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Interparental Aggression and Infant Patterns of Adrenocortical and Behavioral Stress Responses

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Abstract

Drawing on emotional security theory, this study examined linkages between interparental aggression, infant self-regulatory behaviors, and patterns of physiological and behavioral stress responses in a diverse sample of 735 infants residing in predominately low-income, nonmetropolitan communities. Latent profile analysis revealed four classes of adrenocortical and behavioral stress response patterns at 7-months of age, using assessments of behavioral and cortisol reactivity to an emotion eliciting challenge, as well as global ratings of the child's negative affect and basal cortisol levels. The addition of covariates within the latent profile model suggested that children with more violence in the home and who used less caregiver-oriented regulation strategies were more likely to exhibit a pattern of high cortisol reactivity with moderate signs of distress rather than the average stress response, suggesting possible patterns of adaptation in violent households.

Keywords

interparental aggression; infancy; cortisol; negative reactivity; emotion regulation

A long history of research suggests that interparental aggression poses a significant threat to children's development, yet the specific processes linking aggression in the home and child adjustment remain unclear (Cummings, El-Sheikh, Kouros, & Buckhalt, 2009). Central to understanding the processes that place some children at risk are maladaptive or adaptive stress responses; that is, the ways in which children manage internal or external demands

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that strain their resources (Eisenberg, Fabes, & Guthrie, 1997). Emotional security theory suggests that interparental aggression threatens children's feelings of safety and security in the family, and children's stress responses to this emotional insecurity may be an important link between exposure to aggression and early mental health risk (Davies & Cummings, 1994). Over time, patterns of responding to chronic emotional security threats may generalize to other challenging situations, contributing to the formation of less flexible stress responses (Shelton & Harold, 2007).

Although adapting to stress involves the coordination of physiological and behavioral responses (Eisenberg et al., 1997; Stansbury & Gunnar, 1994), much work remains in understanding whether and how aggression in the home may influence integrated patterns of responding across these domains, particularly in infancy. This is a notable gap, because young children are at increased risk of exposure to interparental aggression (Fantuzzo, Boruch, Beriama, Atkins, & Marcus, 1997), and early experiences in the family are thought to play a central role in shaping both behavioral and biological stress responses (e.g., Gunnar & Davis, 2003; Morris, Silk, Steinberg, Myers, & Robinson, 2007). As noted by Katz (2001), "It is only through integrating our understanding of both biological and behavioral processes that we can get a complete picture of the effects of marital conflict on the whole child" (p. 207). It is a central goal of the current study to examine the linkages between interparental aggression and patterns of physiological and behavioral stress responses.

Specifically, there is reason to believe that examining *patterns* of *multiple* behavioral and adrenocortical responses may provide important insight into stress and adaptation in infancy. As one of the main components of the psychobiology of the stress response, HPA axis reactivity and relative elevations in cortisol have been used as physiological indicators of stress, and alterations in adrenocortical functioning may result from chronic stress exposure (Gunnar & Donzella, 2002). The cortisol response is considered to be adaptive in the short term, as it facilitates the mobilization of energy, modulates the biology of growth and repair, and alters the processing of emotionally salient events (Gunnar & Davis, 2003). However, there is evidence that early adversity may have long-term effects on the functioning of the HPA system, with implications for children's adaptation and development. Maladaptive caregiving in infancy has been linked with elevated or blunted adrenocortical activity (e.g, Dozier, Peloso, et al., 2006; Carlson and Earls, 1997), alterations which are associated with impaired physical and mental health later in development. For example, chronically high HPA axis activity may result in atrophy in the hippocampus and prefrontal cortex, components of the neural systems responsible for memory, selective attention, learning, and inhibitory control (Bremner & Vermetten, 2001; McEwen, 2006). On the other hand, abnormally low cortisol levels in older children have been linked with altered brain development, disrupted self-regulation, and risk for behavior problems (e.g., Blair, Granger, & Razza, 2005; Gunnar & Vazquez, 2001), but little is known about the links between low cortisol level and infant development.

With evidence indicating overlap in the neural circuitry of emotion and of HPA responses (Davidson, Jackson, & Kalin, 2000), both behavioral distress and elevated cortisol levels are often used to indicate stress in infancy (e.g., Gunnar, 1992; Levine, 1983). Although it is often assumed that behavioral and adrenocortical stress reactions operate in tandem (cf. Gunnar & Donzella, 1999), evidence suggests that adrenocortical and behavioral reactions serve distinct functions, and might be better thought of as loosely coupled components of the stress response that permit the existence of a variety of patterns of adaptation (Gunnar & Davis, 2003; Quas, Hong, Alkon, & Boyce, 2000). For example, high cortisol levels accompanied by only minimal behavioral signs of distress might result from active attempts to regulate or mask overt signs of negative emotions, a pattern that might be adaptive in the face of threatening caregivers (Spangler & Grossman, 1993). Alternatively, high behavioral distress with abnormally low cortisol levels might be the result of down-regulation of the adrenocortical response after prolonged stress, an adaptation in the face of chronic adversity (Gunnar & Vazquez, 2001). If behavioral and adrenocortical responses constitute a coordinated system with multiple potential “settings” resulting from the individual’s developmental history, then the consideration of only one component of that system at a time could obscure our understanding of child functioning. Thus, examining constellations of functioning across adrenocortical and behavioral domains may provide a more complete understanding of adaptation in the face of stress.

With respect to behavioral responses, emotional security theory suggests that exposure to aggression may heighten vigilance and intensify negative reactivity, providing physical and psychological resources so that the child can react quickly to signs of threat in the home (Davies & Cummings, 1994). Rather than habituating to chronic conflict in the home, several studies have shown that interparental conflict is associated with increased fear, anger, and distress in school-aged children, particularly when the conflict is aggressive or involves the use of physical force (e.g., Davies, Sturge-Apple, Winter, Cummings, & Farrell, 2006; Harold, Shelton, Goeke-Morey, & Cummings, 2004). Discord appears to be a salient stressor even during infancy, with very young children showing clear signs of behavioral distress in response to interparental conflict or interadult anger (Cummings, et al., 1981; Dejonghe, Bogat, Levendosky. von Eye, & Davidson, 2005). Infants who witness interparental violence often show symptoms of hyperarousal, appearing more anxious or irritable on average than children not exposed to violence (Bogat, Dejonghe, Levendowsky, Davidson, & von Eye, 2006; Scheeringa, Zeanah, Drell, & Larrieu, 1995). However, Davies and colleagues (2006) have suggested that children may attempt to “mask” distress expressions in violent households despite high internal arousal, in order to avoid drawing the attention of hostile, angry caregivers. Indeed, restricted and blunted emotional expressions and flat affect have also been linked with exposure to violence (for a review, see Margolin & Vickerman, 2007). Although this restriction of emotional expression may be adaptive in violent homes, inhibiting emotional expression in the face of distress may tax important psychological and physiological resources, and impair long-term functioning (Davies & Forman, 2002).

With respect to adrenocortical functioning, a large body of evidence indicates that chronic stress in the early family environment disrupts normative adrenocortical activity (e.g., Ashman, Dawson, Panagiotides, Yamada, & Willkinson, 2002; Gunnar & Davis, 2003). Although work specifically on interparental aggression and infant cortisol is scarce, a growing body of research links aggression within the home and dysregulated adrenocortical activity. In a sample of kindergarteners and adolescents, low marital satisfaction and concurrent exposure to interparental aggression was associated with higher wakeup and average cortisol levels, even after controlling for maternal emotional functioning and parenting quality (Pendry & Adam, 2007). Similarly, in a sample of 5–13 year olds, Saltzman, Holden, and Holahan found elevated cortisol in children exposed to violence, in comparison to a clinical group without domestic violence exposure. Examining concurrent cortisol responses to conflict, Davies and colleagues (2007) found that kindergarteners’ diminished cortisol reactivity to conflict mediated associations between interparental discord and child externalizing problems two years later. Despite a growing body of empirical evidence, prior research with the current sample found no differences for infants exposed to intimate partner violence in baseline cortisol levels or cortisol reactivity to an emotion eliciting challenge (although mothers from violent households exhibited more concordance between their own cortisol reactivity and that of their infant) (Hibel, Granger, Blair, & Cox, 2009). It was a central goal of the current study to explore whether identifying patterns of behavioral and adrenocortical components of infant stress responses could offer a more complete perspective on children's stress response functioning in the face of interparental aggression.

Additionally, the regulatory behaviors infants use to cope with stressors (e.g., self-soothing, seeking support from caregivers, avoidance) may be linked with distinct patterns of coordination in adrenocortical and behavioral stress responses. Because effective regulatory strategies may reduce stress, it is theorized that such behaviors may keep cortisol and distress levels within an optimal range (see Gunnar & Poggi-Davis, 2003; Nachmias, Mangelsdorf, Parritz, & Buss, 1996). In contrast, failing to implement an effective behavioral regulatory strategy maintains or intensifies the stress of challenging situations, with implications for both behavior and physiology. For example, continued, active attempts to cope with a threat that exceeds the individual's resources may result in distress with prolonged elevations in adrenocortical activity, whereas inability to mount a self-regulatory response and disengagement may be linked with low adrenocortical reactivity and decreased emotional involvement (see Gunnar & Vazquez, 2001; Blair, Granger, & Razza, 2005). Several studies, however, have failed to find linkages between self-regulation in infancy and adrenocortical responses (e.g., Keenan, Grace, & Gunthorpe, 2003; Ramsay & Lewis, 2003). However, it remains to be seen whether purported regulatory behaviors are meaningfully linked with distinct joint configurations of adrenocortical and behavioral stress responses.

In summary, the current study examined associations between interparental aggression and patterns of responding to stress in infancy. First, we explored whether meaningful patterns of behavioral and adrenocortical stress responses could be indentified in 7-month old children using latent profile analysis (LPA). A primary benefit of LPA is that it is probabilistic or model-based (unlike cluster analysis), which implies that the model can be replicated with other, independent samples (Nylund et al., 2007). Further, LPA allows covariates to be included simultaneously within the model, such that the uncertainty associated with class membership is accounted for (Roeder, Lynch, & Nagin, 1999). Because responses to specific stressors may be partially dependent on current, global stress levels (Kopp, 1989), multiple indicators of adrenocortical and behavioral reactivity were carefully selected based on previous research to reflect both the infant's underlying global stress responses for that day, and the infant's responses to a specific, time-limited, emotion eliciting stressor. Global stress responses for the day included basal cortisol levels (e.g., Fortunato et al., 2008) and observational ratings of the child's overall behavioral distress across several hours (e.g., Stifter & Corey, 2001). Stress responses to a time-limited, emotion-eliciting challenge included observational codes for infants' peak negative reactivity to a series of emotional stressors (e.g., Hane et al., 2008), and the intensity and magnitude of their adrenocortical response to the same emotion-eliciting stressors (e.g., Dougherty et al, 2010). Second, we explored associations between interparental aggression, infant regulatory behaviors (e.g., self-soothing, looking to caregivers, avoidance) and membership in these latent stress response classes, in order to describe linkages between specific constellations of stress responses and aspects of individual and family functioning.

Method

Participants

Participants for the current study were drawn from an ongoing longitudinal investigation of child development and family functioning in rural, low-income communities. Three contiguous counties in both Pennsylvania and North Carolina were selected for recruitment to be representative of two geographical regions with chronic rural poverty: the Black South and Appalachia (Dill, 2001). Families were excluded from participation if they did not speak English as a primary language in the home, did not reside in the target county, had plans to move outside of the state within the following three years, or had parental rights terminated by the state (except in cases where the child would be cared for by family members in the target county).

Over the course of the year, 5,471 women gave birth to a child in local hospitals; 72% (n = 3,939) met the inclusion criteria for the study. Of these, 68% (n = 2, 679) agreed to have their name placed in a lottery for selection into the project; 58% (n =1,554) of these families were invited to participate in the project, based on stratified random selection procedures (oversampling for low-income and African American families to address research questions of interest to the overall project); for detailed information regarding the sampling plan and recruitment procedures, see Vernon-Feagans et al., (2008). Of the 1,554 families invited to participate, 1,292 (82%) completed an initial home interview when the infant was 2-months of age. The current study focuses on a home visit that took place when the target child was approximately 7-months of age. Because interparental aggression was a central construct of interest, the sample was restricted to children who resided with their biological mother and her romantic partner. Of the 1,204 (93%) families who participated at the 7-month visit, 781 (67%) of these included children residing with their biological mother and her romantic partner. The majority of these couples were married (74%). To minimize potential developmental differences in children's stress responses (and to be consistent with previously established developmental cut-points for this sample (e.g., Blair et al., 2008)), the decision was made to restrict analyses to children seen between 5 and 9 months of age at the "7-month" visit (M = 7.21, SD = 1.04), resulting in the exclusion of 46 children. Thus, the final sample consisted of 735 children.

Approximately half of the children were female (48%), and 25% were identified as Black (75% identified as White). A large proportion of the families were economically strained, with 51% of the households reporting an income to needs ratio less than 200% of the poverty line.

Procedures

Two trained research assistants visited families in their homes to conduct interviews and to collect observational and physiological assessments of the target child. Mothers completed questionnaires on laptop computers and reported demographic information on all household members (questionnaires were read in a private setting to mothers who could not read at an 8^{th} grade level). Home visitors independently completed post-visit ratings of the child's behavior over the course of the entire visit. During the visit, children participated in a series of developmentally appropriate challenging tasks designed to elicit emotional reactivity and self-regulatory behavior, which were videotaped for later coding (e.g., Buss & Goldsmith, 1998; Stifter & Braungart, 1995).

Challenge tasks—Infants were presented with series of three tasks while seated in a walker: a mask presentation, followed by a barrier challenge, and finally an arm restraint procedure. Mothers were informed that they could stop the procedure at any time, and the research assistant terminated the tasks if the child engaged in 20-seconds of hard crying. For the *mask presentation*, mothers were seated beside their child while the child was presented with a succession of four unusual masks (long-nosed woman, Frankenstein, goofy vampire, Conehead) for 10-second intervals. While wearing each of the masks, the research assistant leaned towards the seated child, turned their head from side to side, and repeated the child's name. Mothers were asked not to interfere or distract their child, but to respond as they normally would if their child looked to them. For the *barrier challenge*, mothers were asked to step outside of the infant's line of sight, but to remain within hearing distance of their child. Infants were given an attractive toy to play with for 30 seconds, which was then removed by the research assistant and placed behind a clear, plastic barrier just beyond the child's reach for 30 seconds. The toy was then returned to the child, and the procedure was repeated twice for a total of three cycles. For the *arm restraint* procedure, the mother remained outside of the child's line of sight, and a research assistant crouched behind the infant and gently restrained the child's arms for two minutes. The infants' arms were then released, and the child was allowed to self-soothe for one minute. Mothers were then told they could comfort their child as they would normally.

Adrenocortical Assessment—To assess overall levels of adrenocortical activity, as well as cortisol reactivity and recovery in response to the emotionally arousing challenge tasks, three saliva samples were collected from the infants: 1) a baseline sample collected prior to the challenge tasks (assessed approximately 35-minutes after arrival to the child's home, with 30-minutes being the recommended acclimation period for obtaining accurate pre-stress baseline measures (Nicolson, 2008)), 2) a sample collected 20-minutes after the completion of the tasks or after the child's peak arousal, and 3) a final sample collected 20-minutes later. An infant was considered to have reached peak arousal if the task was terminated due to 20 seconds of hard crying; the majority of the children who reached peak arousal did so during the final arm restraint task. Unstimulated whole saliva was collected using absorbent cotton dental rope placed in the infant's mouth, and a needleless syringe was used to express saliva into 2-ml cryogenic storage vials (a commonly used technique for assessing cortisol in infancy (e.g., Harmon, Hibel, Rumyantseva, & Granger, 2007; Granger et al., 2007). Prior studies have indicated no differences in cortisol concentrations associated with this collection technique and other commonly used assessments in infancy (such as saliva collected through hydrocellulose absorbent material, and expressed through centrifugation (Harmon et al., 2007)). After collection, samples were placed on ice, temporarily stored in a −20°C freezer, shipped overnight in batches to the Behavioral Endocrinology Laboratory at the Pennsylvania State University, and then stored in −80°C freezers until they were assayed. Of the 735 infants, 5.4% had missing data for the basal cortisol sample, 15.8% for the sample collected 20-minutes after the emotion-eliciting challenge, and 24.4% were missing the final sample.

Measures

Covariates—Mothers reported on demographic information on all household members, including age, race, marital status, and income from all sources. In order to calculate the income-to-needs ratio of the family, total household income from all sources was divided by the federal poverty threshold for that year, adjusted for the number and types of individuals in the household. An income-to-needs ratio of 1 indicates that the household income is at the poverty line for that year. Mothers also reported on their child's temperament, using the revised version of the Infant Behavior Questionnaire (IBQ-R; Gartstein & Rothbart, 2003). Mothers rated the frequency with which their child exhibited specific behaviors in the last two weeks, with 1=never to 7= always (e.g., "When visiting a new place, how often did the baby show distress for the first few minutes?") For the purposes of the current study, mean scores on the fear/distress to novelty subscale (16 items; $\alpha = .89$) and the distress to limitations subscale (16 items; $\alpha = .83$) were used to form a mean negative affect score.

Interparental aggression—Mothers reported on their own and their partners' use of verbal aggression and violence during the past 12-months (Conflict Tactics Scale - Couple Form R (CTS-R); Straus & Gelles, 1990). Given substantial evidence to suggest men under-report their own verbal and physical aggression, it has been recommended to base assessments of aggression in the home by relying on women's report (Stets & Straus, 1989, Straus & Sweet, 1992). The 6-item verbal aggression scale assesses the frequency with which she or the partner used verbal acts that symbolically hurt the other party ($\alpha = .89$; e.g., "How often has he insulted or swore at you?"), and the 9-item violence scale assesses the frequency with which physical force was used as a means of resolving the conflict (α = .81; e.g., “How often has he kicked, bit, or hit you with a fist?”); items ranged from 0 = “never” to 6 = “more than 20 times in the past year”. Because child outcomes may vary depending on the severity of violence in the interparental relationship, the subscales of minor and severe violence were also used. Minor violence consisted of 3 items (e.g., “How often has he slapped you?”). Severe violence consisted of 6 items (e.g., “How often has he beat you up?”). Consistent with estimates suggesting 30% of American children live in families in which interparental violence occurs (McDonald, Jouriles, Ramisetty-Mikler, Caetano, & Green, 2006), 29% of mothers in the current sample reported they or their partner used some form of violence within the past 12-months (for violent families, total violence sum M = 7.67, SD = 8.35).

Adrenocortical functioning—Children’s *basal cortisol* levels were used as an indicator of global adrenocortical levels. In order to assess children’s *adrenocortical reactivity* to the challenge tasks relative to this basal level, “Area under the curve with respect to increase” (AUC_I, Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003) was used as an indicator of the change in cortisol levels after this stressor; this measure incorporates changes in cortisol (from basal levels) in samples taken both 20- and 40- minutes after the child’s peak emotional reactivity to the challenge tasks into a single value. Because AUC_I provides a way to incorporate the intensity and magnitude of adrenocortical reactivity over multiple assessment points, it has been recommended for use in studying the cortisol response over time after a specific challenge (Fekedulegn et al., 2007), and has been used in previous research to assess children’s stress reactivity (Talge, Donzella, & Gunnar, 2008). To account for diurnal variation in cortisol levels, the standardized residuals were used after controlling for time of day for both basal and AUC_I measures.

Child global negative affect—After the home visit, both research assistants independently rated the child’s behavior using an adaptation of the Infant Behavior Record (IBR; Bayley, 1969). Originally developed to assess individual differences in behavior observed during the administration of the Bayley Scales of Development, previous research has applied the IBR to rate child behavior observed across an entire laboratory or home visit (Stifter & Corey, 2001; Stifter, Willoughby, & Towe-Goodman, 2008). In the current study, the IBR was applied globally to infant behavior observed across the entire home visit (2–3 hours), in order to obtain two measures of global negative affect. The IBR items included in the present study were *unhappiness*, and *irritability*. Unhappiness was rated from 1 to 9, with 9 indicating the child seemed unhappy throughout the entire visit, and 1 indicating that nothing was upsetting to the child, and that the child radiated happiness. Irritability was also rated from 1 to 9, with 9 indicating the child was irritable to all degrees of stimulation encountered throughout the home visit, and 1 indicating no irritability. The mean of the home visitors’ ratings were used; cross-rater correlations ranged from .56 to .59 (as research assistants often saw different aspects of the child’s behavior across the home visit, modest cross-rater correlations were not entirely unexpected).

Child negative reactivity & regulation to a stressor—Teams of coders rated the child’s behavior during each of the challenge tasks. Coders were trained to achieve a minimum reliability of .75 (Cohen’s kappa) in order to rate the child’s negative reactivity to an emotion eliciting challenge and the regulatory strategies the child used to cope with this stressor on a second by second basis (Stifter & Braungart, 1995).

The intensity of the child’s negative reactivity was rated on a 4-point scale, where 0 represented observing no negative affect or vocalizations, 1 represented mild negative reactivity (e.g., child is frowning, fussy, or whiny), 2 represented moderate negative reactivity (e.g., crying) and 3 represented high negative reactivity (e.g., screaming, intense crying, wailing, or breath-holding). Reliability was assessed on 15% of the families by task (κ = .86 for arm restraint, κ = .89 for the barrier task, κ = .95 for the mask presentation). The proportion of time the child spent in mild, moderate, and highly negative reactive states during the task were calculated by dividing the number of seconds for each code by the total duration for each task. In order to calculate the mean intensity of negative reactivity, the proportion of time the child spent in mild, moderate, and highly reactive states was multiplied by 1, 2, and 3, respectively, and a mean of these intensity scores was created for each task. The current study used the mean intensity of negative reactivity during the task in which the child evidenced the most overall distress, in order to capture peak behavioral reactivity.

A separate team of coders rated the presence of specific infant regulatory behaviors for each task. Coders rated *re-orienting to adults*, which involved the infant looking to the face of the mother or research assistant, *self-soothing*, which included small, repetitive fine-motor movements (such as sucking on hands or fingers, rubbing eyes, hands or face), and *avoidance*, which involved the child averting eye contact, turning away from the stimulus, or struggling against the restraint of the seat. Reliability was assessed on 15% of the families by task (κ = .82–.93 for arm restraint, κ = .83–.95 for the barrier task, κ = .95–.99 for the mask presentation).

Analytic Strategy

Latent profile analysis (LPA) was used to identify subgroups of children with similar patterns of behavioral and adrenocortical stress responses in infancy, using the child's basal cortisol levels, adrenocortical response to the challenge tasks (area under the curve with respect to the increase; AUC_I), peak negative behavioral reactivity observed in the challenge tasks, as well as global observational ratings of the child's overall unhappiness and irritability. Given that the use and effectiveness of specific regulatory strategies may reduce the stress of challenging situations, the decision was made to include regulatory behaviors as covariates, rather than incorporating these into the patterns of stress responses.

LPA is an exploratory method used to divide a population into mutually exclusive and exhaustive latent subgroups, identifying underlying groups of individuals, or latent classes, who share qualitatively distinct patterns of characteristics (Muthén, 2001). Observed continuous variables are used as indicators of categorical latent classes. Non-normally distributed variables were transformed, and all variables were standardized prior to entry in the models to account for scale differences across the measures. In order to account for missing data (26.3% of data were missing on one or more study variables, with the highest percentage missing on observations of regulatory behavior), all analyses were conducted using multiply imputed missing values. Multiple imputation is considered to provide more accurate estimates than other methods of dealing with missing data (e.g., listwise deletion, mean imputation), and can reduce the impact of having data which is missing not at random (Collins, Schafer, & Kam, 2001, Graham, 2009). LPA models were fit using Mplus version 5.2 (Muthén & Muthén, 2008), and the optimal number of classes was selected based on a balance of model fit, interpretability, and parsimony (e.g., Bayesian information criterion (BIC), Akaike information criterion (AIC), Lo Mendell Rubin (LMR; Lo, Mendell, & Rubin, 2001), and entropy statistic (Celeux & Soromenho, 1996)).

Next, covariates were added to the final latent profile model (within the Mplus program) to examine whether and how interparental aggression during the past year (maternal reports of verbal aggression and violence in the interparental relationship) and concurrent child regulatory behaviors (from the challenge tasks) were associated with the probability of membership in the latent stress response classes at each time point, accounting for various child (i.e., child sex, age, ethnicity, temperament), and family characteristics (i.e., site, income, marital status) that could alter the magnitude of associations.

Results

Table 1 presents the bivariate associations among infant adrenocortical functioning, behavioral reactivity, interparental aggression, infant self-regulatory behaviors, and demographic characteristics. Notably, there were no significant associations between cortisol levels, behavioral distress, or interparental aggression at the bivariate level. A 4-class model was determined to provide the best fit to the data (see Table 2). In order to examine model identification, model parameters were estimated based on 1000 different sets of random starting values; this strategy ensures the maximum likelihood function converges on a distinct global maximum during estimation, rather than terminating on one or more local maxima (Lanza, et al., 2003). One solution emerged from these analyses, suggesting appropriate identification of the model. The average posterior probability for latent class membership (range = .87 – .95) was considered to be high, per criteria established by Roeder and colleagues (1999) (posterior probabilities over .70 considered high).

Table 3 shows the standardized mean scores for the stress response indicators used in the model; classes were assigned labels based on distinguishing characteristics. Over half the sample (55%) was characterized by relatively low global levels of adrenocortical and behavioral functioning, as well as average to low reactivity to challenge; thus, this class was labeled ‘Low Reactors’. Approximately one-third of the sample (34%) were labeled ‘High Cortisol Reactivity, Moderate Negative Behavior’, because they showed the highest levels of adrenocortical reactivity to challenge, but only moderate levels of behavioral stress responses. Two smaller subgroups comprised the remainder of the sample. The ‘High Negative Behavior’ (6%) class showed high negative reactivity to the challenge tasks and were rated as highly irritable and unhappy over the course of the visit, yet showed average adrenocortical responses. Finally, ‘High Baseline Cortisol, Low Cortisol Reactivity’ (6%) were distinguished by high basal cortisol levels, but a markedly low cortisol response to the emotional eliciting challenge.

Interparental Aggression, Child Regulatory Behaviors, and Stress Response Profiles

Table 4 presents results of models examining associations among family and child characteristics, interparental aggression, child regulatory behaviors, and the probability of membership in the latent stress response classes. The ‘Low Reactors’ class was selected as the reference group, because this pattern characterized the majority of infants. Verbal aggression and violence were examined in separate models: Model 1 examined verbal aggression, Model 2 examined violence.

With respect to the covariates, child temperament and data collection site were linked with latent class membership. Specifically, children higher in negative affect were more likely to be in the ‘High Negative Behavior’ class or the ‘High Cortisol Reactivity, Moderate Negative Behavior’ class, relative to the ‘Low Reactors class’ ($p < .01$). Additionally, children residing in Pennsylvania were more likely to be in the ‘High Baseline Cortisol, Low Cortisol Reactivity’ class, relative to the ‘Low Reactors’ class.

Interparental aggression was associated with probability of latent class membership. Specifically, each unit increase in interparental violence was associated with a 33% greater odds of membership in the ‘High Cortisol Reactivity, Moderate Negative Behavior’ class, relative to the ‘Low Reactors’ class ($p < .05$). Post-hoc tests were conducted to explore potential differential associations between minor or severe interparental violence and class membership. A similar pattern of findings emerged as with total violence; each unit increase in minor and severe violence was associated with a 28% and 30% greater odds of membership (respectively) in the 'High Cortisol Reactivity, Moderate Negative Behavior' class, relative to the 'Low Reactors' class ($p < .05$).

Additionally, the self-regulatory behaviors infants engaged in predicted class membership. Specifically, for each unit increase in reorienting to adults, infants were 52–59% *less* likely to be in the 'High Cortisol Reactivity, Moderate Negative Behavior' class relative to the 'Low Reactors' class ($p < .01$).

Discussion

We sought to explore whether meaningful patterns of both behavioral and adrenocortical stress responses could be identified in infancy, and to examine whether interparental aggression and infant regulatory strategies were associated with specific patterns. Evidence was found for distinct constellations of stress responses, providing unique insight into the potential coordination of behavior and physiology in subgroups of individuals. Additionally, interparental aggression was linked, albeit modestly, with a distinct stress response pattern; infants from violent homes were more likely to display a pattern of high adrenocortical reactivity with moderate signs of distress, rather than the average stress response. Infant stress responses were also linked with the use of specific regulatory strategies, consistent with the notion that both family functioning and self-regulatory behaviors may be linked with patterns of coordination in adrenocortical and behavioral stress responses.

First and foremost, these findings highlight that examining patterns of stress responses across physiological and behavioral domains may enable the construction of more comprehensive theoretical and measurement models of how children manage internal and external demands. As noted by Diamond & Aspinwall (2003), merely describing associations between different levels of analysis (e.g., high behavioral and cortisol reactivity) is likely to provide distorted perceptions of the way individuals cope with stress. Although advances have been made by documenting associations between adrenocortical and behavioral reactivity (or the factors that moderate these associations), these findings suggest that unique information can be gained through exploring constellations of stress responses, and by examining how they are linked with patterns of functioning within individuals. Specifically, the findings suggest that there may be subgroups of infants with distinct patterns of coordination in behavioral and adrenocortical functioning, including high and disassociated stress responses. For example, results suggest that the latent subgroup with the most behavioral distress did not have above average levels of adrenocortical reactivity; whether this pattern reflects individual differences in reactivity, or down-regulation of the adrenocortical response remains an open area for inquiry. Similarly, the latent subgroup with high levels of basal adrenocortical activity had below average levels of behavioral distress, in addition to low adrenocortical reactivity to the emotion eliciting challenge. Given that high basal levels of cortisol may reflect chronic stress within the home environment (Evans & English, 2002), understanding the specific precursors to this stress response pattern also warrants further investigation.

Consistent with the notion that individuals should be viewed as an organized totality in order to understand their functioning and development (Bergman & Magnusson, 1997; von Eye & Bergman, 2003), our findings also underscore the strengths of using a "person-oriented" approach in the study of interparental aggression and child outcomes. Because security concerns engendered by violence are theorized to organize children's responses across multiple domains, there have been repeated calls to integrate children's physiological and behavioral functioning in the study of interparental aggression and child outcomes (e.g., Davies et al., 2007; Katz, 2001), but this has, in fact, rarely been done. We found associations between aggression in the home and patterns of stress responses that would have been obscured if only one aspect of child functioning had been examined. For example, bivariate associations showed no direct linkages between aggression and infant behavioral or adrenocortical functioning in this sample, yet we found distinctions in the coordination of adrenocortical functioning and child behavior in relation to violence (see Table 1 and 4).

However, contrary to expectations, interparental violence and infant regulatory behaviors were only modestly, but significantly, associated with these constellations of stress responses. Specifically, interparental violence was linked with stress responses characterized by the greatest adrenocortical reactivity, with only moderate elevations in negative behavioral reactivity. Emotional security theory suggests that exposure to violence in the home may sensitize children to possible threats in their environment, and the current findings offer a potential perspective on this elevated arousal in early childhood. Infants in this class did not manifest the highest levels of behavioral distress, nor did they have the highest basal cortisol levels, yet they had the highest levels of adrenocortical reactivity in response to challenge; despite being clearly aroused by the emotion eliciting stressors, these children did not communicate distress at the highest behavioral levels. Although habituation to distress eliciting contexts could be one potential explanation for the lower levels of behavioral distress, the high physiological arousal associated with this pattern contradicts this explanation. Instead, this pattern is consistent with Davies and Forman (2002) proposal that one strategy for maintaining emotional security in violent households may be a "masking" profile, in which children minimize overt distress displays despite high levels of internal arousal. In the face of interparental violence, drawing caregiver attention may be potentially dangerous, and some children may adapt to the demands of an unstable and threatening home environment by suppressing behavioral signs of distress. Since empirical work has shown strong linkages between marital aggression and parental violence towards children (e.g., Hughes, 1988), it is reasonable to infer that expressing high behavioral reactivity might pose a very real threat to children's safety. However, because a more reactive adrenocortical system may put mental and physical health at risk (McEwen & Seeman, 1999; Gunnar & Vasquez, 2006), the cortisol reactivity associated with this stress response pattern may increase children's vulnerability for future adjustment problems. However, given the descriptive nature of this study, and the modest linkages between violence and this stress response pattern, these findings should be interpreted with caution. The underlying processes linking interparental aggression and stress responses are unclear, as well as whether these pathways are limited to children already at risk due to constitutionally based differences in reactivity.

Additionally, infants in this 'High Cortisol Reactivity, Moderate Negative Behavior' class were less likely to look to their mother or the home visitor as a means of regulating their distress than the "Low Reactors", although this linkage was also modest. Although reliance on caregivers to scaffold regulation is normative in infancy, these findings are congruent with the notion that some children from violent households may be less apt to solicit caregiver attention than those from non-violent homes, perhaps because of the dangers associated with interparental aggression. Parallel findings have emerged in the attachment literature, with insecure-avoidant infants using less caregiver-oriented regulation strategies, and manifesting patterns of heightened physiological reactivity with minimal behavioral distress (e.g., Hill-Soderlund et al., 2008). Given the importance of ongoing interactions with caregivers for the development of more advanced adaptive self-regulatory skills (e.g., Fox & Calkins, 2003), examining whether this early emerging stress response pattern is linked with later regulatory deficits warrants investigation. Further, it will be important for future work to explore linkages between self-regulation and stress response patterns, both to replicate these findings and to examine potential mechanisms responsible for these associations.

A number of limitations of the study should be noted. First, although the findings regarding interparental violence and children's stress responses are in line with emotional security theory, the methodology used was exploratory and sample dependent. Although this allowed for a rich description of infant stress responses across multiple domains, it is possible that different patterns might emerge in different samples, or across different emotion-eliciting contexts. Replication of these findings in other samples is an important area for future investigations. Second, contrary to expectations, violence and infant regulatory behaviors were only modestly, albeit significantly, associated with membership in the latent, stress response classes. However, given that infant stress reactivity may be strongly influenced by genetic or constitutionally based differences (Gunnar & Davis, 2003; Rothbart & Bates, 2006), these small associations are noteworthy. Third, the study only relied on maternal report of interparental aggression, and observer reports of infant behavior; the incorporation of multiple informants on all assessments would be beneficial for future replications. Finally, although the current findings describe linkages between interparental aggression and children's stress responses, the specific mechanisms responsible for these linkages remain unclear. For example, domestic violence may be likely to occur during pregnancy, particularly in low-income families (e.g., Jasinski, 2004), and research suggests that prenatal maternal stress is linked with increased negative reactivity and dysregulated adrenocortical functioning in infancy (e.g., Mulder, et al., 2002; Weinstock, 1997). Alternatively, children in violent homes may be at particular risk for aggressive and harsh parenting (e.g., Hughes, 1988), and emerging evidence suggests linkages between paternal negative and intrusive behavior and early childhood adrenocortical functioning (Mills-Koonce et al., 2011). Research is needed to clarify the processes linking interparental violence and children's stress responses.

Although a number of unanswered questions remain, this study has a number of strengths. Although young children may be particularly at risk for witnessing interparental aggression (Fantuzzo et al. 1997; Shapiro, Gottman, & Carrere, 2000), and infancy is considered foundational for the development of adaptive stress response patterns and self-regulatory skills (Gunnar & Davis, 2003; Morris et al., 2007), associations between aggression and stress responses in infancy remains an understudied area. This is the first study, to our knowledge, to describe the links between interparental aggression and stress response patterns in infancy, integrating both behavioral and adrenocortical measures, as well as independent assessments of infant self-regulatory behaviors. Multiple levels of information on stress responses in these domains were incorporated, including pre-task cortisol levels and total adrenocortical output to an emotion eliciting stressor, micro-analytic assessments of children's reactivity and regulation, and global ratings of children's behavior. Taking into account minor and severe acts of violence and employing a large, diverse sample (including cohabiting and low-income families), this study expands our knowledge of the linkages between interparental aggression and young children's development.

Interparental aggression is considered to be one of the most prevalent stressors children can experience (Margolin & Gordis, 2000). Our findings provide descriptive evidence of links between aggression and patterns of behavioral and adrenocortical functioning, but the potential mechanisms linking aggression and children's stress responses remain unexplored. Given the prevalence and consequences of interparental aggression for child adjustment (Cummings et al., 2009), there is a pressing need for such work. Understanding the pathways through which adaptive or maladaptive stress response patterns develop may provide insight into how to best target interventions to address the specific needs of children exposed to violence, making this an important area for future research.

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Table 1

Means, Standard Deviations, and Intercorrelations of Primary Study Variables.

	M	*SD*	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Adrenocortical Functioning																					
1. Basal Cortisol	.21	.31		--																	
2. Cortisol AUC_I	.60	11.61		−.70*	--																
Behavioral Reactivity																					
3. Negative Reactivity to Challenge	.79	.67		−.01	.04	--															
4. Overall Unhappiness	3.92	1.24		.02	−.02	.18*	--														
5. Overall Irritability	3.27	1.21		−.02	.03	.34*	.64*	--													
Interparental Aggression																					
6. Verbal Aggression	3.29	2.29		.04	−.02	−.03	.05	.01	--												
7. Total Violence	.25	.64		−.01	.04	.01	.02	.01	.55*	--											
8. Minor Violence	.54	1.28		−.01	.04	.01	.04	.02	.58*	.97*	--										
9. Severe Violence	.11	.37		−.01	.03	.01	−.01	−.02	.40*	.90*	.75**	--									
Child Regulatory Behaviors																					
10. Reorienting to Adults	.06	.05		−.02	.03	−.03	−.15*	−.13*	−.03	−.01	−.01	−.01	--								
11. Self-Soothing	.03	.06		−.01	.06	.07	.03	.01	.02	−.03	−.03	−.02	−.07†	--							
12. Avoidance	.07	.07		.06	−.03	.32*	−.08†	.05	−.03	−.01	.02	−.05	.08†	−.01	--						
Covariates																					
13. Site (0= NC, 1= PA)			53	.02	.01	−.01	.16*	.04	.07†	−.05	−.04	−.07†	−.15*	.01	−.12*	--					
14. Child Gender (0=female, 1=male)			52	−.02	.01	−.07†	−.05	−.04	−.01	.01	.01	.01	−.09*	.01	.01	.06	--				
15. Child Age	7.30	1.09		.01	−.03	.08†	−.11*	.01	−.01	.06	.06	.05	.19*	−.01	.19*	−.64*	−.02	--			
16. Child Ethnicity (0=White, 1=Black)			25	.04	−.03	−.08*	−.10*	−.10*	.01	.21*	.19*	.20*	.06	−.04	.02	−.55*	.01	.38*	--		
17. Child negative temperament	3.13	.75		.04	−.02	.10*	.10*	.16*	.16*	.18*	.18*	.15*	.10*	.01	.06†	−.23*	−.06	.24*	.31*	--	

	M	*SD*	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
18. Marital Status (0=not married, 1=married)			74	−.07†	.06	.04	.03	.05	−.16*	−.21*	−.19*	−.20*	−.01	.07†	.04	−.02	−.03	.01	−.15*	−.13*	--
19. Income-to-Needs	2.44	1.81		−.05	.01	.08†	−.02	.04	−.10*	−.17*	−.16*	−.14*	−.04	.04	−.02	.16*	.06	−.10*	−.27*	−.24*	.28*

† $p < .10$,

* $p < .05$;

[a] Frequency of Variable = 1

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Table 2

Comparison of Models for Latent Stress Response Profiles at 7-months (n = 735).

Number of Latent Classes	Log Likelihood	AIC	BIC	Adj. BIC	Lo-Mendel-Rubin	Entropy
1	−5212.10	10444.20	10490.19	10458.44		
2	−5005.64	10043.29	10116.88	10066.08	<.01	.77
3	−4841.14	9726.28	9827.48	9757.62	<.01	.84
4	**−4777.45**	**9610.90**	**9739.70**	**9650.79**	**.02**	**.82**
5	−4731.95	9531.91	9688.30	9580.34	.10	.84

Note: Bold font indicates the model that best fit the data

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Table 3

Standardized Mean Scores for a 4-Class Model of 7-Month Stress Responses (n = 735).

	Low Reactors (55%)	**High Cortisol Reactivity, Moderate Negative Behavior (34%)**	**High Negative Behavior (6%)**	**High Baseline Cortisol, Low Cortisol Reactivity (6%)**
Adrenocortical functioning				
Basal Cortisol	−.18	−.20	.17	**2.59**
AUC_I	.09	**.23**	−.08	**−1.99**
Behavioral reactivity				
Negative reactivity to challenge	**−.29**	**.35**	**.83**	−.16
Overall Unhappiness	**−.59**	**.62**	**1.99**	−.09
Overall Irritability	**−.58**	**.58**	**2.18**	−.11

Table 4

Family and Child Predictors of Membership in Latent Stress Response Classes ($n = 735$)

	Odds Ratio (95% Confidence Interval)					
	Model 1: Verbal Aggression			**Model 2: Total Violence**		
Variable	**High Cortisol Reactivity, Moderate Negative Behavior**	**High Negative Behavior**	**High Baseline Cortisol, Low Cortisol Reactivity**	**High Cortisol Reactivity, Moderate Negative Behavior**	**High Negative Behavior**	**High Baseline Cortisol, Low Cortisol Reactivity**
Covariates						
Site[a]	1.51 (.69, 3.28)	1.07 (.34, 3.36)	4.04* (1.00,16.35)	1.54 (.78, 3.05)	1.07 (.31, 3.62)	4.36* (1.01,18.73)
Child gender[b]	.74 (.38, 1.46)	.50 (.18, 1.40)	.81 (.33, 1.99)	.76 (.46, 1.26)	.49 (.19, 1.28)	.86 (.38, 1.95)
Child age	1.00 (.63, 1.58)	.97 (.53, 1.77)	1.62 (.91, 2.90)	1.00 (.83, 1.21)	.98 (.56, 1.71)	1.58 (.91, 2.75)
Child ethnicity[c]	.65 (.32, 1.33)	.17† (.02, 1.41)	1.54 (.41, 5.88)	.54 (−1.35, 1.14)	.16† (.03, 1.03)	1.83 (.45, 7.46)
Child negative temperament	1.55** (1.09, 2.19)	2.31** (1.48, 3.61)	1.05 (.64, 1.73)	1.55** (1.17, 2.07)	2.26** (1.41, 3.61)	1.06 (.61, 1.84)
Marital Status[d]	1.28 (.66, 1.92)	.97 (.23, 4.08)	.69 (.26, 1.78)	1.40 (.76, 2.57)	1.06 (.29, 3.87)	.67 (.27, 1.70)
Income-to-needs	1.15 (.74, 1.80)	1.18 (.71, 1.96)	.89 (.64, 1.25)	1.15 (.84, 1.58)	1.19 (.76, 1.87)	.88 (.63, 1.22)
Interparental Aggression						
Verbal Aggression	1.18 (.88, 1.57)	.91 (.43, 1.91)	.87 (.53, 1.42)		--	--
Violence	--	--	--	**1.33*** (1.05,1.68)	1.24 (.81, 1.90)	.76 (.44, 1.33)
Child Regulation						
Reorienting to adult	**.66**** (.46, .95)	.66 (.31, 1.40)	.86 (.55, 1.35)	**.63**** (.47, .85)	.65 (.32, 1.31)	.88 (.58, 1.34)
Self-soothing	1.11 (.79, 1.58)	1.12 (.60, 2.11)	.91 (.49, 1.70)	1.11 (.80, 1.55)	1.10 (.64, 1.89)	.91 (.47, 1.77)
Avoidance	1.35 (.54, 3.39)	1.25 (.45, 3.53)	1.46 (.79, 2.69)	1.26 (.69, 2.30)	1.24 (.52, 2.99)	1.42 (.90, 2.26)

Note: Low Reactors is the reference class. All continuous predictors were standardized prior to estimating models; Superscript denotes covariates that significantly predict differences between a single class and the reference class,

† $p < .10$,

* $p < .05$;

[a] Site: 0=NC;1=PA,;

[b] Sex: 0 = female, 1 = male;

[c] Ethnicity: 1= black, 0=not,

[d]Marital Status: 1=married, 0=not.

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