HHS Public Access

Author manuscript

Infant Child Dev. Author manuscript; available in PMC 2019 July 01.

Published in final edited form as:

Infant Child Dev. 2018 ; 27(4): . doi:10.1002/icd.2083.

Examining Morning HPA Axis Activity as a Moderator of Hostile, Over-reactive Parenting on Children's Skills for Success in School

Shannon T. Lipscomb,
Oregon State University-Cascades

Derek R. Becker,
Oregon State University

Heidemarie Laurent,
University of Oregon

Jenae M. Neiderhiser,
The Pennsylvania State University

Daniel S. Shaw,
University of Pittsburgh

Misaki N. Natsuaki,
University of California, Riverside

David Reiss,
Yale Child Study Center

Philip A. Fisher, and
University of Oregon

Leslie D. Leve
University of Oregon

Abstract

This study examined children's morning HPA axis activation as a moderator of links between hostile, over-reactive parenting at age 4.5 years and children's skills for success in school (higher executive function and literacy, and less externalizing behavior) at age 6. Participants included 361 adoptive families. Parenting was self-reported. HPA axis activation was measured by basal levels in morning cortisol. Executive function and literacy were assessed via standardized tasks. Externalizing behavior was reported by teachers. Results indicated that hostile, over-reactive parenting predicted more externalizing behavior and lower executive functioning regardless of children's morning HPA axis activation. HPA axis activation moderated the effects of hostile, over-reactive parenting on literacy. Among children with moderate to high morning HPA axis activation (approximately 60% of the sample), harsh parenting was linked with lower literacy;

Correspondence should be sent to Dr. Shannon T. Lipscomb, Oregon State University-Cascades, 2600 NW College Way, Bend, OR 97701. Phone: (541) 322-3137. Shannon.lipscomb@osucascades.edu.

children with low morning HPA axis activation exhibited better literacy in the context of more hostile, over-reactive parenting. Yet, across the sample, hostile, over-reactive parenting remained in the low to moderate range, not in the high range. Findings are discussed in the context of considering not only whether children's stress system activation moderates responses to their environments, but also how these processes operate for different developmental outcomes.

Keywords

HPA; cortisol; executive function; literacy; externalizing; parenting; school readiness

Examining Morning HPA Axis Activity as a Moderator of Hostile, Over-reactive Parenting on Children's Skills for Success in School

School readiness skills are critical for children's success in early childhood and beyond (Duncan et al., 2007). This study investigates three key skills for school success: executive function, low externalizing behavior, and early literacy. We assess the role of hostile, over-reactive parenting on each of the three school success skills, because parenting practices are foundational for young children's development (Landry, Smith, & Swank, 2003) yet the role of hostile, over-reactive parenting is not yet well-understood relation to school readiness. Evidence suggesting that children vary in their responses to parenting is also accumulating (Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2007; Ellis & Boyce, 2011; Leve et al., 2009). Prior studies have identified children's hypothalamic-pituitary-adrenal HPA axis activity as a moderator of their responses to their early environments (Ellis & Boyce, 2011; Laurent et al., 2013; Obradovic, Bush, Stamperdahl, Adler, & Boyce, 2010).

The current study expands our understanding of children's school readiness by examining basal morning levels of children's HPA axis activity as a moderator of the effects of harsh, over-reactive parenting on externalizing behavior, executive function, and early literacy at age six years. We selected these three skills for the following reasons. Externalizing behavior problems in the classroom can interfere with children's school engagement, learning, and relationships with teachers (e.g. Sutherland & Oswald, 2005), and are associated with school drop-out (Jimerson, Ferguson, Whipple, Anderson, & Dalton, 2002). Executive function involves working memory, attentional flexibility, and inhibitory control (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000); it helps children to follow instructions and stay on-task, and predicts academic success (Becker, Miao, Duncan, & McClelland, 2014; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013). Finally, early literacy skills are an important indicator of early academic competence (Whitehurst, Zevenbergen, Crone, Schultz, Velting, & Fischel, 1999).

Hostile, Over-reactive Parenting and Children's Skills for School Success

Hostile, over-reactive parenting is consistently linked with higher levels of externalizing behavior problems throughout childhood (e.g., Gershoff, 2002; Lipscomb et al., 2014; Maccoby, 2000; Rothbaum & Weisz, 1994; Shaw, Gilliom, Ingoldsby, & Nagin, 2003; Shaw, Winslow, Owens, Vondra, Cohn, & Bell, 1998). Although the conceptualization and measurement of parenting varies somewhat across studies, parenting behaviors that are more

hostile and/or over-reactive (involving yelling, overly strict or harsh punishment, criticizing, anger toward the child, etc.) are linked with children's development of externalizing behavior problems. For example, Shaw and colleagues (2003) found that a measure of "rejecting" parenting that included harshness, hostility, and punitive-ness was linked with chronically high conduct problems from ages 2 to 8 years, compared against high but decreasing conduct problems. In another study, over-reactive parenting was linked with children's externalizing behavior problems across the period from 18 months to 6 years (Lipscomb et al., 2014). Possible mechanisms linking hostile or over-reactive parenting to children's development of externalizing behaviors include modeling and reinforcing disruptive or aggressive behavior (Smith, Dishion, Shaw, Wilson, Winter, & Patterson, 2014). Additionally, hostile, over-reactive parenting may also increase young children's negative arousal, which may interfere with their developing self-regulation and sense of security (Hoffman, 2000; Grusec & Goodnow, 1994; Power, 2004), which could in turn contribute to externalizing behaviors.

Hostile, over-reactive parenting has not been as thoroughly investigated in relation to other indicators of young children's school success, such as executive functioning and early literacy. Although child maltreatment is clearly detrimental to children's executive function and learning (e.g., Pears & Fisher, 2005; Pears, Fisher, Bruce, Kim, & Yoerger, 2010), the role of less extreme levels of hostile, over-reactive parenting is not yet well-understood. Most of the research examining associations between parenting and children's development of executive function and early academic skills such as literacy, have focused on positive (sensitive, stimulating) parenting (e.g. Blair, Raver, Berry, & the Family Life Project, 2014; Sulik et al., 2015). Yet, if hostile, over-reactive parenting increases children's negative arousal and sense of security (Hoffman, 2000; Grusec & Goodnow, 1994; Power, 2004) it could also hinder the development of executive function and early literacy.

Indeed, one study found that children whose mothers used more punitive parenting (e.g., spanking, yelling) during the preschool years scored lower on literacy in kindergarten (Culp, Hubbs-Tait, Culp, & Starost, 2001). In another study, negative, intrusive parenting (e.g., disapproval, harsh physical or unexplained punishment, mother imposing her agenda on the child) predicted less growth in language skills during early childhood (Pungello, Iruka, Dotterer, Mills-Koonce, & Reznik, 2009). There is also some indication that hostile parenting is linked with less effortful control during early childhood (Hopkins, Lavigne, Gouze, LeBailly, & Bryant, 2013), yet little research has examined hostile or over-reactive parenting in relation to children's executive function (Fay-Stammbach, Hawes, & Meredith, 2014).

The current study examines longitudinal associations between hostile, over-reactive parenting during the preschool period on children's development of three important skills for success in elementary school (less externalizing behavior, and higher executive function and early literacy skills). Yet, we also recognize that children vary in their responses to their environments (Belsky et al., 2007), and that understanding such variation may be important to supporting children's development of school readiness skills. In this study, we build upon prior research indicating that HPA axis activation may help explain this variability (e.g., Obradovic et al., 2010).

HPA Axis Activation and Skills for School Success

The HPA axis helps to regulate mental and somatic resources required to confront stress, both through diurnal patterns of cortisol output and acute elevations in response to challenge (Ellis, Jackson, & Boyce, 2006). Although HPA axis responses to acute stressors and diurnal patterns are often linked with psychosocial outcomes in similar ways, they measure different aspects of HPA axis function, with diurnal outputs thought to offer a better index of global activation (Kudielka & Wüst, 2010). A typical diurnal pattern in cortisol is indicated by an increase early in the morning, peaking approximately 30 minutes after waking, followed by a decline throughout the day (Cone, Low, Elmquist, & Cameron, 2002). Diurnal patterns are typically established by three months of age (Gribbin, Watamura, Cairns, Harsh, & LeBourgeois, 2012), and individual differences in diurnal outputs have been linked with children's adjustment during the preschool period (Turner-Cobb, 2005).

Elevated cortisol levels are often indicative of life stress (e.g., Bruce, Fisher, Pears, & Levine, 2009; Doom, Cicchetti, Rogosch, & Dackis, 2013), and can interfere with sustaining attention and completing challenging tasks (Henckens, van Wingen, Joëls, & Fernández, 2012). Young children with elevated cortisol have shown difficulties with executive function and cognition (Berry et al., 2012). Elevated cortisol levels may therefore have important implications for children's success in school. Morning levels are thought to be more stable than evening levels, which may additionally reflect reactivity to and recovery from the day's events (e.g., Bartels, de Geus, Kirschbaum, Sluyter, & Boomsma, 2003). Thus, this study examines morning cortisol levels as an index of HPA axis activation.

HPA axis activity may moderate children's responses to their early environments (Ellis & Boyce, 2011; Laurent et al., 2013; Obradovic et al., 2010). Various models have been put forth to help explain how children's characteristics might moderate links between experience and development (Reiss, Leve, & Neiderhiser, 2013). For example, the differential susceptibility/biological sensitivity to context (BSC) approach focuses on factors that increase children's susceptibility to both protective and harmful environments (Belsky et al., 2007; Ellis & Boyce, 2005), whereas the inherited sensitivity/diathesis-stress approach examines how children's genetic risks increase their sensitivity to adverse environments (Leve et al., 2010). The goodness-of-fit model illustrates how the same experience (e.g., structured parenting) can be associated with better outcomes for some children but with worse outcomes for others (e.g., Leve et al., 2009). The common underlying proposition among these models is the presence of individual differences in the links between children's early experiences and their learning and development. The current study draws from these models to examine how children's basal morning HPA axis activation may moderate links between hostile and over-reactive parenting, and externalizing behavior, executive function, and early literacy at age six years.

Little is known about how children's HPA axis activation may moderate links between early experiences and their skills for success in early elementary school. Obradovic and colleagues (2010) conducted an initial investigation of children's reactivity to acute stressors as a moderator of links between family adversity and school readiness. Stress reactivity was measured by respiratory sinus arrhythmia (RSA) and cortisol reactivity. Findings were partially consistent with BSC. High RSA reactivity was associated with more child

externalizing symptoms, less prosocial behavior and school engagement, as well as with a decline in academic competence in the context of high family adversity, but with better adaptation in these same areas in the context of low family adversity. Similarly, cortisol reactivity to an acute stressor moderated the link between family adversity and children's prosocial behavior such that children with higher cortisol reactivity showed less prosocial behavior in the context of high adversity. However, in the context of low family adversity, no differences in prosocial behavior were detected by cortisol reactivity.

Although this work is an important first step, more research is needed to clarify the contribution of HPA axis activation as a moderator of early environment effects on children's success in school. For example, Obradovic and colleagues (2010) examined cortisol reactivity; it will also be important to understand how diurnal outputs may moderate environmental effects on children's success in school, especially considering that diurnal outputs may offer a better index of global activation (Kudielka & Wüst, 2010). Additionally, prior work has conceptualized environmental context through a composite adversity measure (Obradovic et al., 2010); the importance of specific aspects of the family environment (e.g., hostile and over-reactive parenting) remains unknown. Since negative arousal appears to be a key mechanism linking parent hostility and over-reactivity to children's development (e.g. Beach, Lei, Brody, Simons, Cutrona & Philibert, 2012), individual differences in children's stress system activity (e.g., morning HPA axis activity) may affect how they respond to such types of parenting. Children who are rated higher on emotional negativity and arousal have, indeed, been shown to be more susceptible to the effects of hostile parenting on externalizing behavior problems (Scaramella & Conger, 2003). Understanding how specific aspects of adverse family environments, such as hostile, over-reactive parenting, interact with children's individual differences (e.g., morning HPA axis activity) to predict school success has the potential to more effectively inform efforts to promote positive development for children and families facing adversity.

The Present Study

This study examines how children's morning HPA axis activity interacts with hostile/over-reactive parenting to predict skills for early school success (executive function, low externalizing problems, early literacy). School readiness skills are critical for children's success in early childhood and beyond (Duncan et al., 2007), and the preschool period is foundational for the development of these skills (e.g. McClelland et al., 2013; Olson, & Lunkenheimer, 2009; Shaw et al., 2003; Whitehurst et al., 1999). We expand prior work in three important ways. First, this study examines a specific dimension of the family context: hostile, over-reactive parenting. Second, we include executive function as a key outcome, which has not been included in prior work on HPA axis activity as a moderator of parenting effects on children's skills for success in school. Third, we utilize a longitudinal adoption design to examine prospective effects of children's morning HPA axis activity and hostile, over-reactive parenting without contamination by passive gene-environment correlation that can conflate associations between a child outcome and a parenting measure (Rutter Pickles, Murray, & Eaves, 2001). Our first hypothesis was that hostile, over-reactive parenting measured at age 4.5 years would predict children's externalizing behavior, poorer executive function, and poorer early literacy at age 6 years. We further hypothesized that children's

morning HPA axis activity at age 4.5 years would moderate these effects of hostile, over-reactive parenting on the three outcome measures.

Method

Participants

Participants were drawn from Cohort I of the Early Growth and Development Study, a longitudinal study of adopted children and their birth and adoptive parents. Recruitment of Cohort I participants occurred between 2003 and 2006, beginning with the recruitment of adoption agencies (N = 33 agencies in 10 states located in the Northwest, Mid-Atlantic, and Southwest regions of the United States). Agency staff identified participants who completed an adoption plan through their agency and met the following eligibility criteria: (a) the adoption placement was domestic, (b) the infant was placed within 3 months postpartum (M = 7.11 days postpartum, SD = 13.28; median = 2 days), (c) the infant was placed with a nonrelative adoptive family, (d) birth and adoptive parents were able to read or understand English at the eighth-grade level, and (e) the infant had no known major medical conditions such as extreme prematurity or extensive medical surgeries. Of the families who met eligibility criteria, 68% (n = 361) agreed to participate. The participants were representative of the adoptive parent population that completed adoption plans at the participating agencies during the same time period (see Leve et al., 2013 for more details about recruitment and the sample).

The sample used in this report included male (57%) and female (43%) children with a range of racial/ethnic backgrounds (58% White, 11% Black/African American, 9% Latino, 21% multiracial, less than 1% each of American Indian/Alaskan Native and unknown or not reported). Adoptive parents were predominantly (more than 90%) White and middle class and involved in a stable marital or marriage-like relationship (M = 18.5 years, SD = 5.2 at the first assessment).

Procedures

Parent and child data for this study were collected through in-person interviews, assessments and saliva samples, home-based questionnaires, and web-based assessments. Data for analysis in this study were collected when the child was 4.5 years and 6 years old.

Measures

Hostile, over-reactive parenting—Adoptive mothers' and fathers' hostile and over-reactive parenting was measured when children were 4.5 years old with an aggregate of two self-report instruments: the 5-item hostility subscale from the Iowa Family Interaction Scale (Melby et al., 1998), and the 10-item over-reactivity subscale of the Parenting Scale (Arnold, O'Leary, Wolf, & Acker, 1993). The hostility subscale of the Iowa Family Interaction Scale asks parents, "During the past month when you and your child have spent time talking or doing things together, how often did you…" Sample items include, "get angry at him/her", "criticize him/her or his/her ideas", and "shout or yell at him/her because you were mad at him/her." Each parent responded on a seven-point scale from 1 = *never* to 7 = *always*.

The over-reactivity subscale was designed to identify parental discipline mistakes that relate theoretically to children's behavior problems, with higher scores indicating more over-reactivity. Each identified mistake was paired with its more effective counterpart to form the anchors for a 7-point scale (e.g., "when I'm upset or under stress …" 1= *I am no more picky than usual;* 7 = *I am picky and on my child's back*. "When my child misbehaves…"1= *I speak to my child calmly;* 7 = *I raise my voice or yell*).

Summary scores on the 5-item hostile parenting subscale showed low overall levels of hostility (*M* =10.73; average score per item = 2.15 on a scale from 1 to 7) but meaningful variation across families (*SD* = 2.64, range from 5 to 23). Similarly, scores for over-reactive parenting were low but variable (*M* = 2.36 on a scale from 1 to 7; *SD* = .50; range from 1.05 to 4.0). Scores for adoptive mothers (AM) and adoptive fathers (AF) for both measures were standardized and summed into a composite (with an average correlation of $r = .59$ across the two measures and across AM and AF, $p < .01$). The overall alpha of the four scores (two measures x two respondents) for the negative parenting composite variable was .70.

Morning HPA axis activity-salivary cortisol—Child's morning (*M* time = 7:38 a.m., *SD* = 43 min) saliva samples were collected with the help of the adoptive parents across 3 consecutive days as part of the 4.5-year assessment. Parents were instructed to collect the samples within 30 min after the child awoke in the morning (wake time range = 5:00–10:15 a.m.), but before breakfast. Because it is not always feasible for parents to ascertain the exact time young children wake, we do not measure the Cortisol Awakening Response (CAR). Rather, we utilize this morning cortisol collection as a measure of individual differences in cortisol levels, which is consistent with approaches in prior research (e.g., Funke, Eichler, Distler, Golub, Kratz, & Moll, 2016; Laurent et al., 2013; Zalewski, Lengua, Kiff, & Fisher, 2012).

Parents were trained in sample collection procedures in person, which involved saturating salivettes before placing them in prelabeled plastic vials. Samples were then mailed to the primary study site, at which point they were frozen and stored on site until all samples for all participants had been collected and could be mailed jointly to the analysis laboratory. Samples were stored at −5° F (-20°C) until assay using a competitive solid- phase time-resolved fluorescence immunoassay (Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992) with interassay coefficients of variation (CV) 7.1%–9.0%. Samples were assayed in duplicate, and all three scores were used in analyses (*M* morning cortisol = .63 lg/dl, *SD* = .23; *M* intraassay coefficient of variation = 6%, *SD* = 1.9). Parents recorded the exact time of saliva collection and other information that could affect cortisol measurement, such as illness, medication use, and sleep time, in a collection diary. Standard data screening procedures (e.g., identifying and eliminating extreme outlying values, checks for implausible or contradictory time recording) were used. Such screening resulted in the deletion of 1–6 cortisol values (.5%–3% of the total) from each sampling period due to extreme values (>2 lg/dl), reported sampling time before reported wake time or after sleep time, and/or inconsistency of 30 min or more between reported sampling time and time recorded on the saliva vial.

To prepare data for hypothesis testing, estimates of each child's morning cortisol levels were obtained by fitting a model with cortisol scores measured across the three days of collection as the Level 1 outcome in the Hierarchical Linear Modeling (HLM) program, controlling for time of sample collection: Cortisol (AM) = $\beta_0 + \beta_1$(collection time) + e

Each child's unique intercept (β_0) across the 3 days was extracted from the HLM Level 1 residual file to be used as an indicator of children's basal morning cortisol levels in hypothesis testing. Full information maximum likelihood estimation in HLM allowed for the computation of expected child cortisol values in the presence of missing data.

Child externalizing behaviors—Child externalizing behaviors were measured via teacher report at 6 years of age using the 24-item, broad-band Externalizing factor from the Teacher Report Form (TRF; Achenbach, 2009). The TRF is a variation of the Child Behavior Checklist (CBCL) that is adapted for school personnel report on the child's behaviors in the classroom. It consists of 109 behaviors rated on a 3-point scale with values of 0 (*not true*), 1 (*sometimes true*), and 2 (*very true*). The Externalizing factor is comprised of all items from the narrow-band Aggression and Attention subscales (α = .87) and was selected over specific narrow-band factors in the present analyses because we were concerned with children's development of externalizing behaviors at a general level, rather than specific components such as aggression, oppositionality, or ADHD symptoms. T scores (T > 65 indicates borderline to clinical range) were used for analysis. The majority of children showed behaviors in the normal range (n = 8 borderline clinical), but a range of severity was represented (T-score range = 36 to 72). See Table 1 for descriptive statistics.

Executive Function—Children's executive function at age 6 years was assessed with the Go-NoGo Task, a computerized task that assesses the inhibitory control aspect of executive function (see Nosek & Banaji, 2001). Inhibitory control is critical to academic learning and is also a key factor underlying two additional facets of executive function: working memory and attentional flexibility (Miyake et al., 2000). As the Go-NoGo requires the maintenance of task rules to respond correctly, there is evidence this measure also taps working memory (McVay & Kane, 2009). There are 84 trials and the task takes approximately 5 minutes to complete. For each trial, a letter is displayed in the center of the computer monitor. The children are instructed to press a button for every letter (target stimuli) except for the letter X (nontarget stimulus). During the task, 42 trials contain 100% targets and act as a control or "Go" condition. The inhibition No-Go condition contains 42 trials, 21 Go (i.e., not Xs) and 21 nontargets (i.e., Xs). Following an incorrect response, auditory performance feedback (i.e., a brief buzz) is presented. Similar to Davis, Bruce, and Gunnar (2002), inhibitory control was assessed as the percent correct (nonresponses to false alarms) during the response inhibition (nontarget) condition.

Emergent Literacy—Children's emergent literacy skills were assessed at age 6 years with the Dynamic Indicator of Early Literacy Skills (DIBELS). DIBELS is a set of short (one minute) fluency measures for assessing early literacy skills from kindergarten through third grade related to reading outcomes. Each measure has been thoroughly researched and demonstrated to be reliable and valid indicators of early literacy development and predictive of later reading proficiency (Good & Kaminski, 2002). This study utilized a standardized

aggregate of the number of correct items on four subscales that are appropriate for 6-year-old children: letter naming fluency, phoneme segmentation, nonsense word fluency, and initial sound fluency (α = .78). Alternate-form reliability estimates for these subscales range from .72 to .88 (Good et al., 2004). For the measure of sound fluency, the examiner presents four pictures to the child, names each picture, and then asks the child to identify (i.e., point to or say) the picture that begins with the sound produced orally by the examiner. The assessment of letter naming fluency asks children to name as many letters as they can from a list of upper- and lower-case letters that are arranged in a random order. To assess phoneme segmentation fluency, three to four phonemes are presented to the child orally. The child is required to produce verbally the individual phonemes for each word. For example, the examiner says "sat," and the child says "/s/ /a/ /t/." Nonsense word fluency is assessed by presenting the child with a sheet of paper with randomly ordered nonsense words (e.g., sig, rav, ov), and the child is asked to produce verbally the individual letter sound of each letter or verbally produce, or read, the whole nonsense word.

Covariates—Parents reported on a number of factors that could be important to control for, such as child sex, age (in months), prenatal and birth complications (birth-mother report), adoptive parents' level of education, household income, attendance in early care and education programs, and perceived openness of the adoption and contact between birth and adoptive families. These were considered as possible covariates in analyses. Final models include covariates that were significantly associated with the outcomes in preliminary models: child sex and age, and parent education and income. Other information that parents recorded at the time of cortisol collection (e.g., illness, medication use, and sleep time) were considered in the preliminary models used to generate children's morning cortisol levels.

Analytic Strategy

The main explanatory models tested main and interactive effects of adoptive parents' hostile, over-reactive parenting and child cortisol values at age 4.5 years as predictors of children's skills for early school success at age 6. All analyses were conducted in Stata 13.1 (StataCorp, 2013) using multiple imputation to address missing data. Variables with greater than 10% missingness included hostile, over-reactive parenting (23%), cortisol (35%), teacher-reported externalizing behavior (52%), and assessments of children's executive function (19%) and literacy (18%). Children with missing data did not differ from those without missing data on any of the variables included in the analyses, nor on any additional variables theoretically related to missingness, all p's > .05 (e.g., openness in the adoption, household income) (Steiner, Cook, Shadish, & Clark, 2010). Although data were assumed to be missing at random, this assumption cannot be fully assessed given other (unmeasured) variables could predict missingness. The region of significance was examined for all significant interactions to identify values of the moderator (cortisol) at which parenting had significant effects on the outcomes.

Results

Descriptive statistics and correlations are displayed in Table 1. Overall, scores reflected wide variation in externalizing behaviors, executive function, and emergent literacy. Hostile, over-

reactive parenting at age 4.5 was positively correlated with age-6 teacher reports of externalizing problems ($r = .22$, $p < .001$), and negatively correlated with executive function ($r = -.16$, $p < .001$), but not significantly correlated with emergent literacy. Morning cortisol levels were not associated with the outcomes. Higher externalizing behavior was concurrently linked with lower emergent literacy ($r = -.22$, $p < .001$).

Main Effects of Parenting and Morning HPA Axis Activation on Children's Skills for School Success

Hostile, over-reactive parenting at 4.5 years of age significantly predicted children's externalizing behavior and executive function, but not emergent literacy at age 6 years. In the model that included morning cortisol levels, children who received more hostile, over-reactive parenting at age 4.5 years had significantly higher externalizing behavior ($B = 2.60$, $p = .003$) and lower executive functioning ($B = -3.73$, $p = .019$) at age 6 (see Table 2).

Morning HPA Axis Activation as a Moderator of Parenting

Cortisol levels did not moderate effects of hostile, over-reactive parenting on children's externalizing problems in the classroom or executive functioning at age six (Table 2). As shown in Table 2 and Figure 1, children's level of morning cortisol moderated the effect of hostile, over-reactive parenting on children's emergent literacy. Probing the region of significance for the interaction with cortisol levels revealed that hostile, over-reactive parenting predicted lower emergent literacy for children with moderate to high morning cortisol levels (>0.53; 38th percentile and above). For children with lower morning cortisol levels (<0.51; 31st percentile and below), hostile, over-reactive parenting predicted higher emergent literacy scores. No significant effect of hostile, over-reactive parenting on emergent literacy was detected for children with cortisol levels between the 32nd and 37th percentiles.

Discussion

Findings indicate that children's morning cortisol levels moderate the effect of hostile, over-reactive parenting during preschool on their early literacy skills, but not on their externalizing behavior or executive functioning at age six. These findings are partially consistent with theoretical models positing that children's characteristics moderate links between experience and development (Belsky et al., 2007; Ellis & Boyce, 2011; Leve et al., 2010; Reiss et al., 2013). Considered together with emerging evidence from prior studies (Obradovic et al., 2010), findings suggest that whether and to what extent HPA axis activity moderates children's responses to early caregiving environments may depend, in part, on which child outcomes are considered.

Morning HPA Axis Activation, Parenting, and Skills for Success in School

Findings linking hostile, over-reactive parenting during the preschool years with children's externalizing behavior at age six are consistent with a large body of related research (e.g., Lipscomb et al., 2012; Maccoby, 2000; Rothbaum & Weisz, 1994; Shaw et al., 1998, 2003). Much of the theory and research on links between hostile, over-reactive parenting practices such as those measured in the current study (e.g., verbal aggression, impulsive responses)

and children's behavior has pointed to mechanisms centered around social learning processes unfolding in a coercive cycle in which parents model and reinforce (i.e.., child elicits attention from parent when acting in a disruptive behavior) negative behavior (Bandura, 1977; Smith et al., 2014). One possible interpretation of the current finding that children's morning HPA axis activation did not moderate the link between parenting and externalizing behavior could be that these overt social learning processes unfold regardless of children's underlying stress system activation. Alternative explanations are also possible. Perhaps the hypothesized interaction effect would have been detected in a higher-risk sample with more variability in hostile, over-reactive parenting and/or externalizing behavior.

The current study also adds to the literature on hostile, over-reactive parenting by documenting links with executive functioning, and with emergent literacy for children with moderate-to-high basal levels of cortisol. Combined with findings from the few prior studies of links between hostile or harsh parenting and lower literacy scores (Culp et al., 2001; Pungello et al., 2009) and self-regulatory behaviors (Hopkins et al., 2013), these links are suggestive of mechanisms beyond the social learning processes of modeling and reinforcement. It may be that by increasing young children's negative arousal, hostile, over-reactive parenting, interferes with children's sense of security and emerging self-regulation (Hoffman, 2000; Grusec & Goodnow, 1994; Power, 2004), which in turn hinders their ability to develop and utilize higher cognitive functions involved in executive functioning and academic skills like literacy. This is an important contribution considering that most of the prior research on links between parenting and children's development of executive function and early academic skills has focused on positive aspects of parenting, the home learning environment, and family demographics (Blair, et al., 2014; Sulik et al., 2015; Hackman, Gallop, Evans, & Farah, 2015; Vernon-Feagans, Willoughby, & Garrett-Peters, 2016).

Additionally, this study indicates that children with elevated morning cortisol, who tend to show altered patterns of arousal and emotionality (e.g., Dougherty, Klein, Olino, Dyson, & Rose, 2009), may be more sensitive than other children to the deleterious effects of hostile, over-reactive parenting on emergent literacy. Over-reactive, hostile parenting heightens children's negative arousal (Beach et al., 2012). For young children who already have more highly activated stress-response systems (e.g., higher basal morning cortisol), the added stress imposed by hostile, over-reactive parenting may be especially difficult to overcome. This is consistent with prior evidence that children with more emotional negativity and are more susceptible to deleterious effects of hostile parenting (Scaramella & Conger, 2003).

At the same time, our findings suggest that some children may not experience deleterious effects in all outcome areas when they are faced with somewhat hostile or over-reactive parenting. In this study, children with low morning cortisol exhibited better literacy skills when they received more (although still in the low-to-moderate rather than in the high range) hostile, over-reactive parenting. Future research is needed to better understand this finding. One possible interpretation is that children with lower HPA axis activity (who are often considered less sensitive to the environment) are not only less likely to exhibit a detrimental effect of hostile, over-reactive parenting on their academic-related learning, but also may benefit from strict, even somewhat harsh parenting, when considering outcomes related to academic performance. It is possible that moderate levels of hostile, over-reactive parenting

raise the pressure to succeed just enough to aid children's performance on structured tasks or tests for children with lower cortisol, but interfere with performance for children with higher cortisol, perhaps by introducing added stress. It is important to note that the levels of hostile, over-reactive parenting reported in this study were low overall; the *highest* scores on the over-reactivity and hostility scales were 4.0 and 4.6 respectively (with averages of 2.36 and 2.15), on a scale from 1 to 7. It is possible that these effects are nonlinear and therefore do not apply beyond a certain threshold of parental hostility/over-reactivity.

Other explanations are also possible. For example, it could be that children with varying cortisol levels cope with parental hostility and over-reactivity differently, and that such differences have implications for associations between parenting and their literacy skills. For example, children with lower morning cortisol could be escaping from hostile, over-reactive parenting by reading at home, thus improving their literacy scores. Future research should explore these possible mechanisms.

The finding that children with low morning cortisol exhibited better literacy skills in the context of hostile, over-reactive parenting is somewhat consistent with the report by Obradovic and colleagues (2010), in which family adversity was related to an *increase* in academic competence in children with low RSA reactivity (one of their two indices of sensitivity to the environment). Collectively this emerging work suggests that children with low morning HPA axis activity may exhibit some academic benefits in the context of some adversity. Future research should further examine this possibility, utilizing a goodness-of-fit model (e.g., Leve et al., 2009) to examine mechanisms linking various environmental conditions (e.g., supportive parenting, home learning environment, hostile parenting, etc.), with academic skills for children with varying neurobiological profiles.

In sum, findings from this study highlight the importance of considering not only whether children's stress system activation moderates responses to their environments in the development of skills for success in school, but also how these processes operate for different developmental outcomes. This study did not set out to test one specific model, such as differential susceptibility, diathesis-stress, or goodness-of-fit. Rather, this work builds upon this body of literature collectively, and begins to illustrate that different processes may be at play when considering different developmental outcomes. An important direction for future research will be to identify which aspects of the environment (e.g., hostile, over-reactive parenting) might have a similar effect on particular outcomes (e.g., externalizing behavior) for most, or all, children, and which environmental factors are most closely linked with certain outcomes for children who exhibit markers for heightened sensitivity to positive and/or negative experiences.

Strengths and Limitations

Several methodological strengths were incorporated into this study. By utilizing direct assessments and teachers' reports of children's outcomes at age six, we were able to estimate associations with hostile, over-reactive parenting without shared method variance. Additionally, the prospective adoption design, where infants are adopted at birth and placed with non-relative adoptive parents, permitted examination of the effects of parenting on children's outcomes without contamination by passive genotype x environment correlation

(Rutter et al., 2001). The testing of adoption openness and prenatal and obstetric risk as covariates, neither of which had significant effects, reduced the likelihood that the findings were influenced by prenatal factors or from sharing of information between birth parents and adoptive parents. The use of three different but related outcomes for children's success in school allowed us to examine differences in the ways in which morning HPA axis activity interacts with hostile, over-reactive parenting across outcomes. Additionally, examining a specific dimension of the family context (hostile, over-reactive parenting) contributes to a more nuanced understanding of the effects of caregiving environments.

Limitations of the study should also be noted. Generalizability of findings may be limited because this sample consisted entirely of adoptive families, and because the families also had limited ethnic and sociodemographic diversity. Additionally, this study had limited variability in hostile, over-reactive parenting; thus, more hostile, over-reactive parenting represented fairly moderate levels of these parenting behaviors. This limits our understanding of the associations among the full-range of hostile, over-reactive parenting and children's development of skills for success in school. This limited variability may be responsible, in part, for the fairly small magnitude of differences illustrated in Figure 1, representing the interaction between hostile, over-reactive parenting and morning cortisol on emergent literacy. Further, this study focused on diurnal cortisol levels as the indicator of individual differences in stress system activation; we were not able to examine other markers of children's stress responsiveness, including acute morning HPA reactivity and autonomic activation. Future research utilizing more diverse samples, and multiple indices of stress system activity, can build from this study to expand our understanding of individual differences in the environments children need to develop skills for success in school.

Conclusions

In conclusion, the present study provides new insights by documenting that whether and how children's morning HPA axis activation moderates associations between hostile, over-reactive parenting and children's skills for success in school varies by child outcome. Although findings indicate that children with high morning cortisol may be more sensitive to the deleterious effects of hostile, over-reactive parenting on literacy, they also raise new questions about whether, and why, children with lower morning cortisol activation may experience academic benefits in the context of moderate levels of hostile, over-reactive parenting. Evidence supporting this moderating effect of morning cortisol must be considered within the context that hostile, over-reactive parenting may have a main effect on other outcomes, such as externalizing behavior and executive function.

Acknowledgments

Support was provided by R01 HD042608; NICHD, NIDA, and OBSSR, NIH, U.S. PHS (PI Years 1–5: David Reiss; PI Years 6–10: Leslie D. Leve), R01 DA020585 from NIDA, NIMH and OBSSR, NIH, U.S. PHS (PI: Jenae Neiderhiser), and R01 MH092118 (Multiple PIs: Jenae Neiderhiser and Leslie Leve) The content is solely the responsibility of the authors and does not necessarily represent the official views of NICHD or NIH.

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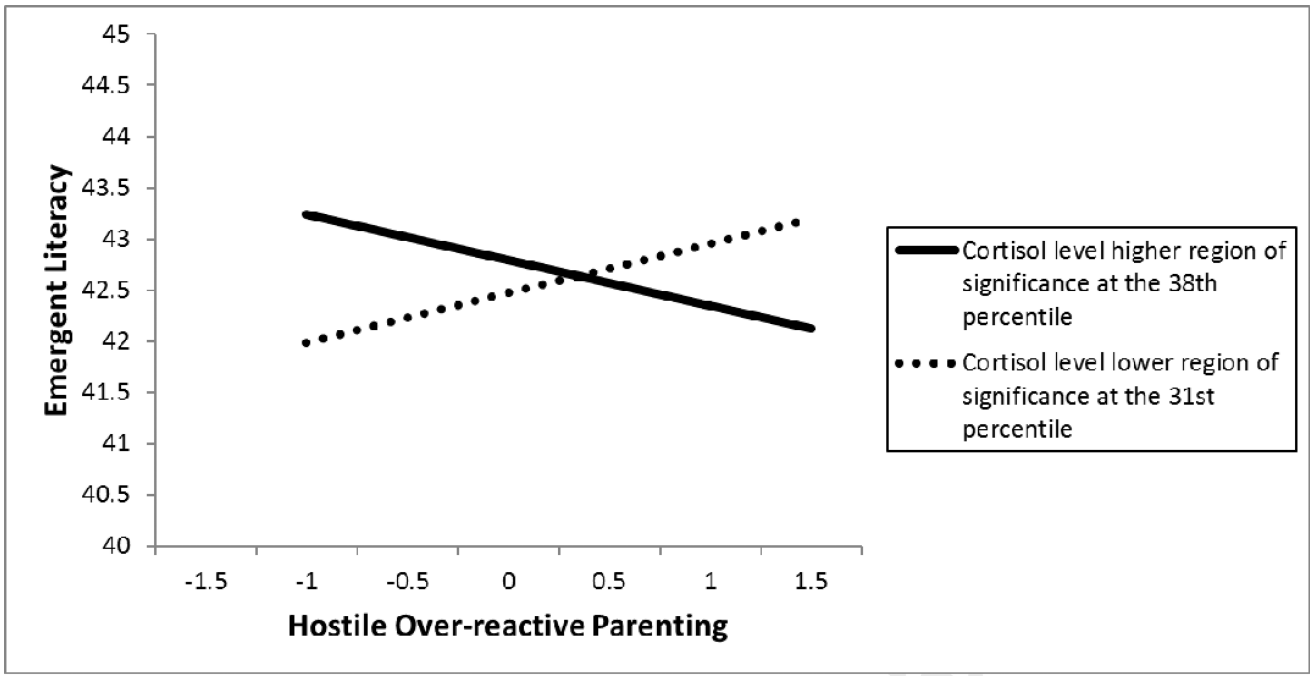

Figure 1. Morning cortisol level moderates the effect of hostile, over-reactive parenting on emergent literacy

Note. Hostile, over-reactive parenting is centered at the mean, which represents low hostile, over-reactive parenting (2 on a scale from 1 to 7). This figure shows that, within the range from low to moderate levels of over-reactive parenting observed in this study, more hostile, over-reactive parented predicted lower emergent literacy for children with morning cortisol levels at or above the 38th percentile. For children with lower morning cortisol levels, at or below the 31st percentile, hostile, over-reactive parenting predicted higher emergent literacy. No significant effect of hostile, over-reactive parenting on emergent literacy was detected for children with cortisol levels between the 32nd and 37th percentiles.

Table 1

Means, Standard Deviations, and Correlations among Study Variables

Variable	1	2	3	4	5	6	7	Min	Max	M	SD
1. Child Age	-	-	-	-	-	-	-	52.47	64.95	55.47	1.89
2. Child Gender [a]	.11†	-	-	-	-	-	-	0.00	1.00		
3. Parent Education	−.01	−.01	-	-	-	-	-	2.50	7.00	5.80	1.11
4. Externalizing Behavior	.07	.02	−.05	-	-	-	-	36.00	72.00	48.05	9.22
5. Executive Function	.02	−.23**	.11*	−.14†	-	-	-	0.00	100.00	62.60	20.56
6. Emergent Literacy	−.12*	−.17*	.09	−.22*	.11	-	-	0.75	72.41	29.08	14.79
7. Morning Cortisol Level	−.02	−.00	.10	.09	.00	.05	-	0.36	0.75	0.55	0.07
8. Hostile, Over-reactive Parenting	.11†	.06	−.01	.22**	−.16**	−.09	.13†	−1.99	3.10	0.02	0.77

Note.

[a] 1 = male; 0 = female

† $p < .10$.

* $p < .05$,

** $p < .01$

Table 2

Main and Interactive Effects of Parenting and Cortisol Levels at Age 4.5 on Children's Skills for Success in School at Age 6.

	Outcomes					
	Teacher Rated Externalizing		Executive function		Emergent Literacy	
	Model		Model		Model	
Variables	Main	Interactive	Main	Interactive	Main	Interactive
Child Sex [a]	.00	.00	−.21*	−.21*	−.15*	−.14*
Parent Education	−.07	−.09	.10†	.09	.07	.08
Parent Income	.66	.06	.04	.05	.01	.01
Child Age	.06	.07	.08	.05	−.10	−.10
Hostile, Over-reactive Parenting	.22*	−.22	−.14*	.18	−.10	1.48*
Morning Cortisol Level	.12	.08	−.00	−.00	.07	.09
Parenting*Cortisol Level	-	.45	-	−.34	-	−1.58*
R^2	.10	.11	.09	.10	.07	.10

Note. Estimates are standardized

[a] 1 = male; 0 = female

† $p < .10$.

* $p < .05$.