Return to School Accompanied by Changing Associations Between Family Ecology and Cortisol

ABSTRACT: This study examines everyday family life as a social regulator of child adrenocortical activity during the normative challenge of return to school. If positive family function facilitates child adaptation, we expected that mother-child relationships following school entry would predict individual differences in evening cortisol, a context-sensitive marker for the response to concurrent demands. Among 28 children followed longitudinally, late in pre-kindergarten those living with single and/or employed mothers had higher evening cortisol. Yet early during the following school year, children with poorer mother-child relationships had higher evening cortisol. Cortisol awakening response, a comparatively stable marker of anticipated demands, was higher with maternal employment, single parents, and busier child schedules before school re-entry, and with maternal employment afterwards. We argue for a layered ecological approach to social regulation, recognizing that family structure, family functioning, and proximal features of everyday life within the family moderate child adrenocortical activity differently across contexts. © 2008 Wiley Periodicals, Inc. Dev Psychobiol 50: 183–195, 2008.

Keywords: cortisol; social ecology; school entry; parent-child relationships

INTRODUCTION

Ecological paradigms draw attention to the role of the practices and settings of everyday life in child development, including parenting behaviors, mealtime routines, spousal relationships, and work/family patterns (Bronfenbrenner, 1986; Weisner, 2002). Yet social address variables and cultural analysis alone have not yet been able to fully explain the diversity of developmental outcomes seen in children. Non-invasive measures of activity in the hypothalamic-pituitary-adrenal (HPA) endocrine axis facilitate evaluating specific associations between ecological contexts and physiological arousal patterns (Gunnar & Donzella, 2002). The HPA axis transduces central affective states into physiologic responses (Sapolsky, Romero, & Munck, 2000). Hence, cortisol activity is a marker for the differential impact of experience, reflecting children’s ability to process social-emotional information in context (Adam, Klimes-Dougan, & Gunnar, 2007). Cortisol assessment can aid in determining whether and how social structure and family ecology “get under the skin” (Lupien, King, Meaney, & McEwen, 2001), and tracks an important physiological component of children’s developing capacity for adaptive, context-sensitive emotion regulation (Davis, Bruce, & Gunnar, 2002; Ellis, Jackson, & Boyce, 2006).

The recognition that cortisol is both socially and endogenously regulated has prompted interest in describing with specificity which stressors stimulate a response under what circumstances, and the time course of that response (Adam, Hawkley, Kudielka, & Cacioppo, 2006; Dickerson & Kemeny, 2004; Gunnar & Donzella, 2002).
Distinctive patterns of family and individual adaptation often become evident during an ecological challenge, such as the transition into a new school year. For example, more pronounced cortisol responses to preschool entry are associated with extroversion (Davis, Donzella, Krueger, & Gunnar, 1999), but cortisol reactivity declines in outgoing children and increases in solitary children across the first few weeks of preschool (Gunnar, Tout, de Haan, Pierce, & Stansbury, 1997). However, it is not merely relations between children’s functioning and their endogenous characteristics that become apparent during such transitions. Boyce et al. (1993) have reported that greater parent distress following a major earthquake was the strongest predictor of increased behavior problems in children. Family responses during a challenge can moderate a child’s capacity to cope.

**Family Ecology and Child Outcomes**

In general, relations between structural factors (e.g., maternal employment, household income) and cortisol are mediated or moderated through more proximal elements of the social ecology (for a broader discussion, see Bronfenbrenner, 1986). For example, poverty is associated with higher basal cortisol in children, but this effect disappears during the transition into high school (Lupien et al., 2001). High quality care and secure attachment moderate infant cortisol responses to maternal separation (Gunnar & Donzella, 2002), while children whose mothers report poor job quality and emotional exhaustion show elevated mean evening cortisol, an effect moderated by frequent child care use (Chryssanthopoulos, Turner-Cobb, Lucas, & Jessop, 2005). Hence, we may conclude that associations between cortisol and even relatively stable aspects of family ecology (such as family structure) are unlikely to be uniform across time or context.

We set out to further test this proposition by measuring, before and after the normative challenge of kindergarten entry, three proposed social regulators of adrenocortical activity that operate at different levels of child experience: the parent-child relationship, the “density” of the child’s daily schedule, and family structure. Children entering kindergarten, even with previous school experience, encounter new peers and teachers, larger and more diverse classrooms, new rules, expectations for greater independence, and increased structure (Cowan, Cowan, Schultz, & Heming, 1994; Rimm-Kaufman & Pianta, 2000). Children’s routines shift (Quas, Murowchick, Bensadoun, & Boyce, 2002), as do household schedules to accommodate child needs (Worthman & DeCaro, 2007). Moreover, the school transition is an important developmental milestone, since adaptation at school entry predicts future academic achievement and social functioning (Cowan et al., 1994; Ladd & Burgess, 2001; Spinrad et al., 2006). Features of child ecology proximally related to adaptation and coping should selectively emerge as predictors of adrenocortical regulation following a challenge of this kind.

Mother-child relations are important moderators of young children’s capacity to adaptively cope with social challenges. Maternal warmth and responsiveness protect against young child anxiety and promote the development of social competence (Chorpita & Barlow, 1998; Repetti, Taylor, & Seeman, 2002). Socially competent and well-regulated children, in turn, better adapt to the novelty of a new school year (Cowan et al., 1994; Ladd & Price, 1987; Supplee, Shaw, Hailstones, & Hartman, 2004). More functional parent-child interactions during physical play (Barth & Parke, 1996), parent-child connectedness during conversational episodes (Clark and Ladd, 2000), and maternal sensitivity during play (National Institute of Child Health and Human Development Early Child Care Research Network, 2003) also are each associated with better social adjustment following school entry.

In our ethnographic work, we found that parents see overscheduling as a feature of family ecology that can generate young child distress (DeCaro & Worthman, 2007). Plausibly overscheduling leads to the chronic accumulation of stress through overload, daily hassles, and/or a loss of perceived control (Cronin & Greenberg, 1990; DeLongis, Folkman, & Lazarus, 1988). A recent review suggested popular concerns about overscheduling as a developmental risk in 5- to 18-year-old children may be unfounded (Mahoney, Harris, & Eccles, 2006). Nevertheless, parental concern about overscheduling young children is significant enough to influence the construction of the daily family schedule (DeCaro & Worthman, 2007), and large shifts in child routines after return to school predict greater adrenocortical arousal (Quas et al., 2002). Children’s daily schedules warrant further study in relation to child stress and adaptation, but compared to mother-child relations, the case is less clear for an effect specifically linked to school entry.

Family structure and parental (especially maternal) employment arrangements are not only social addresses (Bronfenbrenner, 1986), but also implicit scheduling variables. Dual parent employment and single parent status constrain the parental time available for child care activities, and may yield special challenges in busy households (DeCaro & Worthman, 2007). Yet, many families deploy strategies that mitigate the added burden, such as shifting family time and housework to weekends (Bianchi, Milkie, Sayer, & Robinson, 2000; DeCaro & Worthman, 2007; Zuzanek & Smale, 1992). Further, the relations between social addresses and specific developmental outcomes are mediated through proximal processes (Bronfenbrenner, 1986). For example, in the
NICHD Early Child Care Research Network study, greater time spent in a single parent home predicted poorer first grade social skills, but controlling for maternal sensitivity and classroom quality the effects were limited (National Institute of Child Health and Human Development Early Child Care Research Network, 2003). Distal structural variables should predict child adaptation to the school transition less powerfully than appropriately selected proximal relationship variables.

If dysfunctional parent-child interactions and maternal warmth and responsiveness moderate the impact of the school transition, we expect associations between these variables and child adrenocortical regulation to emerge that are not present in the absence of a uniform challenge. Maternal employment, household composition, and the density of the child’s schedule also may be social regulators of adrenocortical activity. Yet available data suggest that these more structural and distal variables serve as markers for general logistical strain that children and families consistently must cope with, rather than specifically moderating child adaptation during a period of challenge.

Morning Versus Evening Cortisol as a Stress Marker

The possibility that ecological influences on the social regulation of cortisol vary by context highlights an important challenge in psychobiology research. Adrenocortical arousal flowing from interactions between the individual and his/her context range from rapid and fleeting to subtle and persistent. It is often unclear a priori whether a particular ecological variable will be have a strong impact on an acute or chronic time scale, or both.

Differences between early morning and late evening HPA activity can help distinguish between the effects of chronic stress and acute novelty or social challenges. In adults, the cortisol awakening response (CAR), or magnitude of the early morning rise in cortisol, is moderately to highly stable across several weeks at least (Pruessner et al., 1997), and correlates with chronic stress. For example, lower socioeconomic status (Kunz-Ebrecht, Kirschbaum, Marmot, & Steptoe, 2004), chronic work overload and worry on workdays (Schlotz, Hellhammer, Schulz, & Stone, 2004), and worries, social stress or lack of social recognition in general (Wust, Federenko, Hellhammer, & Kirschbaum, 2000) each are associated with higher CAR. Studies regarding children are sparse. Higher early morning cortisol, and no significant difference in evening cortisol, has been reported in low SES primary school children and those with immigrant parents (Gustafsson, Gustafsson, & Nelson, 2006; Lupien et al., 2001); this measure is, however, not strictly equivalent to the awakening response. Greater trait anger, although not trait anxiety or depression, has been reported in adolescents with a higher CAR (Adam, 2006).

CAR also is responsive to daily variation in mood and subjective experience. In two studies, CAR was larger on work than on weekend days, mediated by chronic work overload, worrying, and/or perceived lack of control in the work context (Kunz-Ebrecht et al., 2004; Schlotz et al., 2004). Adam and colleagues have reported that prior day feelings of loneliness, sadness, or being overwhelmed in older adults predict a larger CAR. The CAR functions as a physiological “boost” for the upcoming day based on anticipated demands (Adam et al., 2006). Since expectancies regarding demands that will be encountered in specific social contexts are entrained by experiences that may span days, months or years, the stability of CAR and its association with chronic stress fit well within an anticipated demands framework.

By contrast, the HPA axis is highly subject to acute stimulation near the nadir of its diurnal rhythm in the evening (Dallman et al., 1992; Kertes & Gunnar, 2004), and stability across evening measurements is very low (Pruessner et al., 1997). While this instability can impede interpretation (Kertes & Gunnar, 2004), it also provides an opportunity to assess the impact of quotidian experience. For example, unlike CAR, same day feelings of anger and tension predict higher evening cortisol (Adam et al., 2006). Uses of evening cortisol to assess the impact of concurrent daily experience in children include reports of heightened late afternoon or early evening cortisol following family conflict (Flinn & England, 1995), and showing that changes in evening cortisol over the first 5 days following school entry depend on child temperament (Davis et al., 1999). In contrast to CAR, evening cortisol appears to index accumulated psychosocial demands on a particular day (Adam et al., 2006).

In sum, extant literature supports a distinction between an evening cortisol measure with acute sensitivity to changes in affect driven by current social context, and a more stable CAR nonetheless responsive to anticipated demands as guided by prior experience. If this distinction is valid for children, as in adults, the effects of a novel challenge such as school entry will be evident first in evening cortisol. CAR, while modifiable with sustained changes in perceived landscapes of risk and daily psychosocial demand, should remain comparatively stable while children and their families establish a new social-ecological equilibrium.

The Present Study

The present study followed a cohort of children from late in pre-kindergarten (pre-K; Time 1) through the beginning of a new school year (Time 2). We aim to extend existing literature on the role played by family structure and family
relations in child adaptation, before and after the developmentally important challenge of school entry, using evening cortisol and CAR as two distinct psychobiological markers of children’s response to daily experience. At each time, parents collected saliva samples and recorded detailed time diaries for the focal child. We tested three hypotheses:

First, higher quality parent–child interactions should be associated with improved child adaptation and family coping during the school year transition, and hence diminished HPA activation. We hypothesized that higher maternal warmth and responsiveness, and less maternal stress from mother-child dysfunctional interactions, would correlate with lower evening cortisol during the early weeks of the new school year. We did not expect a correlation prior to school onset, nor did we expect a correlation with the less acutely sensitive CAR.

Second, dense child schedules and family structures that increase scheduling burden may yield high anticipated and realized daily demands, but we do not expect these to be linked specifically to the school year transition. Hence, we hypothesized that both at Time 1 and Time 2, dense child schedules, maternal employment, and single parent status would be associated with a larger cortisol awakening response and higher evening cortisol.

Third, as a corollary of the first hypothesis, when evaluating factors that contribute to the social regulation of adrenocortical activity, the distinction between chronic and acute effects should be least evident during social-ecological stability, and most evident during an acute challenge. Hence, we hypothesized that at Time 1, but not at Time 2, evening cortisol and CAR would be associated with the same elements of the social ecology.

METHODS

Participants

Thirty-eight families in metropolitan Atlanta were recruited through letters sent home at preschool programs for a broader study of child developmental ecology reported elsewhere (DeCaro & Worthman, 2007); of these, 32 (84%) were retained through the school transition. However, four families were ineligible for this analysis, due to sample timing that fell outside the late/early school year paradigm, use of asthma medications that may confound cortisol measures, or home schooling. All children attended pre-K programs (regular or Montessori) at Time 1, and regular kindergarten or Primary Montessori classrooms at Time 2. Twenty children lived with married parents, and eight with a single mother. At Time 1, median child age was 60.1 months, range 53.7–67.3 months; and at Time 2, Medn = 67.3 months, range 61.6–73.2 months. At both times, mothers were employed or in school at least 20 hr per week in 10 (50%) of the married families. However, at Time 1 all single mothers were employed or in school, whereas at Time 2, 6 of 8 were employed (75%). Median household income was $64,000, range $17,184–$175,000. Twenty-one mothers (75%) had a 4-year college degree or higher. Among the 28 children, 20 (71%) were identified by their parents as non-Hispanic White, 6 (21%) as African American, 1 (4%) as Hispanic, and 1 (4%) as “Other.” Volunteers were paid for participation.

General Procedure

Interviewers visited participants in their homes throughout 1 week between January and May of the child’s pre-K year (Time 1), and again 3–12 weeks into the subsequent school year (M = 52 days, range = 22–83 days; Time 2). During each week, interviewers first trained participants in saliva collection and daily schedule recording. Then, at three follow-up visits, interviewers retrieved saliva samples and daily schedule data. During the final visits for each week, children completed the Parent-Child Relationship scales of the Berkeley Puppet Interview (Ablow & Measelle, 2003; Cowan, Cowan, Ablow, Johnson, & Measelle, 2005; Pike, Coldwell, & Dunn, 2005), among others. Parents completed the Parenting Stress Index Short Form (PSI/SF; Abidin, 1995) at both times and the MacArthur Health and Behavior Questionnaire (HBQ; Essex et al., 2002) at Time 2. Follow-up calls prior to the end of the fall semester were used to fill in partially missing HBQ data for three families. Additional procedures not considered in this analysis are ethnographic interviews and a vagal reactivity protocol.

Saliva Collection and Handling

At Times 1 and 2, parents collected unstimulated saliva samples from their child immediately after awakening (+0 min), 30 min post-awakening (+30 min), and at 19:00 hr (7 p.m.) across 7 contiguous days. Salivette collection devices (Sarstedt, Germany), all from a single lot, were used. Parents used provided electronic timers to ensure 60 s chewing on the swab, and to time the interval between the +0 and +30 min samples. Parents stored samples in their home freezer until collection at the next visit, after which samples were transported on ultra-low cold packs to a −25°C laboratory freezer. Participants were instructed not to eat, drink, or brush their teeth during the 10 min prior to collection, and to discard samples if the +0 min sample was missed by more than +5 min, the +30 min sample was missed by more than ±5 min, or the 7 p.m. sample was missed by more than ±1 hr. Participants wrote exact sampling and wake times on a record sheet. Additional days were collected if the record indicated fewer than 5 complete days sampled, although some families provided fewer useable samples due to contamination or insufficient swab saturation. Only weekday samples are considered here.

Cortisol Analysis

Salivary cortisol laboratory analysis was completed by staff of the Laboratory for Comparative Human Biology (Emory University Department of Anthropology, Atlanta, GA). A competitive high sensitivity enzyme linked immunoassay kit (Salimetrics #1-0102/1-0112, State College, PA) was used for the quantitative determination of cortisol in saliva. Assay sensitivity, defined as the quantity of unlabeled hormone...
required to inhibit binding of tracer by an amount equal to 2 SD below the mean binding observed in the absence of unlabeled hormone, is .007 μg/L. Inter-assay CVs were 5.64% for the high control (M = 1.04 μg/dL) and 19.94% for the low control (M = .11 μg/dL). Intra-assay CVs were 6.20% and 4.31%, respectively.

Schedule Density
The Daily Life Architecture (DLA) approach to tracking daily experience, described in detail elsewhere (DeCaro & Worthman, 2007), was used to determine the “density” of each child’s schedule. Briefly, PROUST for PalmOS is a customizable, icon-based program for Personal Digital Assistants that scaffolds self-report through a cascade of menus comprising categorical options from which users may select. Participants were prompted thrice daily to reconstruct activities, physical settings, companions, and moods for each 15 min since the last update, creating a 24 hr, 7-day record. Mothers and fathers completed records for themselves, and jointly for the focal child. Child weekday schedule density is his/her average frequency of transitions per hour across the entire day between any physical settings (e.g., home to school, one store to another). Missing data were imputed from the average number of transitions per 15 min block within the same 3 hr time band across all other weekdays. However, only 2.7% of 15-min segments at Time 1 and .2% at Time 2 were missing across the total pool of DLA records for mothers, fathers, and children. The improvement came from enhanced data review procedures and participant familiarity with the task.

Parenting Stress Index
The Parenting Stress Index Short Form (PSI/SF) gauges distress related to the experience of parenting, and is a 36-item subset of the full Parenting Stress Index generated through exploratory factor analysis and separately validated in diverse samples (Abidin, 1995; Reitman, Currier, & Stickle, 2002; Whiteside-Mansell et al., 2007). Items are rated on a 5-point scale, 1 (strongly disagree) through 5 (strongly agree), or item-specific. The PSI/SF comprises three 12-item scales: Parental Distress, Difficult Child, and Parent-Child Dysfunctional Interactions (PCDI). High P-CDI indicate perceived non-reinforcing interactions with the child and a weak parent-child bond, including alienation from and/or rejection by the child (e.g., “My child smiles at me much less than I expected”), P-CDI is valid and frequently used separately from other PSI/SF scales to assess stress caused by the parent-child relationship, by contrast to the temperamental or parental factors captured by Difficult Child and Parental Distress (Whiteside-Mansell et al., 2007). Hence, only scores on the P-CDI scale are considered here. P-CDI scores were converted into percentiles according to published norms prior to analysis (Abidin, 1995).

Berkeley Puppet Interview
The Berkeley Puppet Interview is an age-appropriate puppet-mediated psychobehavioral interview that assesses 4.5- to 7.5-year-old children’s self-perceptions through an exchange with two identical, non-threatening dog puppets. Puppets describe themselves using bipolar options (e.g., “My mom says she loves me”/“My mom doesn’t say she loves me”), and encourage the child to identify him/herself as more similar to one or the other. Responses are coded on a 7-point scale, from 1 (strong negative) through 7 (strong positive). The Parent-Child Relationship Scales assess children’s perception of parents’ affect, responsiveness, and emotional availability; scales are independently valid (Ablow and Measelle, 2003; Cowan et al., 2005; Measelle, Ablow, Cowan, & Cowan, 1998; Pike et al., 2005). Although maternal care is often construed to include both warmth and responsiveness (Chorpita & Barlow, 1998), variance in BPI Mother Responsiveness scores was so restricted as to render that scale unusable. Hence, raw scores on the 6-item Mother Positive Affect: Warmth and Enjoyment scale were selected for this analysis, based on maternal warmth’s reported role in reducing childhood anxiety and enhancing the development of social competence (Chorpita & Barlow, 1998; Repetti et al., 2002).

Health and Behavior Questionnaire
To control for individual variation in social and academic competence at Time 2, Academic Functioning, Peer Relations, Social Withdrawal, and Prosocial Behavior scales from the Parent-Report MacArthur Health and Behavior Questionnaire (HBQ) were employed (Armstrong, Goldstein, & The MacArthur Working Group on Outcome Assessment, 2003; Essex et al., 2002). Raw scores are used, based on item means within each scale. Possible scores range from 1 to 5 for Academic Functioning (AF; 16 items), 1–4 for Peer Relations (PR; 11 items), 0–2 for Social Withdrawal (SW; 9 items), and 0–2 for Prosocial Behavior (PB; 20 items). Higher scores represent better adaptation, except for social withdrawal which is reversed. While AF, PR, and SW can be calculated as the mean of two subscales, only PR reaches acceptable internal consistency by that method. Hence, all scales were calculated as the mean of individual items,1 which yields Cronbach’s α from .76 to .95 (Armstrong & Goldstein, 2003).

Statistical Procedures
Given limited power due to the small sample, and the risk of model overfitting, statistical procedures were designed to minimize the number of covariates included in any single analysis. Bivariate associations were evaluated between dependent variables (Time 1 and Time 2 CAR and evening cortisol) and each of the five proposed ecological predictors from that same year (child schedule density, maternal employment, single parent status, PSI/SF P-CDI, and BPI maternal warmth). Correlations with cortisol also were computed for child age, and at Time 2 only, HBQ scores and number of days post school entry, given their special interest as possible confounders in the early/late school year paradigm. Linear models were constructed when multiple ecological independent variables correlated with

1Note, however, that correlations between HBQ scales computed each way in the present sample exceeded r = .95 in all cases, and the method of calculation does not materially affect the results.
the same dependent variable, to evaluate whether any one held clear predominance as a predictor. For Time 1 multivariate analyses involving both, single parent status and maternal employment were dummy coded as a three-level categorical variable, since all single parents were employed. Finally, the following variables were entered into models one at a time, to rule out confounding: maternal employment, single parent status, child age, maternal education, and household income; for CAR only, mean awakening time as determined through DLA data; and for Time 2 only, HBQ scores and days post school entry. This final procedure is conservative in relation to our hypotheses. Although it generates some risk of Type I error by increasing the number of comparisons, such error is biased toward uncovering apparent confounding effects that undermine our interpretations; no independent variables are accepted as significant predictors based on multivariate modeling alone. All analyses were completed using Intercooled Stata 9.1.

RESULTS

Descriptive Statistics

Means, standard deviations, and ranges for salivary cortisol levels at awakening +0 min, +30 min, and 7 p.m., and the cortisol awakening response calculated as +30 min – +0 min, are shown in Table 1. An average net increase over the first 30 min post-awakening was exhibited by 19 participants (68%) at Time 1 and 26 participants (93%) at Time 2. All children in both years exhibited a diurnal decrease from morning to evening, but the magnitude of this decrease varied considerably. CAR was normally distributed. However, evening cortisol values were expectably right-skewed, and thus were log-transformed prior to analyses.

Means, standard deviations, and ranges for maternal warmth, dysfunctional interactions, and child schedule density also are shown in Table 1. Maternal warmth scores were neither normally distributed nor continuous: at Time 1, there were 10 discrete values across the sample with a skew toward high values, and at Time 2, only 6. Therefore, maternal warmth is treated in this analysis as an ordinal variable. One child participant at Time 1, and two at Time 2, did not provide sufficiently complete answers to BPI queries for maternal warmth to be calculated. Hence, only for those analyses involving maternal warmth, n = 25.

The mean Parent-Child Dysfunctional Interaction score at Time 1 represents the 35th percentile, and at Time 2 the 45th percentile, compared to published norms (Abidin, 1995). Only one mother at Time 1 (3.5%), and two mothers at Time 2 (7%), exhibit scores above the 90th percentile. Child schedule density was normally distributed. The mean density, .23, did not change between Time 1 and 2, and equates to M = 5.5 physical setting transitions per day.

For Time 2, HBQ scores are displayed in Table 1. Scores on all scales are similar to published norms (Armstrong, Goldstein, & The MacArthur Working Group on Outcome Assessment, 2003; Essex et al., 2002), suggesting age-appropriate adaptation during the early months of school. One family at Time 2 did not provide sufficiently complete answers for Academic Functioning to be calculated, so for those analyses involving HBQ-AF, n = 27.

Intercorrelations Among Ecological Variables and Stability of Measures

Zero-order correlations among child and ecological variables are shown for Time 1 in Table 2, and for Time 2 in Table 3. There were no significant relations between ecological variables and child age, although a non-significant trend toward better HBQ scores for older children is evident at Time 2. At Time 2, there are several
significant correlations in expected directions among the HBQ social scales, dysfunctional interactions, and maternal warmth. Overall, strong associations that impede planned analyses were absent.

All physiological and ecological variables except evening cortisol and maternal warmth were moderately to highly stable across the 4–10 months between measurements. The magnitude of CAR was moderately stable between Times 1 and 2, \( r(26) = .43, p < .05 \). Evening cortisol expectably showed no stability, \( r(26) = -.18 \), ns. Dysfunctional interactions were highly correlated across the school years, \( r(26) = .68, p < .001 \). Child schedule density was also stable, \( r(26) = .59, p < .001 \). Maternal warmth was unrelated between Times 1 and 2, \( \rho(23) = .21 \), ns. No family changed marital status, although one couple had recently separated. Six mothers changed employment status, with 4 becoming non-employed and 2 becoming employed.

**Bivariate Relations Between Child or Ecological Variables and Cortisol**

Bivariate relations between cortisol and those child or ecological variables measured at both times are displayed in Table 4. Zero-order correlations between Time 2 cortisol and recency of, or functioning following school entry are displayed in Table 5.

**Cortisol Awakening Response at Time 1.** At Time 1, higher mean CAR was associated with higher child density, \( r(26) = .49, p < .01 \), maternal employment, \( t(26) = 2.22, p < .05 \), and single parent status, \( t(26) = 2.48, p < .05 \). No associations with maternal warmth, child age, or dysfunctional interactions were found. Year 1 CAR varied by family structure: for children with employed mothers, \( M = .16, SD = .15 \); with non-employed mothers, \( M = .03, SD = .14 \); with married mothers, \( M = .07, SD = .14 \); and with single mothers, \( M = .22, SD = .16 \).

**Evening Cortisol at Time 1.** At Time 1, higher mean evening cortisol levels were found in children of employed mothers, \( t(26) = 3.73, p < .001 \), and of single parents, \( t(26) = 2.25, p < .05 \). No other associations were found. Untransformed year 1 evening cortisol for children with employed mothers had \( M = .07, SD = .03 \); with non-employed mothers, \( M = .04, SD = .02 \); with married mothers, \( M = .05, SD = .03 \); and with single mothers, \( M = .08, SD = .03 \).

**Cortisol Awakening Response at Time 2.** At Time 2, higher mean CAR was found in children of employed mothers, \( t(26) = 2.36, p < .05 \). No other associations were found. For children with employed mothers, \( M = .25, SD = .04 \); non-employed mothers, \( M = .10, SD = .04 \).

**Evening Cortisol at Time 2.** At Time 2, higher mean evening cortisol levels were associated with lower maternal warmth, \( \rho(23) = -.42, p < .05 \), and higher dysfunctional interactions, \( r(26) = .56, p < .01 \). Higher mean evening cortisol was also associated with fewer days since school entry, \( r(26) = -.44, p < .05 \), poorer academic functioning, \( r(25) = -.46, p < .05 \), and marginally

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**Table 2. Zero-Order Correlations Among Child and Ecological Variables at Time 1**

<table>
<thead>
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<th>1</th>
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<th>4</th>
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<tr>
<td>(3) PSI/SF P-CDI</td>
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*Note: All statistics are Pearson *r*, except correlations involving BPI maternal warmth, which are Spearman *ρ*. *p < .05.*

**Table 3. Zero-Order Correlations Among Child and Ecological Variables at Time 2**

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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) HBQ peer relations</td>
<td>—</td>
<td>-.27</td>
<td>.57**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) HBQ social withdrawal</td>
<td>—</td>
<td>-.49**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) HBQ prosocial behavior</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: All statistics are Pearson *r*, except correlations involving BPI maternal warmth, which are Spearman *ρ*. *p < .05. **p < .01.*
Table 4. Bivariate Relations Between Child or Ecological Variables and Cortisol

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1 CAR</th>
<th>Log T1 PM Cort.</th>
<th>T2 CAR</th>
<th>Log T2 PM Cort.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPI maternal warmth</td>
<td>.01</td>
<td>-.20</td>
<td>-.36</td>
<td>-.42*</td>
</tr>
<tr>
<td>Child age</td>
<td>-.12</td>
<td>.23</td>
<td>.14</td>
<td>-.33</td>
</tr>
<tr>
<td>PSI/SF P-CDI</td>
<td>-.10</td>
<td>-.08</td>
<td>.03</td>
<td>.56**</td>
</tr>
<tr>
<td>Child density</td>
<td>.49**</td>
<td>.18</td>
<td>.18</td>
<td>.24</td>
</tr>
<tr>
<td>Maternal employment</td>
<td>2.22*</td>
<td>3.73***</td>
<td>2.36*</td>
<td>-.31</td>
</tr>
<tr>
<td>Single parent</td>
<td>2.48*</td>
<td>2.25*</td>
<td>1.09</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Note: Values represent Spearman ρ for ordinal variables, Pearson r for continuous variables, and independent samples t for dichotomous variables. For dichotomous variables, positive r indicates higher values of the dependent variable in the presence of the condition evaluated.

* p < .05.
**p < .01.
***p < .001.

with poorer peer relations, r(26) = -.34, p < .10. No other associations were found.

Multivariate Models

Linear models were constructed containing only hypothesized ecological predictors of child cortisol that displayed significant bivariate associations. In the model predicting Time 1 CAR, R² = .37, F(3, 24) = 4.70, p < .05; single parent (B = .14, SE B = .07, p < .05) and child density (B = 1.24, SE B = .55, p < .05) remained significant, while maternal employment in dual parent homes did not (B = .03, SE B = .06, ns). In the model predicting Time 1 evening cortisol, R² = .37, F(2, 25) = 7.30, p < .01; single parent (B = .72, SE B = .20, p < .01) and dual parent maternal employment (B = .54, SE B = .19, p < .01) remained significant.

Predicting Time 2 evening cortisol, R² = .49, F(2, 22) = 10.60, p < .001; dysfunctional interactions remained significant (B = .012, SE B = .003, p < .01), while maternal warmth faded to a marginal trend (B = -.32, SE B = .19, p = .099). However, in bivariate analyses, maternal warmth was treated as an ordinal variable, and its association with year 2 evening cortisol was identified using nonparametric statistics. Hence, a partial Spearman ρ controlling for ranked dysfunctional interactions scores was also calculated, and in this test the effect of maternal warmth was undiminished, ρ(23) = -.45, p < .05.

Next, maternal employment and single parent status (if not already included), child age, maternal education, household income, and, for CAR only, mean awakening time were entered into each model one at a time, to search for evidence of confounding or significant interactions. No such effects were found. Finally, HBQ scores and days post school entry were entered into the Time 2 models. No confounding was identified; however special attention is warranted to variables that had significant or marginal zero-order correlations with Time 2 cortisol (days post school entry, academic functioning, and peer relations).

When adding days post school entry to the model predicting Time 2 evening cortisol, R² = .50, F(3, 21) = 7.03, p < .01; the effect of dysfunctional interactions remained unchanged (B = .012, SE B = .003, p < .01), whereas days post school entry (B = -.004, SE B = .006, ns) and maternal warmth (B = -.27, SE B = .21, ns) were not significant. Adding academic functioning to the model produced similar results, R² = .48, F(3, 20) = 6.24, p < .01; dysfunctional interactions retained its significant effect (B = .012, SE B = .003, p < .01), but not academic functioning (B = -.044, SE B = .18, ns) or maternal warmth (B = -.31, SE B = .20, ns). Finally, adding peer relations into the model, R² = .49, F(3, 21) = 6.81, p < .01; dysfunctional interactions was significant (B = .013, SE B = .004, p < .01), but peer relations (B = .089, SE B = .27, ns) and maternal warmth (B = -.34, SE B = .20, ns) were not. In sum, only dysfunctional interactions had a robust, independent association with Time 2 evening cortisol, controlling for other ecological correlates. Nevertheless, the regression coefficients and error terms for BPI maternal warmth were

Table 5. Zero-Order Correlations Between Recentness of and Adaptation to School Entry and Time 2 Cortisol

<table>
<thead>
<tr>
<th>Variable</th>
<th>T2 CAR</th>
<th>Log T2 PM Cort.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days post school entry</td>
<td>-.36</td>
<td>-.44*</td>
</tr>
<tr>
<td>HBQ academic functioning</td>
<td>-.37</td>
<td>-.46*</td>
</tr>
<tr>
<td>HBQ peer relations</td>
<td>-.02</td>
<td>-.34†</td>
</tr>
<tr>
<td>HBQ social withdrawal</td>
<td>-.17</td>
<td>-.18</td>
</tr>
<tr>
<td>HBQ prosocial behavior</td>
<td>.01</td>
<td>-.18</td>
</tr>
</tbody>
</table>

* p < .05.
† p < .10.
nearly identical across models. Hence, even for this weaker effect, there is no evidence that the recentness of school entry or child academic and social competence acted as confounders.

DISCUSSION

This study examines the role of family ecology in children’s adrenocortical activity within the range of normative, rather than traumatic, experience. Cortisol regulation is embedded in the activities of everyday life. Return to school is a highly predictable, minor life event that nonetheless perturbs these everyday activities, challenging child and family adaptive capacity. We found that, shortly following this perturbation, qualities of the mother-child relationship became key correlates of the context-sensitive evening cortisol measure. Yet, they were not important to Time 1 evening cortisol prior to the challenge, or to CAR at Time 1 or Time 2, which were instead associated with structural and logistical features of family life (maternal employment, single parent status, and/or child schedule density). Family structure in turn was not related to evening cortisol activity during the early months of the new school year.

Evaluating Hypothesis 1: Mother-Child Relations and PM Cortisol Following School Entry

We hypothesized that warm parenting and low parent-child dysfunction would be associated with lower evening cortisol following the transition into a new school year. This hypothesis was affirmed whether relying on simple correlations, or in regression models controlling for the effects of time since school entry, academic functioning, or peer relations. The correlation between maternal stress from parent-child dysfunctional interactions and year 2 evening cortisol was particularly robust. Further, since the quality of the mother-child relationship moderates the impact of the normative challenge of school entry, we expected—and found—that the association with evening cortisol would emerge only at Time 2.

Pendry and Adam (2007) recently reported a steeper diurnal cortisol slope for kindergarteners and adolescents experiencing higher maternal parenting quality, a measure comprising maternal warmth and involvement. This effect was driven by lower bedtime cortisol; there were no morning cortisol differences by parenting quality (although there were morning differences by marital functioning). The authors proposed that high quality parenting may moderate children’s capacity to cope with daily demands. Our data support that interpretation. We extend it by suggesting that family coping resources will preferentially emerge as a predictor of children’s HPA activity when a concurrent ecological challenge tests coping capacity.

Evaluating Hypothesis 2: Logistical Strain/ Scheduling Load and Cortisol

We also hypothesized that high child schedule density, or family structural features that increase logistical complexity by reducing the availability of parent “staffing,” would yield higher CAR via greater anticipated daily demands, and higher evening cortisol via greater realized daily demands. This hypothesis was only supported at Time 1. Consistent with expectations, children living with single or employed mothers had higher Time 1 CAR and Time 1 evening cortisol, and children with the most mobile daily activity patterns (high schedule density) had higher CAR at Time 1. Greater morning adrenocortical activation that anticipates a busy or logistically complex schedule is consistent with CAR’s role as a preparatory “physiological boost” (Adam et al., 2006).

At Time 2, however, these effects disappeared except for the association of CAR with maternal employment. In a similar vein, Lupien et al. (2001) have reported that the association between poverty and basal cortisol in children is not stable across time, disappearing after high school entry. These findings fit with current developmental theory emphasizing that ecological factors differ in their relations with child outcomes depending on the time and circumstances of measurement (Adam et al., 2007), and that social address has a less consistent relationship with child outcomes than proximal processes (Bronfenbrenner, 1986; National Institute of Child Health and Human Development Early Child Care Research Network, 2003). As social ecologies shift with school entry, children’s development increasingly becomes centered around teachers, peer groups and non-home contexts (Boyce et al., 1998). Hence, such interactions, together with family function, may have shaped daily demands at Time 2 more profoundly than family structure. However, we do not have the data to confirm this proposal, nor to rule out the possibility of statistical artifact.

Evaluating Hypothesis 3: CAR and PM Cortisol Concordant at Time 1, Discordant at Time 2

The third hypothesis stems from the interpretation of CAR as a marker of anticipated demands and chronic stress, and evening cortisol as a marker of concurrent demands. If this distinction holds for young children, we predicted that during a period of social stability the fit should be strong between CAR and evening cortisol. During a challenging transition ecological predictors of CAR and evening cortisol are likely to become discordant until a new
social-ecological equilibrium is established. Consistent with these expectations, at Time 1, 2 of the 3 ecological predictors of higher CAR also were associated with higher evening cortisol. At Time 2, there was no overlap between CAR and evening cortisol. Moreover, consistent with prior reports, CAR was stable across Times 1 and 2, whereas evening cortisol was not. These findings parallel an expanding adult literature demonstrating that morning and evening adrenocortical activity provide different and dissociable information regarding the psychobiological impact of quotidian experience (Adam et al., 2006).

Limitations

This research was limited by its small and self-selected sample, risk of sampling bias, and narrow variation with respect to key variables. The high level of involvement for each family, which required intensive interviewer effort, made it necessary to spread Time 2 measurements across several weeks, yielding challenges of interpretation. We also have not assessed temperamental effects, nor effects of differences among the particular school environments to which each child was exposed.

Our interpretations beg the question of whether the school transition remained an ongoing challenge through the first 3 months post entry. We recognize, for instance, that social groups coalesce sufficiently during the first 5 weeks of preschool that associations between temperamental cortisol already have shifted relative to a week 1 baseline (Gunnar et al., 1997). Yet one alternative explanation for the patterns of association seen in this study can largely be eliminated: better academic and social functioning are associated with lower evening cortisol, but these variables do not confound the independent effect at Time 2 of mother-child relationship quality. Moreover, if children’s adaptation to school entry were largely complete at the study’s outset, we would not expect evening cortisol to decline linearly with greater time since school entry, as is the case here. The linear decline was not limited to children measured first (r = -.30 for the 14 children measured before Day 51; r = -.46 for the 14 measured after). Nevertheless, data for the spring semester of the kindergarten year would be required to clearly distinguish the challenge of school entry from kindergarten as a persistent shift in the child’s social ecology.

Shifting associations between ecological variables and cortisol activity also raise the important question of the validity of the cortisol assessments. Data for the sample as a whole reflect the circadian pattern of cortisol secretion expected by the late preschool years, and similar absolute morning and evening values to those previously reported (Gunnar & Donzella, 2002). Magnitude, shape, and stability of the CAR was as expected, given the ages of the children in this sample. The circadian pattern is both more pronounced and more consistent at Time 2, with nearly all participants showing a net morning increase, a larger mean CAR, and a larger average decline from +30 min to 7 p.m. levels. Such changes reflect continuing development of the HPA axis into the late preschool years (Gunnar & Donzella, 2002). Considerable variability in the shape of the circadian rhythm is also expected, with some children showing zero decline or an increase across the day while at home or school (Watamura, Sebanc, & Gunnar, 2002), and most but not all children exhibiting a positive cortisol awakening response (Rosmalen et al., 2005). Our data also show continuity across the school year transition for adrenocortical regulation and nearly every measure of family ecology. The stability of CAR from Time 1 to Time 2, with r = .43, is comparable with previously reported stability of r = .39–.67 across days or weeks (Pruessner et al., 1997). These comparisons increase our confidence that our findings reflect the child-context-ecology interactions predicted by theory, rather than problems with the stability or validity of the physiological assessment. Nevertheless, given limited statistical power, null or shifting associations are particularly important to replicate.

Conclusion

Elevated adrenocortical activity is not inherently negative, but patterns of adrenocortical activity do show relations with individual differences in child adaptation. While such work has been primarily child-focused, the key role of the primary caregiver in regulating children’s HPA activity is well documented. In infants and young children, emotionally supportive and available primary caretakers buffer the child’s HPA response to naturalistic or experimental stressors such as separations and challenging peer interactions (Gunnar & Donzella, 2002). Later in childhood, lower evening cortisol levels are associated with maternal warmth and involvement and reduced family conflict (Adam et al., 2007; Chorpita & Barlow, 1998; Flinn & England, 1995; Repetti et al., 2002). The present study suggests that primary caregiver relationships and structures reflecting the management of daily life inside and outside the home are important social regulators of a child’s HPA activity surrounding school entry, particularly positive maternal affect and the absence of conflict in the mother-child relationship. If replicable, these findings warrant exploration as a possible psychobiological analogue to the important role family function plays in social adaptation and child self-regulation at school entry (Barth & Parke, 1996; Clark and Ladd, 2000; National Institute of Child Health and Human Development Early Child Care Research Network, 2003).
This study was designed to move past static associations between family ecology and child cortisol by examining interactions between multiple layers of context evaluated simultaneously (Bronfenbrenner, 1986). The first layer of context was the time of measurement, either the stable period during late winter or spring when family adaptations to preschool are well-established, or the period of challenge at the beginning of the following school year when children and their families must cope with the substantial novelty of kindergarten. The second layer of context was the combination of structural characteristics and markers of family function that collectively represent a child’s family ecology. Family structure, the architecture of daily life, and mother-child relationship quality each figured in the social regulation of HPA activity, but differentially so. This interaction between layers of context complements person-by-context interactions reported in the literature on child temperament and cortisol surrounding the school transition (Davis et al., 1999; Gunnar & Donzella, 2002; Gunnar et al., 1997), and exemplifies how multi-level approaches to context can guide intervention research by identifying key interactions of structural settings, everyday conditions, and psychobiological responses in the developmental pathways that lead toward differential well-being.

NOTES

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