ABSTRACT

Title of Thesis: PARENTAL HOSTILITY AND PARENT STRESS PHYSIOLOGY: THE MODERATING ROLE OF CHILD EFFORTFUL CONTROL

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This study examined the moderating role of child effortful control on the association between observed parental hostility and parents' cortisol awakening response (CAR), a critical index of stress system functioning. Participants included 99 medication-free parents and their preschool-aged children. Parents obtained salivary cortisol samples at waking, 30, and 45 minutes post-waking and at bedtime across two consecutive days. Parental hostility was assessed during an observational parent-child interaction task, and child effortful control was assessed using parent report.

Observed parental hostility was associated with parents' lower cortisol levels at 30 and 45 minutes post-waking and lower CAR. Low levels of child effortful control were associated with parents' lower bedtime cortisol. Moreover, results demonstrated an interaction effect between parenting and child behavior on parent CAR. The findings highlight the significance of continued examination of the neurobiology of parenting with a focus on the interactive effects between parenting and child behavior.

PARENTAL HOSTILITY AND PARENT STRESS PHYSIOLOGY:

THE MODERATING ROLE OF CHILD EFFORTFUL CONTROL

by

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Chapter 1: Introduction

Parenting and its effects on the parent-child relationship have long been a focus of research. Cross-sectional and longitudinal studies have consistently demonstrated the profound impact of parenting on children's brain, behavioral, emotional, and social development (Belsky & de Haan, 2011). Research has also demonstrated that the parent-child relationship involves bidirectional processes that impact the parent's own physical and mental health as well the child's health (Barrett & Fleming, 2011; Deater-Deckard, 2004). Indeed, the daily chronic stress from parenting has been found to be a stronger predictor of parent, child, and family functioning than exposure to acute major life stressors (Crnic & Greenberg, 1990). Moreover, chronic exposure to parenting stress contributes to increased negative parenting behaviors and decreased parental well-being (Deater-Deckard, 2004).

Given the importance of parenting for both the parent and child's well-being, emerging research has begun to investigate the biological basis of parenting in order to identify underlying mechanisms influencing individual differences in parenting and the parent-child dyad. Parental regulatory capacities may impact the parent's ability to effectively parent and are a likely mechanism for the transgenerational transmission of stress reactivity and attachment in humans (Fonagy & Target, 2005). Recent research has documented associations between parenting and parents' autonomic reactivity (Lorber & O'Leary, 2005), brain function, including amygdala reactivity (Rilling, 2013), and hormone levels (Feldman, Weller, Zagoory-Sharon, & Lavine, 2007).

One specific mechanism of stress physiology, the parent's hypothalamic-pituitary-adrenal (HPA) axis, is of particular importance due to its relation to a number of factors influencing parenting, including physical health, vulnerability to life stress, and risk for psychopathology (Chida & Steptoe, 2009). Research examining associations between parenting and parental HPA axis functioning has demonstrated associations between maternal sensitivity and mothers' lower diurnal cortisol, decreased cortisol reactivity, and greater adrenocorticol attunement with their child (Gonzalez, Jenkins, Steiner, & Fleming, 2012; Sethre-Hofstad, Stansbury, & Rice, 2002; Thompson & Trevathan, 2008). In addition, controlling and inconsistent parenting practices were associated with mothers' increased cortisol reactivity (Sturge-Apple, Davies, Cicchetti, & Cummings, 2009). These studies provide evidence for the association between parenting behaviors and parent stress physiology, and suggest that parent's HPA axis functioning may underlie certain individual differences in parenting.

Little work has examined associations between parenting, child behavior, and parents' own stress physiology. Only two studies have examined parent cortisol reactivity in relation to parenting and child factors (Kiel & Buss, 2013; Martorell & Bugental, 2006). Martorell and Bugental (2006) found that in a sample of 60 mothers in family-support programs, mothers with low perceived power were more reactive to children with difficult temperaments and displayed higher cortisol reactivity. Kiel and Buss (2013) found that in a sample of 92 mother-child dyads, maternal cortisol reactivity moderated the relation between maternal intrusiveness and child inhibited temperament, such that mothers with high cortisol reactivity were observed to be more intrusive with highly inhibited children.

While no previous research has examined links between parenting and child behavior and parents' diurnal cortisol levels (i.e., peak cortisol levels at waking and the gradual decline throughout the day), a few studies have examined parents' diurnal cortisol levels in parents of children with disabilities (Bella, Garcia, & Spadari-Bratfisch, 2011; Seltzer et al., 2010). These studies demonstrate that parents of children with disabilities, who likely experience greater chronic stress, display lower levels of diurnal cortisol, including both the morning and evening cortisol levels, suggesting that the additional chronic stress of caring for a child with a disability disrupts parents' HPA axis functioning, leading to decreased cortisol secretion. These findings are consistent with the literature indicating that higher levels of chronic stress are related to blunted cortisol activity (Fries, Hesse, Hellhammer, & Hellhammer, 2005; Heim, Ehlert, & Hellhammer, 2000) and highlight the important role child factors play on parent's stress physiology.

No study, to date, has examined the moderating role of child behaviors on the association between parenting behaviors and parent HPA axis functioning. Given the importance of child factors influencing parenting and parental stress, the current study examined whether the association between parenting behaviors and parents' stress physiology is moderated by child behavior. We examined this question in a sample of 99 *medication-free* parents and their preschool-aged children. Observed parental hostility was assessed during laboratory-based parent-child interaction tasks. Parents reported on their child's effortful control, which reflects the child's self-regulatory abilities, accounting for the child's ability to suppress dominant behaviors and maintain subdominant behaviors (Kochanska, Murray, & Harlan, 2000). Effortful control was chosen as a temperamental construct to reflect difficult child behaviors, as lower levels of effortful control are associated with children's increased internalizing and externalizing behavior problems (Eisenberg et al., 2001). Lastly, parents' HPA axis functioning was measured across two days through the parents' cortisol awakening response (CAR) and bedtime cortisol. The CAR is the natural rise in cortisol 30 – 40 minutes after waking. The CAR is a reliable marker of an individual's HPA axis activity (Pruessner et al., 1997), and has been found to be sensitive to everyday stressors (Chida & Steptoe, 2009). Importantly, the CAR is related to a number of health outcomes, both physical and psychological, including chronic stress, fatigue, depression, and other stress-related disorders (Chida & Steptoe, 2009).

We first examined associations between observed parental hostility and child effortful control and parents' cortisol activity. Consistent with the literature on parental stress and negative parenting behaviors (Deater-Deckard, 2004), and the literature on hypocortisolism as it relates to chronic stress (Fries et al., 2005; Heim et al., 2000), we hypothesized that higher levels of observed parental hostility and lower levels of child effortful control would be associated with parents' decreased cortisol levels across the day. Next, we examined the moderating effect of child effortful control on the associations between parental hostility and parents' cortisol activity. Given the paucity of research examining the moderating role of child behavior on associations between parenting and parent stress physiology, we tentatively hypothesized that associations between observed parental hostility and parents' lower cortisol responses would be stronger in parents of children with lower levels of effortful control.

Chapter 2: Method

Participants

Participants consisted of 175 parents and their biological preschool-aged children (Dougherty, Tolep, Smith, & Rose, 2013). Participants were recruited from the Washington, DC metropolitan area using print advertisements distributed to local schools, daycares, and health care providers (73.1%) and a commercial mailing list (26.9%). The larger study targeted a subsample of parents with a history of depression. Families were included that had a child between three and five years of age, who had no significant medical condition or developmental disabilities, with no parental history of bipolar or psychotic disorder, and who lived with at least one English-speaking biological parent. This study was approved by the human subjects review board of the University of Maryland, and informed consent was obtained from all parents.

Of the 175 families recruited for the larger study, 156 parents (145 mothers, 11 fathers) provided home cortisol samples. Of these 156 parents, 55 were taking medications at the time of the assessment (e.g., psychotropic, pain, and/or general health medications such as thyroid or high blood pressure medications and oral contraceptives). Evidence suggests that HPA axis activity is sensitive to prescription or over-the-counter medication use (Granger, Hibel, Fortunato, & Kapelewski, 2009). Medication use can have agonistic or antagonistic effects on the HPA axis, iatrogenic effects on the composition of saliva, or may have indirect effects through physiological systems associated with the HPA axis (Granger et al., 2009). Thus, cortisol samples from the 55 parents who were taking medication were excluded from all analyses. Of the remaining 101 parents, one parent was excluded because of extreme cortisol values (>3 *SD* above the mean; Gunnar & White, 2001), and one parent was excluded based on noncompliance to the instructed sampling times (see below for details on sampling compliance). Thus, the final sample consisted of 99 *medication-free* parents (93 mothers, 6 fathers) with valid cortisol samples. Participants included in analyses (N = 99) were compared to those excluded (N = 57) on all study variables. There was only one significant difference between parents excluded from analyses and those included: parents who were included were younger (M = 33.9 years, SD = 6.00) than parents excluded (M = 37.20 years, SD = 7.14), $t(145) = -2.92$, $p < .01$.

Parent's mean age was 33.9 years (SD = 6.00; mothers: M = 33.7, SD = 6.03, fathers: M = 37.7, SD = 4.79). Children's mean age was 43.81 months (SD = 8.72). Participating families identified themselves as White (N = 39; 39.8%), Black/African-American (N = 40; 40.8%), multiracial (N = 7; 7.1%), or other race (N = 12; 12.2%); 19 (19.6%) families were of Hispanic/Latino descent. Approximately half of parents (N = 56; 56.6%) reported having at least a 4-year college degree. Of the 99 parents, 29.2% reported a family income greater than $100,001; 26.0% of families reported a family income ranging from $70,001 to $100,000; 24.0% of families reported a family income ranging from $40,001 to $70,000; 11.5% of families reported a family income ranging from $20,001 to $40,000; and 9.4% of families reported a family income less than $20,000. The majority of participating parents (N = 71; 71.7%) were married or cohabitating. See Table 1 for demographic characteristics of the sample.

Measures

Observed parental hostility. During the first laboratory visit, parents and children participated in an observational parent-child interaction task, based on a modified version of the Teaching Tasks battery (Egeland et al., 1995). The battery included five standardized tasks including book reading, a guessing game, a maze, a story sequencing task, and a puzzle game. Each task was videotaped and coded for parental hostility. Parental hostility was defined as the parent's expression of anger, frustration, and criticism toward the child. For each task, parental hostility (M = 1.17, SD = 0.33) was rated on a 5-point scale and scores were then averaged across the five tasks. The parental hostility scale demonstrated adequate internal consistency (α = .76), and the intraclass correlation coefficient (ICC) for the inter-rater reliability based on video-recordings of 38 dyads was good (ICC = .89).

Parental Psychopathology. Parents were interviewed using the Structured Clinical Interview for DSM-IV, Non-Patient version (SCID-NP; First, Spitzer, Gibbon, & Williams, 1996). Interviews were conducted by telephone, which yields similar results as face-to-face interviews (Rohde, Lewinsohn, & Seeley, 1997), by a master's level rater with extensive training in the SCID. SCIDS were obtained by 98 parents (93 mothers, 5 fathers). A history of major depressive disorder (MDD) and/or dysthymic disorder (DD) were collapsed into a single category reflecting depressive disorder. Of parents who gave cortisol samples, 45 parents (45.5%; 43 mothers, 2 fathers) had a lifetime depressive disorder. Based on audiotapes of 16 SCID interviews, the kappa for inter-rater reliability was 1.00 for a lifetime depressive disorder.

Child effortful control. Ninety-eight parents completed the Child Behavior Questionnaire-Short Form (CBQ-SF; Putnam & Rothbart, 2006), a 94-item parent-report measure for assessing temperament in children ages 3 to 7 years. The effortful control scale (M = -0.08, SD = 2.95, α = .78) was created as a composite of 5 standardized (z-score) subscales including a total of 32 items (Low Intensity Pleasure: 8 items, Smiling/Laughter: 6 items, Inhibitory Control: 6 items, Perceptual Sensitivity: 6 items, and Attentional Focusing: 6 items). Parents rated each item on a scale from 1 to 7 where 1 indicates “extremely untrue of your child” and 7 indicates “extremely true of your child”. Items characteristic of the scale include “my child will move from one task to another without completing any of them” (reverse scored) and “my child can easily stop an activity when s/he is told no”.

Parent salivary cortisol assessment. Parents were instructed to obtain a total of 8 salivary cortisol samples across two consecutive days. For each day, they were instructed to take samples immediately after waking, 30 and 45 minutes post-waking, and 30 minutes before bedtime. Sampling times were selected to capture the cortisol awakening response (CAR), or the rise in cortisol after awakening, and nadir cortisol levels at bedtime. Samples were collected on two days in order to assess reliably the CAR (Hellhammer et al., 2007), and on weekdays only as the type of day has been associated with cortisol levels (Kunz-Ebrecht, Kirschbaum, Marmot, & Steptoe, 2004). Of the 795 samples collected, 24 (3.02%) were excluded due to extreme cortisol values (i.e., > 3 standard deviations above the mean; Gunnar & White, 2001), leaving 771 cortisol samples from 100 participants.

For the collection of cortisol, parents were instructed to chew on a cotton dental roll. After the cotton roll was saturated, parents were instructed to use a needleless syringe to expel the saliva into a vial. Parents were instructed to label and refrigerate the samples until returning to the laboratory for a second visit. At that time, the samples were then stored at -20° Celsius until assayed. Samples were assayed in duplicate at the

University of Trier, Germany. Samples were assayed with a time-resolved immunoassay with fluorometric end point detection (DELFIA). Inter- and intra-assay coefficients of variation ranged between 7.1%-9.0% and 4.0%-6.7%, respectively.

Cortisol variables used in analyses included cortisol values at waking, 30 minutes post-waking, 45 minutes post-waking, and bedtime, and the CAR. The CAR was captured in two ways: the area under the curve with respect to ground (AUC_g; total cortisol secreted across morning samples) and with respect to increase (AUC_i: the change in morning cortisol levels) for the waking, 30, and 45 minute post-waking samples (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

Cortisol variable distributions were inspected for normality. Bedtime cortisol values showed positive skew; therefore, bedtime cortisol values were $\log_{10}$ transformed. All other cortisol values and the AUC variables were normally distributed and untransformed values were used in analyses. Data presented in Table 1 are based on untransformed values for ease of interpretation.

Parental compliance to cortisol sampling. Parents completed a daily diary measure to record their time of waking, sampling times, and bedtime. Previous studies have indicated that participant compliance to sampling procedures is necessary for accurate measurement of cortisol levels as compliance influences cortisol levels, including lower CAR in noncompliant participants (Broderick et al., 2004).

To define compliance at the sample level, time window criteria were applied to samples. Based on previous work (e.g., Broderick et al., 2004), a time window of ± 10 minutes has been selected for samples that compose the CAR (waking, 30, and 45 minute post-waking samples), as cortisol levels change rapidly during the morning (Clow, Thorn, Evans, & Hucklebridge, 2004). In the evening, cortisol levels change more slowly; thus, a time window of ± 1 hour was applied for the bedtime samples (Fries, Dettenborn, & Kirschbaum, 2009). Samples collected within these respective time windows were considered to be collected in compliance with the specified sampling time. Based on this assessment of compliance, 163 (21.14%) of 771 samples were excluded from analysis, leaving a final total of 608 valid cortisol samples from 99 participants.

Data Analysis Plan

The dependent variables were cortisol levels at each sampling time (waking, 30, 45 minutes post-waking, and bedtime) and AUC_g and AUC_i. The independent variables were parental hostility and child effortful control. To examine main and interactive effects of parental hostility and child effortful control on parent's cortisol, we conducted repeated-measures analyses using generalized estimating equations (GEE). GEE is a statistical method that accounts for within-person correlations over time (Liang & Zeger, 1986). Since cortisol samples were taken across days, GEE accounts for the within-person correlation between the repeated cortisol measurements. For each GEE model, parental hostility and child behavior and their respective cross-product were entered as independent variables, and cortisol values at each time point (waking, 30, and 45 minutes post-waking), AUC_g, and AUC_i were included as dependent variables in separate models. Significant interactions were probed using simple slopes analyses, as described by Aiken and West (1991). Lastly, given that our sample was drawn from a study examining risk for depression and given that parental depression has been associated with more hostile parenting behaviors (Lovejoy, Graczyk, O'Hare, Neuman, 2000), dysregulated HPA axis activity (Fries et al., 2009) and child behavior problems (Downey & Coyne, 1990), we explored the role of parental depression on associations between parenting, child effortful control, and parents' cortisol.

Chapter 3: Results

Descriptive Data

Table 1 shows descriptive statistics for the sample's demographics, potential covariates, and cortisol levels in nanomoles per liter (nmol/L). Pearson product-moment correlations were conducted to assess the stability of cortisol levels across sampling days. The correlation between day 1 and day 2 waking, 30 and 45 minutes post-waking cortisol were r = .48, r = .52, and r = .64, respectively (*p's* < .001). The correlation between day 1 and day 2 bedtime cortisol was r = .18, p = .17. The correlation between day 1 and day 2 AUC_g was r = .69, p < .001; the correlation between day 1 and day 2 AUC_i was r = .39, p = .002. Figure 1 shows that on average across days, cortisol values (nmol/L) followed a typical daily pattern: they were high upon awakening (*M* = 9.33, *SD* = 5.25), increased and peaked 30 minutes post-waking (*M* = 11.68, *SD* = 5.84), declined slightly 45 minutes post-waking (*M* = 9.99, *SD* = 4.83) and then declined more steeply, reaching a nadir 30 minutes before bedtime (*M* = 1.83, *SD* = 3.07).

Next, we examined associations between cortisol and several potential covariates, including time of waking, parental education, parental marital status, annual income, ethnicity, and parent gender. Time of waking was negatively associated with cortisol at 45 minutes post-waking (*B* = -0.02, *SE* = .01, p = .013), AUC_g (*B* = -0.08, *SE* = 0.04, p = .033) and AUC_i (*B* = -0.06, *SE* = 0.03, p = .021). Parent gender (0 = female, 1 = male) was negatively associated with AUC_i (*B* = -16.78, *SE* = 4.98, p = .001). Parental education (0 = no college degree, 1 = at least college degree) was positively associated with cortisol at waking (*B* = 2.26, *SE* = 0.97, p = .020), 30 minutes post-waking (*B* = 2.14, *SE* = 1.07, p = .046), 45 minutes post-waking (*B* = 2.07, *SE* = 0.94, p = .028), and

AUC_g (*B* = 10.60, *SE* = 4.37, *p* = .015). Therefore, time of waking, parent gender, and parental education were included as covariates in subsequent analyses, with the exception of analyses examining effects on bedtime cortisol in which time of waking was not included as a covariate. Child effortful control was not significantly associated with observed parental hostility (*r* = -.13, *p* =.081).

Parental Hostility, Child Effortful Control, and Parent CAR

The main effects of parental hostility and child effortful control on parents' CAR are presented in Table 2. Higher levels of observed parental hostility were significantly associated with parents' lower cortisol levels at 30 minutes and 45 minutes post-waking, as well as for lower AUC_g and AUC_i. Lower levels of parent-reported child effortful control was significantly associated with parents' lower bedtime cortisol.

Next, we examined the moderating role of child effortful control on the associations between parental hostility and parent salivary cortisol. For each GEE model, parental hostility and child behavior and their cross-product were entered as independent variables, and cortisol values at each time point (waking, 30, and 45 minutes post-waking), AUC_g, and AUC_i were included as dependent variables in separate models. As seen in Table 3, there was a significant interaction between parental hostility and child effortful control on parents' AUC_i. Figure 2 shows that for parents of children with lower levels of effortful control, higher levels of parental hostility were associated with lower AUC_i (*B* = -8.43, *SE* = 1.73, *p* < .001), whereas for parents of children with higher levels of effortful control, parental hostility was not significantly associated with parent AUC_i (*B* = -1.44, *SE* = 1.17, *p* = .220). There was no significant interaction between parental hostility and child effortful control (*B* = 1.64, *SE* = 2.43, *p* = .501) on parent AUC_g.

We also examined the interaction effects between parenting and child effortful control on cortisol levels at each sampling time. There was a marginally significant interaction between parental hostility and child effortful control on parents' cortisol at 45 minutes post-waking (*B* = 0.66, *SE* = 0.35, *p* = .055). Consistent with the findings reported above, for parents of children with lower levels of effortful control, higher levels of parental hostility were associated with lower cortisol levels at 45 minutes post-waking (*B* = -1.77, *SE* = 0.47, $p < .001$), whereas for parents of children with higher levels of effortful control, parental hostility was not significantly associated with parent cortisol at 45 minutes post-waking (*B* = -0.45, *SE* = 0.45, *p* = .320). There were no other significant interactions between parenting behavior and child effortful control on cortisol levels at waking or 30 minutes post-waking.

Parental lifetime depression and parent cortisol

We explored the main and interactive effects between parental lifetime depression, parental hostility, child effortful control, and parent cortisol. There was a significant interaction between parental lifetime depression and observed parental hostility on parents' AUC_g (*B* = 7.71, *SE* = 3.46, *p* = .026). For parents with a lifetime history of depression, higher levels of observed parental hostility were associated with lower AUC_g (*B* = -9.44, *SE* = 3.07, *p* = .002). In contrast, for parents with no lifetime history of depression, observed parental hostility was not associated with AUG_g (*B* = -1.74, *SE* = 1.55, *p* = .264). There were no other significant main or interaction effects involving parental lifetime depression on parents' cortisol. All results presented above were similar when parental lifetime depression and the interaction between parental lifetime depression and parental hostility were included in the models.

Chapter 4: Discussion

This study examined the main and interaction effects between parenting and child behavior on parents' stress physiology. We found that observed parental hostility was associated with parents' lower cortisol levels at 30 and 45 minutes post-waking and lower CAR, as indicated by a lower total increase in cortisol across waking (AUC_i) and a lower total volume of cortisol secreted across waking (AUC_g). We also found that lower levels of parent-reported child effortful control were associated with parents' lower cortisol levels at bedtime. Moreover, child effortful control moderated the association between parental hostility and the total increase in parents' cortisol across waking or AUC_i. To our knowledge, this is the first study to examine associations between parenting, child behavior, and parents' CAR. Our results suggest that parents' HPA axis functioning may be impacted specifically by the interplay between negative parenting and difficult child behaviors.

Parental hostility and child effortful control demonstrated significant main effects on parents' cortisol across the day. Parents who demonstrated high levels of hostility toward their child during a parent-child interaction task displayed a lower CAR (demonstrated by lower cortisol levels at 30 and 45-min post-waking and lower AUC_g and AUC_i). Previous literature has demonstrated associations between parenting and maternal cortisol reactivity (Sturge-Apple et al., 2009; Thompson & Trevathan, 2008); however, to our knowledge no study has examined the effects of parenting on parents' CAR. It is notable that hostility was not related to waking or bedtime cortisol levels; rather, the associations were specific to the morning rise in cortisol, capturing the CAR. The CAR is a critical aspect of the HPA axis related to psychosocial factors and physical health, and may reflect a physiological response in anticipation of the day's demands (Fries et al., 2009). Lower CAR, in particular, has been related to a number of negative outcomes, including chronic fatigue, burnout, exhaustion, and depression (Chida & Steptoe, 2009; Fries et al., 2009; Huber et al., 2006). The significance of lower CAR as it relates to individuals' stress exposure and health highlights the critical role of parenting in stress physiology.

We also found that lower levels of child effortful control were significantly associated with parents' lower cortisol at bedtime. Lower evening cortisol has been linked to daily and chronic stress exposure (e.g., Miller, Chen, & Zhou, 2007; Saxbe, Repetti, & Nishina, 2008). This is consistent with previous work that demonstrated parents of children with disabilities, who may also be experiencing greater daily stress from parenting, had lower cortisol levels throughout the day, including lower evening cortisol (Bella et al., 2011). Studies have shown that parents of children with difficult temperaments or behaviors experience greater stress and strain (Coplan et al., 2003); thus, our findings suggest that parenting a child with low effortful control may be more challenging for parents, which may contribute to greater parental stress and greater chronic strain on the body's stress system.

Next, we investigated the moderating role of child effortful control on the associations between parenting and parents' salivary cortisol. We found that child effortful control moderated the association between parental hostility and parent CAR. For parents of children with lower levels of effortful control, higher levels of parental hostility were associated with lower CAR (as indicated by a lower rise in cortisol post-waking or AUC_i) and lower cortisol at 45 minutes post-waking. There were no significant associations between parental hostility and parent CAR and cortisol at 45 minutes post-waking for parents of children with high levels of effortful control. Two studies have previously reported interaction effects between negative parenting behaviors and child difficult or inhibited temperament styles on parents' cortisol reactivity (Kiel & Buss, 2013; Martorell & Bugental, 2006); and the current study provides the first evidence of the moderating role of child behavior on associations between parenting and indices of parents' CAR. Taken together, these findings suggest that parents' stress physiology is particularly linked to the interplay between negative parenting behaviors and difficult child behaviors, highlighting the bidirectional and transactional processes likely involved in associations among parenting, child behavior, and parents' stress physiology.

Given evidence that the CAR is sensitive to everyday stressors (Chida & Steptoe, 2009), the CAR may capture one aspect of the chronic daily stress from challenging parenting contexts. Our findings of lower CAR in parents who display more hostility toward their child and whose child has lower levels of temperamental effortful control may reflect an aspect of allostatic load, or the general wear and tear on the body resulting from chronic stress exposure (McEwen, 1998). Consistent with our findings, one possible result of allostatic load is blunted cortisol responses or hypocortisolism, which may reflect depletion of cortisol from the adrenal gland due to repeated stress exposure (McEwen, 1998). The use of ineffective parenting and difficult child behaviors appear to adversely impact the parent's regulatory capacities, highlighting the critical and far reaching impact of the parent-child relationship. It will be important for future research to extend our findings and investigate how the parent-child relationship impacts certain stress sensitive brain structures and networks, such as the hippocampus, in order to delineate further the biological mechanisms underlying parenting.

Lastly, we explored the role of parental lifetime depression on the associations among parenting, child behavior, and parents' stress functioning, as our sample was drawn from a larger study that over-selected parents with a history of depression. We observed no main effects of parental depression on parents' cortisol. However, we found a significant interaction between parental lifetime depression and parental hostility on parents' AUC_g or total volume of cortisol secreted across waking. For only parents with a history of lifetime depression, higher levels of observed parental hostility were associated with lower AUC_g. Depression has been previously associated with both higher (Bhagwagar et al., 2005) and lower CAR (Huber et al., 2006); however, no previous research has examined the role of parenting in these associations. Nevertheless, a large body of research has consistently reported that depressed parents demonstrate more hostile and less warm parenting behaviors (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Thus, our findings may suggest that parents with a history of depression and who use ineffective, hostile parenting strategies may be generating stress in the parent-child relationship, which may lead to greater parenting stress and subsequently blunted CAR (Hammen, 2006). Nevertheless, we interpret this interaction with caution as our study had limited statistical power to examine multiple interactions. Thus, the role of parental depression on these associations warrants further examination. It is also important to note that all findings described above remained significant when parental depression and interactions between parental depression and parental hostility were included in the models.

This study had several strengths. This is the first study, to our knowledge, to examine the main and moderating effects of parenting and child behavior on parents' CAR. This study also had a number of methodological strengths, including the use of a medication free sample, multiple samples of morning cortisol in the first hour of waking across two days, attention to sampling compliance, and an observational measure of parenting. Finally, we recruited a more ethnically diverse sample than obtained in many previous studies.

This study also had limitations. First, given our exclusion of parents using medication, our sample size was reduced, which limited our statistical power. In addition, as a result of this exclusionary criterion, our sample may represent a sample of higher functioning parents. This poses issues for generalizability and future studies should use larger samples to examine the effects of medication use. Third, we relied on parent reports of child effortful control. Parent reports provide the benefit of assessing child behavior across different contexts and time and allow for an assessment of multiple aspects of child effortful control; nevertheless, parent reports are also more vulnerable to informant biases. Future research should incorporate objective, observational measures of child behavior, along with multiple informant reports. Fourth, the majority of parents in our sample were mothers (93.9%). It will be important for future studies to investigate the biological basis of parenting in both mothers and fathers. Lastly, due to the cross-sectional nature of this study, we are unable to test the causality or directionality of our findings.

In closing, our findings highlight the complex interplay between parenting and child behavior on parents' stress physiology and regulation. Investigations on the biological basis of parenting hold great promise in elucidating individual differences in parenting behavior and its subsequent effects on numerous parent and child health outcomes. Understanding the biological mechanisms that influence parenting, including the unique impact of child behavior on these mechanisms, holds great promise in informing the development of novel parenting interventions that target the intersection of biology and behavior within one of the most fundamental social relationships across development: the parent-child dyad.

Table 1.

Participant characteristics and salivary cortisol indicators (N = 99)

	% (*N*)	*M (SD)*	Min	Max
Parent sex (female)	93.9 (93)			
Parent age (years)		33.94 (6.00)	21.00	47.00
Child age (months)		43.81 (8.72)		
Parent marital status				
Married or cohabitating	71.7 (71)			
Divorced, separated	8.0 (8)			
Never married	19.2 (19)			
Parent education				
Some high school	1.0 (1)			
High school graduate (or GED)	5.1 (5)			
Some college (or 2 year degree)	36.4 (36)			
4 year college degree or more	56.6 (56)			
Child race/ethnicity				
White	39.8 (39)			
Black/African-American	40.8 (40)			
Mixed	7.1 (7)			
Other	12.2 (12)			
Hispanic	19.6 (19)			
Income				
<$20,000	9.1 (9)			

$20,001-$40,000	11.1 (11)			
$40,001-$70,000	23.2 (23)			
$70,001-$100,000	25.3 (25)			
>$100,000	28.3 (28)			
Parental lifetime depressive disorder	45.5 (45)			
Parental observed hostility		1.17 (0.33)	1.00	2.60
Child effortful control		-0.08 (2.95)	-7.31	6.28
Parental salivary cortisol indicators				
Time of waking (h), Day 1		6:56 (1:04)	3:00	10:30
Time of waking (h), Day 2		6:55 (1:05)	3:45	10:20
Bedtime (h), Day 1		22:29 (00:51)	19:30	0:00
Bedtime (h), Day 2		22:22 (2:03)	20:30	4:00
Cortisol waking values (nmol/L), Day 1		9.45 (5.70)	.44	31.52
Cortisol waking values (nmol/L), Day 2		9.19 (4.75)	.37	23.38
Cortisol waking + 30 min values (nmol/L), Day 1		11.54 (6.32)	.53	34.16
Cortisol waking + 30 min values (nmol/L), Day 2		11.83 (5.31)	.81	26.37
Cortisol waking + 45 min values (nmol/L), Day 1		10.03 (5.21)	.52	33.31
Cortisol waking + 45 min values (nmol/L), Day 2		9.96 (4.42)	.77	23.01

Cortisol evening values (nmol/L), Day 1	1.88 (3.50)	.26	18.79
Cortisol evening values (nmol/L), Day 2	1.79 (2.63)	.19	12.47
AUC_g (nmol/L), Day 1	48.57 (23.93)	2.24	141.17
AUC_g (nmol/L), Day 2	48.02 (19.86)	3.62	103.05
AUC_i (nmol/L), Day 1	5.26 (16.92)	-32.41	52.41
AUC_i (nmol/L), Day 2	7.12 (14.46)	-20.43	58.72

Note. Categorical variables are presented as frequency and percentage; continuous variables are presented as mean and standard deviation. The child effortful control scale was created as a sum of 5 standardized (z-score) subscales. For ease of interpretation, cortisol values reflect raw values and are presented in nmol/L. Area under the curve (AUC) was measured with respect to ground (AUC_g) and increase (AUC_i).

Table 2.

Generalized estimating equations: Main effects of parenting behavior and child effortful control on parent salivary cortisol

	Parental Hostility			**Child Effortful Control**		
	B	*SE*	*p*	*B*	*SE*	*p*
Dependent Variable						
Salivary cortisol						
Waking	-0.26	0.51	.611	0.58	0.44	.182
30 minutes post-waking	-1.28	0.40	.001**	0.22	0.58	.970
45 minutes post-waking	-1.36	0.32	<.001***	0.31	0.46	.504
Bedtime	0.00	0.04	.991	0.14	0.03	<.001***
AUC_g	-5.06	1.80	.005**	1.02	2.34	.662
AUC_i	-4.55	1.53	.003**	-0.90	1.30	.488

Note. *$p < .05$; **$p < .01$; ***$p < .001$. AUC_g = area under the curve with respect to ground; AUC_i = area under the curve with respect to increase.

Table 3.

Generalized estimating equations model: The interactive effects between parenting behavior and child effortful control on parent AUC_i

	Parent AUC_i		
Variable	*B*	*SE*	*p*
Day	-1.14	2.06	.280
Time of waking	-0.06	0.03	.037*
Parent gender	13.34	4.65	.004**
Parent education	5.09	2.67	.057
Parental hostility	-4.93	1.19	<.001***
Child effortful control	-0.82	1.15	.476
Child effortful control X Parental hostility	3.49	0.88	<.001***

Note. $*p < .05$; $**p < .01$; $***p < .001$. AUC_i = area under the curve with respect to increase; parent gender 0 = female, 1 = male; parent education 0 = less than 4 year college degree, 1 = 4 year college degree or more.

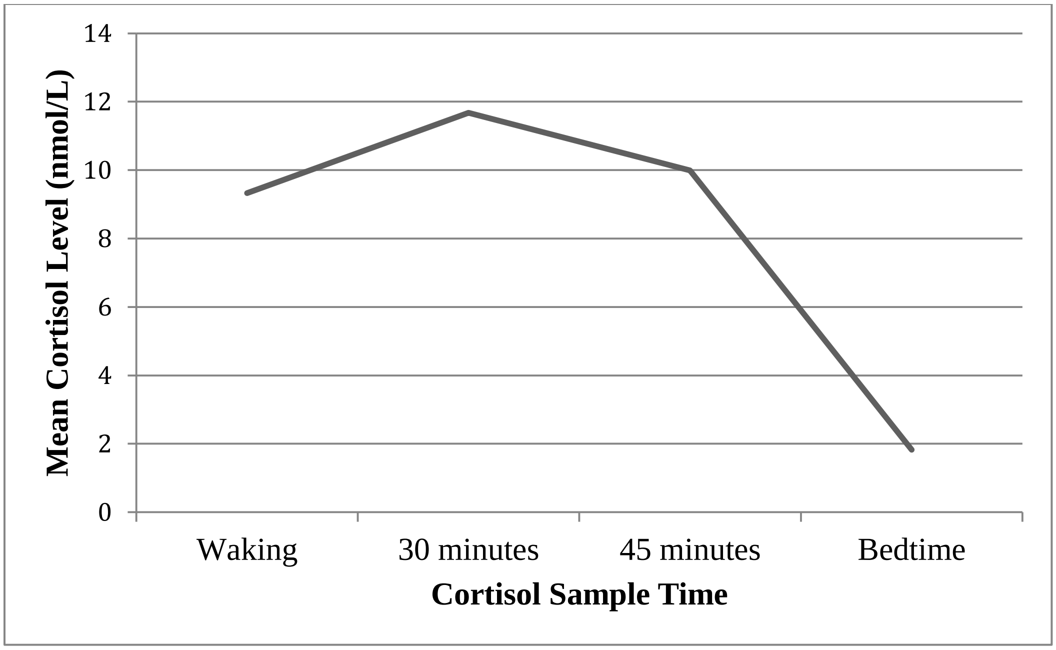

Figure 1. Mean parent cortisol level (nmol/L) as a function of sampling time. The graph shows mean cortisol values across days for each of the four sampling times: waking, 30 minutes post-waking, 45 minutes post-waking, and 30 minutes before bedtime.

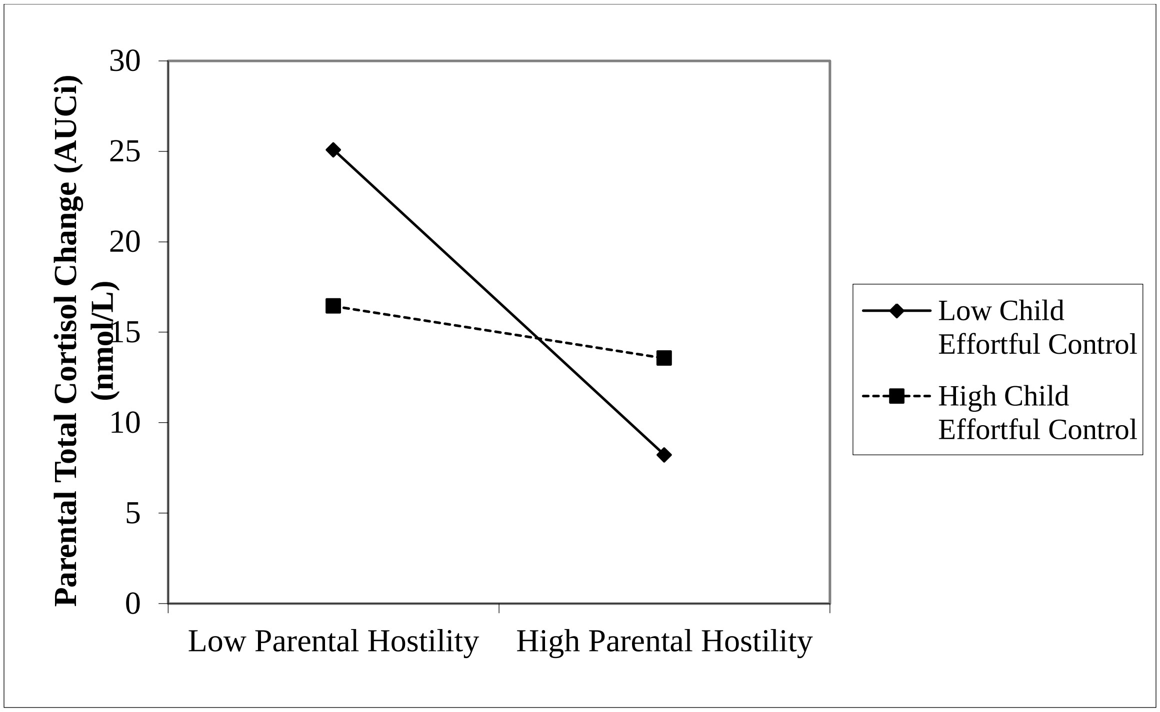

Figure 2. Parents' total change in cortisol as a function of child effortful control and parental hostility. Cortisol change was calculated as area under the curve with respect to increase (AUC_i).

References

Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions.* Newbury Park, CA: Sage.

Barrett, J., & Fleming, A.S. (2011). Annual research review: all mothers are not created equal: Neural and psychobiological perspectives on mothering and the importance of individual differences. *Journal of Child Psychology and Psychiatry, 52*, 368-397.

Bella, G.P., Garcia, M.C., & Spadari-Bratfisch, R.C. (2011). Salivary cortisol, stress, and health primary caregivers (mothers) of children with cerebral palsy. *Psychoneuroendocrinology,36,* 834-842.

Belsky, J., & de Haan, M. (2011). Annual research review: parenting and children's brain development: The end of the beginning. *Journal of Child Psychology and Psychiatry, 54*, 409-428.

Bhagwagar, Z., Hafizi, S., & Cowen, P.J. (2005). Increased salivary cortisol after waking in depression. *Psychopharmacology, 182,* 54-57.

Broderick, J. E., Arnold, D., Kudielka, B. M, & Kirschbaum, C. (2004). Salivary cortisol sampling compliance: comparison of patients and healthy volunteers. *Psychoneuroendocrinology*, *29*, 636–650.

Chida, Y., & Steptoe, A. (2009). Cortisol awakening response and psychosocial factors: A systematic review and meta-analysis. *Biological Psychology*, *80*, 265-278.

Clow, A., Thorn, L., Evans, P., & Hucklebridge, F. (2004). The awakening cortisol response: methodological issues and significance. *Stress, 7*, 29-37.

Coplan, R.J., Bowker, A., & Cooper, S.M. (2003). Parenting daily hassles, child temperament, and social adjustment in preschool. *Early Childhood Research Quarterly, 18,* 376-395.

Crnic, K.A., & Greenberg, M.T. (1990). Minor parenting stresses with young children. *Child Development, 61,* 1628-1637.

Deater-Deckard, K. (2004). Parenting Stress. United States of America: Yale University Press.

Dougherty, L.R., Tolep, M.R., Smith, V.C., & Rose, S. (2013). Early exposure to parental depression and parenting: Associations with young offspring's stress physiology and oppositional behavior. *Journal of Abnormal Child Psychology, 41,* 1299-1310.

Downey, G., & Coyne, J.C. (1990). Children of depressed parents: An integrative review. *Psychological Bulletin, 108,* 50-76.

Egeland, B., Weinfield, N., Hiester, M., Lawrence, C., Pierce, S., & Chippendale, K. (1995). *Teaching tasks administration and scoring manual.* University of Minnesota.

Eisenberg, N., Cumberland, A., Spinrad, T.L., Fabes, R.A., Shepard, S.A., Reiser, M., … Guthrie, I.K. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development, 72,* 1112-1134.

First, M. B., Gibbon, M., Spitzer, R. L., Williams, J. B. W. (1996). *Structured clinical interview for DSM-IV Axis I disorders: Non-patient edition (SCID-I, Version 2.0).* New York: Biometrics Research, New York State Psychiatric Institute.

Fonagy, P., & Target, M. (2005). Bridging the transmission gap: An end to an important mystery in attachment research? *Attachment & Human Development, 7,* 333-343.

Fries, E., Dettenborn, L., & Kirschbaum, C. (2009). The cortisol awakening response (CAR): Facts and future directions. *International Journal of Psychophysiology, 72*, 67-73.

Fries, E., Hesse, J., Hellhammer,J., & Hellhammer, D.H. (2005). A new view on hypocortisolism. *Psychoneuroendocrinology, 30,* 1010-1016.

Gonzalez, A., Jenkins, J.M., Steiner, M., & Fleming, A.S. (2012). Maternal early life experiences and parenting: The mediating role of cortisol and executive functioning. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*, 673-682.

Granger, D.A., Hibel, L.C., Fortunato, C.K., & Kapelewski, C.H. (2009). Medication effects on salivary cortisol: tactics and strategy to minimize impact in behavioral and developmental science. *Psychoneuroendocrinology, 34,* 1437-1448.

Gunnar M.R., & White B. (2001). Salivary cortisol measures in infant and child assessment. In L.T Singer & P.S. Zeskind (Eds.), *Biobehavioral Assessment of the Newborn.* (p. 167-189). New York: Guilford Press.

Hammen, C. (2006). Stress generation in depression: Reflections on origins, research, and future directions. *Journal of Clinical Psychology, 62*,1065-1082.

Heim, C., Ehlert, U., & Hellhammer, D.H. (2000). The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. *Psychoneuroendocrinology, 25,* 1-35.

Hellhammer, J., Fries, E., Schweisthal, O. W., Schlotz, W., Stone, A. A., & Hagemann, D. (2007). Several daily measurements are necessary to reliably assess the cortisol rise after awakening: State-and trait components. *Psychoneuroendocrinology, 32*, 80–86.

Huber, T.J., Issa, K., Schik, G., & Wolf, O.T. (2006). The cortisol awakening response is blunted in psychotherapy inpatients suffering from depression. *Psychoneuroendocrinology, 31*, 900-904.

Kiel, E.J., & Buss, K.A. (2013). Toddler inhibited temperament, maternal cortisol reactivity and embarrassment, and intrusive parenting. *Journal of Family Psychology, 27*, 512-517.

Kochanska, G., Murray, K.T., & Harlan, E.T. (2000). Effortful control in early childhood: continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36*, 220-232.

Kunz-Ebrecht, S. R., Kirschbaum, C., Marmot, M., & Steptoe, A. (2004). Differences in cortisol awakening response on work days and weekends in women and men from the Whitehall II cohort. *Psychoneuroendocrinology*, *29*, 516–528.

Liang, K. Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, *73*, 13–22.

Lorber, M.F., & O'Leary, S.G. (2005). Mediated paths to overreactive discipline: Mothers' experienced emotion, appraisals, and physiological responses. *Journal of Consulting and Clinical Psychology, 73,* 972-981.

Lovejoy, M.C., Graczyk, P.A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review, 20,* 561–592.

Martorell, G.A., & Bugental, D.B. (2006). Maternal variations in stress reactivity: Implication for harsh parenting practices with very young children. *Journal of Family Psychology, 20*, 641-647.

McEwen, B. S. (1998). Stress, adaptation, and disease: Allostasis and allostatic load. *Annals of the New York Academy of Sciences*, *840*, 33–44.

Miller, G.E., Chen, E., & Zhou, E.S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin*, *133*, 25-45.

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*, 916–931.

Pruessner, J. C., Wolf, O. T., Hellhammer, D. H., Buske-Kirschbaum, A., von Auer, K., Jobst, S., ... Kirschbaum, C. (1997). Free cortisol levels after awakening: a reliable biological marker for the assessment of adrenocortical activity. *Life Sciences*, *61*, 2539-2549.

Putnam, S. P., & Rothbart, M. K. (2006). Development of Short and Very Short forms of the Children's Behavior Questionnaire. Journal of Personality Assessment, *87*, 103-113.

Rilling, J.K. (2013). The neural and hormonal bases of human parental care. *Neuropsychologia, 51,* 731-747.

Rohde, P., Lewinsohn, P.M., & Seeley, J.R. (1997). Comparability of Telephone and Face-to-Face Interviews in Assessing Axis I and II Disorders. *American Journal of Psychiatry, 154,* 1593 1598.

Saxbe, D.E., Repetti, R.L., & Nishina, A. (2008). Marital satisfaction, recovery from work, and diurnal cortisol among men and women. *Health Psychology, 27*, 15-25.

Seltzer, M.M., Greenberg, J.S., Hong, J., Smith, L.E., Almeida, D.M., Coe, C., & Stawski, R.S. (2010). Maternal cortisol levels and behavior problems in adolescents and adults with ASD. *Journal of Autism and Developmental Disorders*, *40,* 457-469.

Sethre-Hofstad, L., Stansbury, K., & Rice, M.A., (2002). Attunement of maternal and child adrenocortical response to child challenge. *Psychoneuroendocrinology, 27,* 731-747.

Sturge-Apple, M.L., Davies, P.T., Cicchetti, D., & Cummings, E.M. (2009). The role of mothers' and fathers' adrenocortical reactivity in spillover between interparental conflict and parenting practices. *Journal of Family Psychology*, *23*(2), 215-225.

Thompson, L.A., & Trevathan, W.R. (2008). Cortisol reactivity, maternal sensitivity, and learning in three-month-old infants. *Infant Behavioral Development, 31*, 92-106.