotional functioning (e.g., Cicchetti, 2006). It is possible that biologically based individual differences in children's sensitivity to threat and their adaptability to context may operate as a mechanism through which children evidence increased emotional problems when exposed to high levels of CM and IPV.

One neurobiological characteristic that has been routinely implicated in the full range of psychopathological outcomes is individual differences in parasympathetic functioning. According to Porges' Polyvagal Theory (Beauchaine, 2001; Porges, 1995, 2001, 2007), engagement of the parasympathetic system marks an evolutionary advance in the control of arousal, which allows individuals to attend to environmental demands without activating the more costly sympathetic system. Parasympathetic, or vagal, influence is quantified from the amplitude of respiratory sinus arrhythmia (RSA), or influence of respiration on the heart, and provides an index of the impact of the myelinated vagus on the heart (Porges, 1995). Individual differences in RSA have been related with measures of attentional, emotional, and behavioral control, and appear to reflect a general capacity for carefully allocating arousal to facilitate behavioral flexibility in engaging with environmental demands. During a mild challenge (i.e., need to engage in emotionally eliciting, attentional, or cognitive tasks), RSA is suppressed, allowing for an increase in physiological arousal. Because the parasympathetic system exerts control over the heart neurally, the degree of control from the parasympathetic system can be altered rapidly, giving it a distinct advantage over the sympathetic nervous system that relies in part on adrenalin to provide a robust and relatively prolonged activation that is difficult to regulate (Porges, 1995, 2001, 2007; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). Given this, baseline, or resting RSA, is thought to represent the degree of regulatory ability at the individual's disposal (Porges, 1995, 2001, 2007), and low baseline RSA has been associated with psychopathology across multiple domains (Beauchaine, 2001). Additionally, the degree of RSA suppression associated with mild challenge may serve as an independent marker of regulatory ability and has also been implicated in deficient emotion regulation (Beauchaine, 2001; Calkins, 1997). Therefore, both resting RSA and RSA suppression are physiological indicators to consider in relation to children's emotional functioning.

In general, higher resting RSA and RSA suppression during cognitive, social, and emotional tasks is associated with several adaptive outcomes in normally developing infants and children. Specifically, both greater resting RSA and RSA suppression to challenge are associated with greater social engagement, exploration, activity, expression of empathy and positive emotion, fewer behavior problems, better emotional regulation, and less antisocial behavior (e.g., Beauchaine, 2001; Calkins, 1997; Calkins, Smith, Gill, & Johnson, 1998; Fox & Field, 1989; Porges et al., 1996; Stifter & Corey, 2001). However, research focused on patterns of RSA in high-risk children presents a different picture, with some reports associating greater levels of baseline RSA and RSA suppression with poorer emotional adjustment. In a sample of older children exposed to community violence, those with greater

resting RSA displayed more reactive aggression than children with lower RSA (Scarpa, Tanaka, & Haden, 2008). Likewise, greater RSA suppression has been observed in young children at risk for mixed internalizing/externalizing disorders (Calkins, Graziano, & Keane, 2007).

One possible explanation for the divergent findings regarding the role of vagal tone in children's emotional adjustment is that parasympathetic control may actually reflect a general sensitivity to one's environmental context, rather than a specific emotional predisposition. However, research examining the moderating effects of children's vagal tone has not always demonstrated a consistent direction of effects with regard to protection versus risk. Some research has supported the notion that RSA suppression represents a resilience factor in the face of stress. Research with community samples has shown how children's vagal suppression while exposed to a simulated adult argument moderated the relationship between exposure to conflict and children's adjustment. Generally, greater vagal suppression has been shown to buffer children against the negative effects of marital conflict (El-Sheikh et al., 2009; El-Sheikh, Harger, & Whitson, 2001; Katz & Gottman, 1995, Katz & Gottman, 1997). Alternatively, Obradovi, Bush, Stamperdahl, Adler, and Boyce (2010) targeted children exposed to multiple forms of family adversity (i.e., parental depression, marital conflict, financial stress, etc.) and report a different effect regarding the moderating role of children's vagal suppression. They found that children who showed greater vagal suppression, compared to those who minimally suppressed, were more affected by how much family adversity they were exposed to. Rather than representing an underlying vulnerability that exacerbates the adverse consequences of early adversity, their findings suggest that vagal suppression may operate in a bivalent, contextually sensitive manner, such that high vagal suppressors showed better adjustment when exposed to less adversity and poorer adjustment when exposed to greater adversity.

Given the inconsistency in these findings regarding the moderating role of children's vagal suppression, recent models have proposed that children's reactivity and regulatory ability may actually evidence a bivalent relationship, where high reactivity/regulation correlates with both healthy and pathological outcomes, depending on the developmental context. In the Biological Sensitivity to Context (BSC) model proposed by Boyce and Ellis, high levels of physiological reactivity appear to be associated with positive outcomes in healthy environments and negative outcomes in unhealthy environments, whereas outcomes in individuals with moderate or low level reactivity appear to be less contextually sensitive (Boyce & Ellis, 2005; Ellis & Boyce, 2008; Ellis, Essex & Boyce, 2005). However, the BSC model was developed with respect to cortisol reactivity, a slow-response system typically activated in response to sympathetic arousal (Boyce & Ellis, 2005). It remains unclear whether or not additional markers of regulatory ability, in particular those associated with parasympathetic influence, also evidence bivalent associations or retain a unidirectional association with respect to resilience.

Given this, we hypothesized to extend previous work applying the BSC model to children's parasympathetic functioning by exploring the moderating role of children's parasympathetic reactivity when exposed to family violence. More specifically, because exposure to family violence (i.e., CM and IPV) represents an extremely adverse developmental environment, we hypothesized that individual differences in parasympathetic reactivity to various challenges would moderate the environmental influence of family violence exposure on children's emotional adjustment in a sample of low-income, rural children. Consistent with the BSC model, we hypothesized that greater RSA suppression in response to cognitive, emotional, and relational challenges would be associated with more adaptive emotional functioning among children living in low violent families and poorer adjustment among children exposed to greater levels of family violence.

Method

Participants

Ninety-two mothers and their preschool age children were recruited to participate in a study investigating the influence of CM and family stress on children's self and emotion regulation development. The current project in which these data were drawn reflects the first wave of data collection with processed and completed data from 92 families available for the present study. Families were recruited from Department of Public Welfare agencies, including Children & Youth Services (CYS), Domestic Relations, and their community service providers operating in four rural counties in central Pennsylvania, and a university database maintained on birth announcements published in local newspapers. Children ranged in age from 3 to 5 years ($M = 3.75$, $SD = .75$ years), and 53.3% were female. The majority of the children were White (76.1%), with 19.6% multiracial and 2.2% African American (2 unreported). Mothers averaged 30.0 years of age ($SD = 6.45$) and were predominantly White (89.1%, $N = 82$), unmarried (57.6%, $N = 53$), and most held a high school degree or less (67.4%, $N = 62$). In terms of household income, 25.0% of mothers reported incomes at \$10,000 or less, 42.4% at \$10,001–\$30,000, 10.9% at \$30,001–\$50,000, and 20.7% were above \$50,001 (1 unreported). Based on the income-to-needs ratio, 34.8% of families were below the poverty line threshold.

Electrocardiograph (ECG) data was not available for some children due to equipment failure or excess movement artifacts ($N = 13$) or children who refused to wear electrodes ($N = 5$), resulting in a final sample of 74 mother–child dyads. Independent samples t tests and logistic regression revealed no differences between children with physiology data available and those without it on children's age, gender, violence exposure, and assessments of children's frustration and positive affect. One significant difference was revealed on parent's ratings of children's emotional adjustment, $t(2, 90) = -2.57$, $p < .01$, indicating that children who provided physiology data were rated higher on emotional problems ($M = 2.01$) compared to children for whom physiology data was unavailable ($M = 0.83$).

Procedures

Mother–child dyads were invited to participate if the mother was 18 years of age or older, spoke fluent English, and was living with her preschool child. As part of the project's three visit protocol, dyads participated in two 2-hr home visits and a 2½-hr laboratory session conducted by a team of two trained interviewers and spaced approximately 2 weeks apart. During home visits, mothers completed demographic and psychosocial assessments of IPV and rated children's behavioral and emotional adjustment. During the laboratory visit, the mother and child participated in a resting baseline period and a series of moderately challenging mother–child joint and individual child tasks, during which children's cardiac physiology was recorded. Following the baseline assessment, the child remained with the mother and completed a moderately stressful joint task (i.e., Duplo Blocks) before they were separated in order for the child to complete a series of individual tasks. Approximately 20–25 min after the Duplo task, children engaged in a moderately emotionally challenging task (i.e., Transparent Box), then a mildly challenging cognitive task (i.e., Shapes) 5–7 min later, followed by a moderately challenging cognitive task (i.e., Day/Night) approximately 2 min thereafter. Tasks were spaced in such a way to allow the child time between each task in order to facilitate return to baseline before starting the next task. Following, two interviewers globally rated children's behavior based on their observations during the laboratory visit.

Measures

Violence exposure—Given the high co-occurrence of CM and IPV (e.g., Sternberg, Baradan, Abbot, Lamb, & Guterman, 2006), children's violence exposure was examined by considering the joint contribution of CM exposure and mother's IPV ratings. All families consented to review of CYS agency records, regardless of source of referral into the study. The Maltreatment Classification System (MCS; Barnett, Manly, and Cicchetti, 1993) was used to classify these CYS case records to ascertain maltreatment type and severity. In the final sample of 74 dyads, 41 were involved with CYS protective or preventive services. Of these families, 33.3% of children were identified with physical abuse only or comorbid abuse with neglect or emotional maltreatment, 43.1% as neglected only or comorbid with emotional maltreatment, 11.8% with emotional maltreatment only, and 11.8% were CYS referred but without a codable instance of maltreatment using the MCS (Barnett et al., 1993). All mothers of physically abused, neglected, and emotionally maltreated children were implicated in CYS case records as a perpetrator. Of those children identified as physically abused or neglected, 43.6% experienced comorbidity with another form of maltreatment. Families in which sexual abuse occurred were excluded from study participation because such cases more often involve perpetrators other than the child's mother and are more likely to result in the child's removal from the home (Berliner & Elliot, 2002). The MCS (Barnett et al., 1993) was also used to classify children's CYS case records for maltreatment severity. For each act of physical abuse, neglect, or emotional maltreatment, severity ratings ranged from 1 (*mild*) to 5 (*severe*). For each child, the highest severity rating was used. For those children who experienced multiple forms of maltreatment, their greatest severity rating obtained for all forms of CM experienced was used in the present study. A master's level clinician with expertise in CM research was trained to a criterion weighted Kappa of .74 on a set of case records, and coded all subsequent families after reaching training reliability. CYS-involved dyads without a codable instance of physical abuse, neglect, or emotional maltreatment and non-CYS involved families were assigned scores of 0. Mean MCS severity scores within the CM group were $M = 2.73$, $SD = 1.47$. The remaining 33 non-CM dyads were recruited from other public welfare agencies and a university database maintained on birth announcements published in local newspapers. Non-CM mothers consented to verification that their family was free of CYS preventive or protective services.

The Conflict Tactics Scale (CTS-Couple Form R; Straus, 1990) was used to assess IPV. The CTS is a 19-item, self-report assessment of the mother and her most recent romantic partner's methods of resolving conflict during the course of a disagreement, in the preceding 12 months. Mothers rated themselves and their partner on the 6-item Verbal Aggression (i.e., “*Insulted or swore at him/you*,” “*Sulked or refused to talk about an issued*”) and the 9-item Violence scale (i.e., “*Threw something at him/you*,” “*Beat him/you up*”) in which mothers rated each item once for self and again for their partner on a 1 to 7 scale (i.e., 1 = *once in past year*, 2 = *twice in past year*, 3 = *3–5 times in past year*, 4 = *6–10 times in past year*, 5 = *11–20 times in past year*, 6 = *more than 20 times in past year*, 7 = *0 or never*). The Reasoning subscale was excluded from the present study. Weighted frequency scores were calculated for the mother and her partner on the Verbal Aggression ($M = 26.79$; $SD = 27.44$; range = 0–123) and Violence subscales ($M = 2.65$; $SD = 10.07$; range = 0–87). Items were weighted according to frequencies indicated in the response categories presented to mothers such that higher ratings on items were more heavily weighted.

Children's exposure to family violence was determined through use of a composite of MCS severity scores on physical abuse, neglect, and/or emotional maltreatment and the CTS Verbal Aggression and Violence subscale scores. Scores were standardized and summed across the two indices, such that higher scores reflected greater family violence exposure.

Physiology—Children's cardiac physiology was monitored in the laboratory visit and included a 5-min neutral children's video, a joint mother–child problem-solving task called Duplo Blocks, an emotional challenge task called the Transparent Box, and two individual Stroop-type (e.g., attentional control) tasks called Shapes and Day/Night. Three electrodes were placed in a modified Lead II placement. Electrodes were connected to Mindware© (Westerville, OH) ambulatory ECG equipment and output was transmitted through a wireless signal to a computer equipped with data acquisition software.

Mother–child joint task—The mother and child completed the 3- to 5-min Duplo Block joint problem-solving task (Hoffman, Crnic, & Baker, 2007) in which the child was required to replicate a three-dimensional model with a set of identical blocks provided. Children were shown 12 disassembled duplo blocks and a completed model and were instructed to recreate the model shown. Mothers were instructed to assist their child without touching any of the pieces. After the task was completed, the mother was instructed by the researcher that she could help her child complete the figure in any manner she wished. Once the model was completed, the child was awarded a choice of stickers for his or her effort in order to allow the child time to return to baseline.

Individual emotional task—Children participated in a 4-min emotionally challenging task designed to elicit frustration called the Transparent Box (Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999). This task has been shown to elicit anger, vagal reactivity, and emotion regulation strategies (e.g., Calkins & Keane, 2004; Jahromi & Stifter, 2008). The child was presented with two sets of toys (two trains and two dolls) and instructed to choose which set they liked better. The researcher placed the preferred toys in a clear, locked box and demonstrated to the child how to unlock it. The child was encouraged to open the box, was given a set of nonworking keys, and was left alone. The researcher returned to the room at the conclusion of the task, provided the child with the correct key, and apologized for the mistake. The child was permitted to play with the toys for several minutes following task completion in order to facilitate a return to baseline.

Individual cognitive tasks—Children's physiology was recorded during two executive function tasks (i.e., Shapes and Day/Night) designed to assess the ability to inhibit a dominant response in order to perform a subdominant behavior (e.g., Gerstadt, Hong, & Diamond, 1994; Kochanska, Murray, Jacques, & Coy, 1997). The Shapes task (approximately 30 s to 3 min) presented children with three large and small pictures of fruits and then three pictures depicting a small fruit embedded in a different large fruit (e.g., a small orange pasted on a large banana). The child was asked to point to each of the small fruits (e.g., “Show me the little banana”) that were embedded within the larger fruits. In the Day/Night task (30 s to 4 min; Gerstadt et al., 1994), 16 trials were completed in which children were shown a series of cards with pictures of a sun or moon and instructed to say “day” whenever they saw a card with a moon on it and to say “night” when they saw a card with a sun on it.

RSA scores—Heart rate data were quantified by passing the ECG signal, sampled at 1000 Hz, through an A/D converter. ECG data were then visually inspected and manually edited to remove artifacts. RSA values were derived from the interbeat interval series and were resampled at 25 ms to create a stationary wave form. The integral of the power in the RSA band (.24 to 1.04 for children) was extracted to obtain the RSA statistic. RSA was extracted in 30 s epochs across the 5-min resting episode, 3–5 min joint problem-solving task (Duplo Block), 4 min emotional task (Transparent box), and 30 s to 4 min cognitive tasks (Shapes and Day/Night). Scores on RSA baseline were obtained by taking the mean RSA scores across 30 s epochs and averaging them. Similarly, average RSA scores were created for each

of the four challenge tasks by taking the mean of RSA across the 30 s epochs. RSA suppression scores were calculated by subtracting mean RSA_{task} scores from mean $RSA_{baseline}$ scores, resulting in RSA_{change} scores associated with each of the four challenge tasks.

Emotional adjustment parent ratings—Mothers rated the extent of children's emotional problems using the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997). The SDQ is a 25-item questionnaire assessing conduct, emotional, and peer problems, hyperactivity, and prosocial behavior, on which children's behaviors are rated using a scale of 0 (*never*) to 2 (*always true*). The SDQ Emotional Problems scale is comprised of 5 items assessing children's emotional difficulties such as children's worries, somatic symptoms (i.e., complaining about headaches, stomach aches, etc.), happiness (i.e., depressed, unhappy), nervousness in new situations, and fears. The Emotional Problems scale had an $\alpha = .66$ in the present study and is comparable to those reported in a meta-analysis assessing the psychometrics of the SDQ (Stone, Otten, Engels, Vermulst, & Janssens, 2010) and in studies using the SDQ with high-risk samples (e.g., Aguilar-Vafaie, Roshani, Hassanabadi, & Masoudian, 2011). Further, SDQ scores are moderately to highly correlated with scores on similar questionnaires, such as the Child Behavior Checklist (CBCL; e.g., Goodman & Scott, 1999), and SDQ scores above the 90th percentile have been shown to substantially predict psychiatric symptoms (Goodman, 2001).

Emotional adjustment observer ratings—After completing the lab visit, each child's behavior was rated using the Observed Child Temperament Scale (OCTS; Stifter, Willoughby, & Towe-Goodman, 2008) to obtain scores on children's Frustration (degree of anger expressed) and Positive Affect (level of happiness/positive mood). Two observers blind to the child's status on all other study variables came to a consensus and rated each child's level of Frustration and Positive Affect on a 1–9 scale. Higher scores reflected greater child Frustration or Positive Affect. To simulate conditions under which parents rated their children, observers were minimally trained on the application of the scale prior to its use (for details see Stifter et al., 2008).

Results

Preliminary Analyses

The bottom section of Table 1 contains the descriptives for RSA change scores by task, and the top section of the table contains correlations among the RSA change scores. A repeated measures ANOVA was conducted in order to determine whether children's RSA suppression scores significantly varied across the four types of challenge tasks. After controlling for baseline levels of RSA, the results revealed a significant within-subjects effect, $F(3, 57) = 5.47, p = .001$. Follow-up paired samples t tests revealed that RSA_{change} scores from the joint Duplo challenge task were not significantly different from those observed in the following Transparent Box task, $t(66) = -1.05, p = .30$ (M difference = $-.11, d = -.17$). However, RSA change scores were greater in the (emotional) Transparent Box task compared to the following (cognitive) Shapes task, $t(62) = 6.77, p < .001$ (M difference = $.61, d = .83$). Also, children's RSA change scores were lower in the Shapes task compared to the subsequent (cognitive) Day/Night task, $t(64) = -2.35, p = .02$ (M difference = $-.16, d = -.29$). These results indicate that the intended experimental task manipulations were effective at influencing children's parasympathetic responses, as documented in other studies exploring variability in children's RSA responses when engaging in various challenges (e.g., Obradovic et al., 2010). However, because of the high correlations across RSA change scores in the four challenge tasks, a composite RSA change score was calculated for each child by summing RSA_{change} scores across the four tasks and taking their average. Higher

RSA_{change} scores (e.g., positive scores) reflected greater RSA suppression whereas lower scores (e.g., negative scores) reflected lower suppression.

Descriptive statistics for the study variables can be found in Table 2. Research has documented age and gender differences in children's cardiac physiology scores (e.g., Fabes, Eisenberg, Karbon, Troyer, & Switzer, 1994; Quas, Hong, Alkon, & Boyce, 2000), though analyses in the current sample revealed no gender differences on children's RSA_{change} scores, and no relations between children's age and RSA_{change} scores. Child age was positively correlated with Positive Affect ($r = .33, p < .001$). Negative correlations were revealed for Violence Exposure with household income ($r = -.41, p < .001$) and maternal education ($r = -.53, p < .001$). Lower income and less maternal education were associated with higher family violence exposure scores. Therefore, household income, maternal education, and child age were included as covariates in the primary analyses.

Intercorrelations among the study variables are shown in Table 3. Children rated higher on Emotional Problems were also rated higher on Frustration and lower on Positive Affect. A negative correlation was revealed between Frustration and Positive Affect. Further, children with greater baseline RSA scores showed greater RSA change scores during the challenge tasks, and therefore, baseline RSA was entered as an additional covariate in the regression analyses.

Primary Analyses

Three hierarchical regressions were performed to test whether relations between children's family violence exposure and emotional adjustment (i.e., Emotional Problems, Frustration, and Positive Affect) were moderated by their level of RSA suppression across the four challenge tasks. Violence Exposure and moderator (i.e., RSA_{change}) scores were centered in order to eliminate multicollinearity effects between the main effect and the interaction terms (Aiken & West, 1991). In each regression analysis, child age and baseline RSA (child covariates) were entered in the first step. In the second step, family income and maternal education (SES covariates) were entered. In the third step, centered Violence Exposure and centered RSA_{change} scores were entered. The interaction term (Violence Exposure $\times$ RSA_{change}) was entered in the final step for each of the three separate regressions with children's Emotional Problems, Frustration, and Positive Affect as outcome variables. When significant interactions were observed, procedures recommended by Aiken and West (1991) were employed to examine simple effects of each interaction.

Table 4 contains the regression coefficients and R^2 change values for each step of the three hierarchical regression analyses conducted. As can be seen in the table, only significant Violence Exposure $\times$ RSA_{change} effects were observed when predicting Emotional Problems. No significant effects were revealed when Frustration or Positive Affect were the criterion variables. The first three steps of the model with Emotional Problems as the criterion variable were nonsignificant: child covariates, $\Delta R^2(2, 67) = 1.98, p = .15$; SES covariates, $\Delta R^2(2, 65) = .86, p = .43$; and main effects, $\Delta R^2(2, 63) = .81, p = .45$, respectively. However, the fourth step entry of the interaction term was significant, $\Delta R^2(1, 62) = 7.39, R^2 = .20, p = .009$, indicating that children's RSA suppression scores moderated relations between Violence Exposure and Emotional Problems.

Regression lines for Violence Exposure and Emotional Problems scores were then plotted for high (+1 *SD*) and low (−1 *SD*) RSA_{change} values. Results indicated that children's Violence Exposure predicted Emotional Problems, at +1 *SD* RSA_{change}, $B = .60, t(7, 62) = 2.73, p < .01$, but was not significant at −1 *SD* RSA_{change}, $B = -.07, t(7, 62) = -.20, p = \text{n.s.}$ In other words, extent of family violence exposure influenced the slope of the regression line for children with greater RSA suppression. As shown in Figure 1, children who showed

greater RSA suppression during the challenge tasks (i.e., withdrawal of parasympathetic input in response to challenge) and were exposed to lower family violence, were rated lower on Emotional Problems compared to children with lower RSA suppression scores. However, in the context of high violence, children with high and low RSA suppression scores showed similarly high Emotional Problems ratings.

Discussion

This study sought to examine relations between family violence exposure (i.e., CM and/or IPV), children's cardiac physiology (i.e., RSA suppression), and their emotional adjustment. Children's RSA suppression in challenging situations was shown to moderate the effects of exposure to family violence on their emotional adjustment. Specifically, among children living in lower violent contexts, greater vagal suppression during challenge was associated with greater parent ratings of emotional adjustment. However, among children living in high violent contexts, vagal suppression was unrelated to their emotional adjustment, and all these children tended to display poorer emotional adjustment. Recall that RSA suppression is characterized by withdrawal of parasympathetic input and is thought to be a physiological marker of dynamic regulation or "active coping" (Beauchaine, 2001; Porges, 1995, 2001, 2007). Suppression of RSA is theorized to occur in response to challenge to allow an individual to increase arousal in order to accomplish related tasks, such as a cognitive effort, behavioral response, and/or engaging in social interactions (Porges, 1995, 2001, 2007).

The findings from the present study provide partial support of the BSC model (Boyce & Ellis, 2005; Ellis & Boyce, 2008; Ellis et al., 2005). As predicted, children with higher levels of RSA suppression who live in less violent homes showed better emotional adjustment. This suggests that in contexts low in family violence, individual differences in children's neurobiological function seem to have a greater impact on children's emotional adjustment. It is possible that greater RSA suppression may enhance the extraction of environmental resources and promote active coping and regulation in these individuals. However, the effect of children's variability in physiological regulatory capacity may be overpowered by the effects of high family violence exposure, suggesting it as a powerful risk factor on children's functioning. Violence exposure is likely to affect children through different routes, only some of which may be moderated by regulatory capacity. Direct victimization and chronic exposure to family violence may increase fear in children, leading to chronic hypervigilance to threat cues that, while adaptive in the home context, may become especially maladaptive in other social contexts. Alternatively, young children are especially sensitive to the social modeling effects of their parents and may develop emotional volatility specific to stress physiology and emotional dysfunction as a normative interpersonal reactive style.

This study joins a growing number of studies documenting associations between children's violence exposure and neurobiological functioning (e.g., Cicchetti & Rogosch, 2001; De Bellis et al., 1999; Pollak et al., 1997; Saltzman et al., 2005), and together with work recently published by Obradovi and her colleagues (2010), provides further support for the environmental context-dependent nature of the parasympathetic system. The present study only found support suggesting that RSA reactivity may enhance children's ability to extract benefits in low-risk circumstances. However, the parasympathetic system only accounts for one of two branches within the autonomic nervous system, and the parasympathetic system does not operate in isolation from the sympathetic system (e.g., Beauchaine, 2001; Berntson, Cacioppo, & Quigley, 1991) with evidence of both systems independently contributing to poor adjustment in children from families with high violence (e.g., Gunnar, Fisher, et al., 2006; Saltzman et al., 2005). However, it is unknown how the two systems jointly contribute to differential outcomes in children exposed to violence, and it is an important avenue for future research to explore.

Although RSA suppression was conceptualized as a composite measure of RSA suppression from resting baseline to each of the four challenge tasks (i.e., a parent–child joint task, emotionally challenging situation, and two cognitive tasks), interesting differences in children's level of parasympathetic suppression emerged between tasks. More specifically, children showed greater suppression during an emotionally challenging task for which there was no clear solution, followed by the most challenging cognitive task (i.e., Day/Night). While studies have revealed that children's RSA reactivity can vary across challenge tasks (e.g., Bazhenova, Polnskaia, & Porges 2001; Calkins & Keane, 2004), other studies investigating the impact of RSA reactivity on the relationship between children's environmental context and their adjustment also have employed composite measures of RSA suppression across multiple challenges (Obradović et al., 2010) with the justification that they are able to elicit variability in RSA suppression. However, subsequent research should further explore whether children who suppress in all types of challenge tasks versus those who only suppress during certain types of challenges show important differences in their susceptibility to their environmental context.

Additionally, future work is needed in order to investigate patterns of autonomic functioning in maltreated children exposed to domestic and other forms of family violence over time in order to better understand the salient mechanisms of risk. The generalizability of findings is limited too by the primarily white, low-income, and rural nature of the sample, and next step research is needed to replicate findings in other samples of children from diverse racial/ethnic and economic backgrounds. Although children's emotional adjustment scores were assessed in a multi-method fashion and both parent report and observer ratings of children's emotional adjustment scores were positively related, moderation findings were only revealed when predicting parent's ratings of their children's emotional adjustment. Therefore, in addition to parent and observer ratings, including evaluations of children's global emotional functioning conducted by trained assessors using the KID-SCID (Matzner, 1994) would provide more comprehensive assessments of children's emotional functioning. Further, emerging studies suggest that the rate of children's RSA recovery after challenge in situations may have important implications for children's adjustment (e.g., Santucci et al., 2008). Therefore, in addition to considering changes in children's parasympathetic function in response to challenge, future research should also include assessments of children's parasympathetic recovery after challenge, as it may prove to be an important resiliency or risk factor for children's emotional adjustment.

The findings from the present study suggest that children with greater vagal suppression showed better emotional adjustment in low violent contexts. Further, children showed poorer emotional adjustment when from families high in violence, regardless of their level of vagal suppression. Although individual differences in children's physiology contributed to differences in emotional adjustment when from low violent contexts, it would be useful for interventions with children from high family contexts to aim their efforts at reducing the amount of violence that occurs within the home in order to improve children's emotional adjustment. Specifically, interventions should be comprehensive and include involvement with the child, family context, and relationships within the family. For example, interventions should include components aimed at improving parent–child relationships by providing parents with skills to help manage their children in effective ways in order to reduce the likelihood of CM occurring in these families. Additionally, components should focus on helping the mother and her partner develop nonviolent ways to resolve conflict. Further, one-on-one work with children should be provided to teach them methods to effectively manage, express, and self-regulate their emotions.

Previous work employing the BSC model has primarily focused on global, macro-level environmental influences, and it is unknown how micro-level processes may interact with

children's physiology to impact their emotional adjustment. Given that children exposed to family violence often experience harsher and negatively controlling parenting on a daily basis (e.g., Cerezo & D'Ocon, 1995), it is possible that children's physiology may differentially affect how children are affected by the type of parenting they experience. Although the present study found that children's physiology did not influence their emotional adjustment when from high violent contexts, it is possible that variability in parenting experienced by these children, in conjunction with their physiological functioning, may impact their emotional adjustment.

The findings from this study support the notion that individual differences in children's neurobiology are important factors to consider and to model in efforts to better understand heterogeneity in outcomes among children living in violent families. Future research should consider how other individual differences, such as children's temperament (i.e. behaviorally based individual differences in children's level of emotional reactivity and regulation; Rothbart & Bates, 2006), may influence the relationship between exposure to family violence and emotional adjustment. This seems especially important to investigate, given that research has found linkages between children's vagal reactivity and components of their temperament (e.g., Stifter & Corey, 2001). Therefore, examining the relationship between children's temperamental characteristics in conjunction with physiology may further explain heterogeneity in children's emotional adjustment when they are exposed to family violence.

In conclusion, this study contributes to the growing literature documenting the role of vagal suppression as an important individual difference characteristic to consider in children exposed varying degrees of family violence. These findings partially support the environmental context-dependent nature of the parasympathetic system and are consistent with Boyce and Ellis' concept of BSC (e.g., Boyce & Ellis, 2005; Ellis & Boyce, 2008; Ellis et al., 2005) and other studies (e.g., Obradović et al., 2010) documenting the risk and protective functions of individual differences in physiology depending on the developmental context.

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Figure 1.

Regression lines for relationship between family violence exposure and emotional problems, moderated by RSA suppression. Low and high family violence exposure values and low and high RSA suppression scores are graphed a 1 SD below and 1 SD above the mean, respectively.

Table 1
Intercorrelations and Descriptives for RSA_{change} Scores Across the Four Challenge Tasks

	1	2	3	4
1. Duplo RSA _{change}				
2. Transparent Box RSA _{change}	.55 **			
3. Shapes RSA _{change}	.63 **	.71 **		
4. Day/Night RSA _{change}	.60 **	.68 **	.82 **	
Mean	.58	.71	.09	.27
Standard deviation	.75	.91	1.06	.98
Range	-1.74 to 2.57	-2.30 to 3.05	-4.53 to 2.22	-4.31 to 2.29

Note. RSA_{change} scores = Mean Baseline RSA – Mean RSA during the task.

**
 $p < .01$.

Descriptives of Study Variables**Table 2**

	<i>M</i>	<i>SD</i>	Range
^a Violence Exposure	0.02	1.60	−1.74 to 4.80
^b CM Severity	0.00	1.0	−.87 to 4.12
^c CTS (Inter-partner violence)	0.00	1.0	−.88 to 4.12
^d RSA _{baseline}	6.24	1.30	3.23 to 8.86
^e RSA _{change}	0.42	0.80	−3.22 to 2.08
Emotional Problems	1.78	1.80	0 to 7.0
Frustration	4.26	1.78	1.0 to 9.0
Positive Affect	5.93	1.52	2.0 to 9.0

Note.

^a Sum of standardized scores of CM severity and CTS.

^b MCS CM severity standardized scores.

^c Sum of the weighted frequency scores on the CTS Verbal Aggression and Violence scales.

^d Average RSA during baseline period.

^e Average RSA change scores across the four challenge tasks.

Table 3

Correlations Among Study Variables

	1	2	3	4	5	6
1. Violence Exposure		.01	-.21	.15	.24*	-.09
2. RSA _{baseline}			.56**	-.19	-.08	-.09
3. RSA _{change}				.00	.09	.13
4. Emotional Problems					.23*	-.24**
5. Frustration						-.38**
6. Positive Affect						

Note. RSA_{baseline} was partialled out in correlations between RSA_{change} with Violence Exposure, Emotional Problems, Frustration, and Positive Affect.

* $p < .05$.

** $p < .01$.

Table 4
Multiple Regression Analyses for RSA_{change}

	<i>B</i>	<i>SE (B)</i>	β	ΔR^2
I. Emotional problems				
Step 1				
Child Age	-.13	.30	-.05	
RSA _{baseline}	-.34 [*]	.17	-.24	.06
Step 2				
Household Income	-.27	.24	-.16	
Maternal Education	.01	.09	.00	.08
Step 3				
Violence Exposure	.20	.17	.18	
RSA _{change}	.20	.36	.08	.02
Step 4				
Violence Exposure $\times$ RSA _{change}	.40 ^{**}	.15	.39	.20
II. Frustration				
Step 1				
Child Age	-.32	.27	-.14	
RSA _{baseline}	-.10	.16	-.08	.02
Step 2				
Household Income	-.27	.21	-.18	
Maternal Education	-.09	.08	-.14	.10
Step 3				
Violence Exposure	.16	.15	.17	
RSA _{change}	.44	.31	.21	.14
Step 4				
Violence Exposure $\times$ RSA _{change}	.10	.13	.12	.15
III. Positive Affect				
Step 1				
Child Age	.61 ^{**}	.23	.32	
RSA _{baseline}	-.08	.13	-.06	.11
Step 2				
Household Income	.10	.18	.08	
Maternal Education	.01	.07	.03	.12
Step 3				
Violence Exposure	-.09	.13	-.10	
RSA _{change}	.30	.28	.16	.14
Step 4				
Violence Exposure $\times$ RSA _{change}	-.21	.11	-.27	.19

Note. *B* = unstandardized beta coefficient. *SE (B)* = standard error of unstandardized beta coefficient. β = standardized beta coefficient. ΔR^2 = R square change value.

*
 $p < .05$.

**
 $p < .01$.