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BRIEF REPORT

Preschoolers' Everyday Conflict at Home and Diurnal Cortisol Patterns

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Objective: Early life family conflict is associated with physical health problems later in life, but little is known about the biological pathways through which conflict at home exerts it deleterious effects on health. The goal of this study was to investigate the associations between naturalistically assessed conflict in everyday family environments and diurnal cortisol in preschool-aged children. ***Design:*** Forty-four children aged 3–5 from two-parent families provided six saliva samples per day over 2 days from a Saturday morning through Sunday night. For a full day on either Saturday or Sunday, children wore a child version of the Electronically Activated Recorder, a digital voice recorder that records ambient sounds while participants go about their daily lives. Parents provided reports of child externalizing behaviors as well as daily reports of child conflicts. ***Main Outcome Measures:*** Diurnal salivary cortisol over the two weekend days of the study. ***Results:*** Greater Electronically Activated Recorder-assessed child conflict at home was associated with children having lower cortisol at wakeup ($p < .009$) and flatter diurnal cortisol slopes ($p < .007$). These associations remained significant even after controlling for parent reports of child externalizing behaviors, parent reports of daily child conflicts, and child age and sex. ***Conclusion:*** These findings indicate that taking into consideration everyday conflicts at home may be key to our understanding of stress-health links in young children.

Keywords: Electronically Activated Recorder, families, conflict, cortisol, naturalistic, ecological momentary assessment

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Nearly a decade ago, Repetti and colleagues proposed that conflict at home is a hallmark of "risky" family environments that set the stage for physical health problems in adulthood (Repetti, Taylor, & Seeman, 2002). However, despite ample evidence that family conflict early in life is associated with physical health problems later in life (Miller, Chen, & Parker, in press), relatively little is known about the biological pathways through which conflict at home exerts it deleterious effects on health. One potential mechanism through which early life conflict may affect health in adulthood is via alterations in the activity of the hypothalamic-pituitary-adrenal (HPA) axis and its chief hormonal product, cortisol.

A large number of studies have demonstrated that fluctuations in daily cortisol patterns in response to the social environment emerge very early in childhood (for reviews, see Gunnar & Quevedo, 2007; Vermeer & van Ijzendoorn, 2006). A consistently replicated finding is that young children produce higher afternoon cortisol levels when they are in daycare compared with when they are at home (Vermeer & van Ijzendoorn, 2006). Previous research has examined problematic child behaviors (e.g., externalizing behaviors) that may moderate this effect (Alink et al., 2008). However, surprisingly, almost no studies have examined how young children's problematic behaviors *at home* (e.g., conflict with family members) impact diurnal cortisol.

Only one study to our knowledge has examined the links between family life and young children's diurnal cortisol rhythms when children are at home, showing that higher maternal parenting quality is associated with steeper diurnal cortisol slopes in kindergarteners (Pendry & Adam, 2007). However, no previous studies have directly examined the associations between young children's actual behaviors at home and diurnal cortisol. This study utilized a novel naturalistic assessment device called the Electronically Activated Recorder (EAR) to assess to preschoolers' everyday conflict in the family

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environment and its links to diurnal cortisol patterns. Further, we investigated whether naturalistically assessed conflict has incremental validity in predicting children's diurnal cortisol patterns above and beyond commonly used parent reports of children's externalizing behaviors and daily child conflict.

Method

In total, 44 two-parent families with 3- to 5-year-old children from Austin, TX, were recruited through local daycare centers and postings on *craigslist.com*.[1] The sample of children included 26 girls and 18 boys, with an average age of 4 years and 5 months (SD = 9.9 months). Annual household income ranged from $17,000 to $500,000, with a median of $80,000. The sample was 76.1% White, 17.0% Latino/Hispanic, 4.5% African American, and 2.3% other.

At a baseline data collection session, each parent completed the externalizing subscale of the Child Behavior Checklist (CBCL; Achenbach, 1991; $M = 9.61$, $SD = 5.74$, $\alpha = .45$). The following weekend, parents separately completed a two-item daily measure each day assessing whether or not they experienced (1) an argument with the target child and/or (2) tension/disciplinary problem with the child, each rated *no* = 0, *yes* = 1 (Bolger, DeLongis, Kessler, & Schilling, 1989; $M = 0.96$; $SD = 0.57$; $\alpha = .80$; range of 0 to 2).

On Saturday or Sunday, the target child wore an ambulatory naturalistic assessment device called the EAR (Mehl, Pennebaker, Crow, Dabbs, & Price, 2001) for a full day. The EAR records ambient sounds while participants go about their daily lives, giving researchers a window into everyday behaviors as they naturally unfold. The Child EAR used in this study (Sony model ICD-P320) was able to record for up to 19 hr in standard play mode (that limited EAR data collection to 1 day per child). The recorder was worn by the child inside a "special magic shirt" designed for the study that has a pocket with colorful cartoon characters on it, allowing the EAR to be "out of sight, out of mind." To standardize recording times across children, 150 randomly selected 30-s sound files were coded for each child. For this coding, we adopted the definition of conflict used in previous EAR studies (e.g., Holtzman, Vazire, & Mehl, 2010), which defined conflict as an interpersonal conflict, argument or fight (e.g., child: "*No! Uh uh! I don't want to!*"; parent: "*You are going to shut your mouth and be quiet!*"). Conflict was coded *no* = 0, *yes* = 1 for each sound file, indicating a conflict episode within that sound file ($M = 1.45$ conflict sound files per child, $SD = 2.65$, with a range in this sample of 0 to 10 out of a possible 150). Intercoder reliability was determined from a set of training recordings (235 30-s sound files) independently coded by the 20 research assistants who coded these data (ICC[2,K] = .92). EAR-coded conflict was significantly correlated with parent reports of daily parent–child conflict ($r = .37$, $p = .03$) but not correlated with parent reports of child externalizing behavior ($r = .23$, $p = .18$).

From Saturday morning through Sunday evening, parents collected saliva samples from their child at six time points each day: immediately upon wakening, 45 min later (before any eating, drinking, or exercise), at three semirandom beeped time points in the early evening (~5 p.m., 6 p.m., and 7 p.m., beeped with a Casio DataBank DBC-60 programmable watch), and then at bedtime. The timing of these samples corresponds to recommendations by the MacArthur Research Network on Socioeconomic Status and Health (MacArthur Foundation Network on Socioeconomic Status & Health, 2000) for researchers interested in diurnal cortisol rhythm profiles. Parents (trained at outset of the study) collected saliva from the child using Salivettes (Sarstedt 1534, Sarstedt Inc., Newton, NC). Cortisol levels were determined via luminescence immunoassay (IBL-International, Hamburg, Germany) at the laboratory of Dr. Clemens Kirschbaum at the Technical University of Dresden. To correct for positive cortisol skewness a natural Log_{10} transformation was performed and constant of 1 was added before transformation so that all values would be positive.

Because of the strong diurnal rhythm of cortisol, multilevel modeling (MLM) was used for data analyses. MLM allows researchers to simultaneously estimate multiple cortisol parameters (e.g., elevation of curve at waking, slope, and cortisol awakening response), and to predict individual differences in diurnal cortisol parameters from individual difference variables of interest as well as covariates (Hruschka, Kohrt, & Worthman, 2005). The MLM equations for used in our analyses may be found in the Supplementary online material (available online only) for this article.

Results

As shown in Table 1, greater EAR-assessed child conflict at home was associated with children having lower cortisol at wakeup ($p < .009$), a flatter diurnal cortisol slope ($p < .007$), and a reduced effect of Time^2 ($p < .03$)[2]; recent studies of adults indicate that flatter slopes are indicative of less "healthy" cortisol patterns (e.g., Kumari, Shipley, Stafford, & Kivimaki, 2011). The diurnal cortisol slopes of children high (1 SD) and low (−1 SD) in conflict are depicted in Figure 1. As shown in Model 2 of Table 1, the associations between EAR-assessed conflict, wakeup cortisol, and cortisol slope remained significant after controlling for child age, sex, wakeup time, and parent reports of child externalizing behaviors and daily child conflicts.[3]

Discussion

This study investigated the links between preschoolers' interpersonal conflicts at home and diurnal cortisol patterns. We found that preschoolers' daily conflicts measured by the Child EAR were associated with lower cortisol levels at wakeup and with flatter

[1] Previously published findings from this study (Slatcher, Robles, Repetti, & Fellows, 2010) focused on the links between parents' momentary work worries and their own salivary cortisol. The findings presented here relating to EAR-measured behaviors and child cortisol have not been published elsewhere.

[2] Currently, it is unknown whether the degree of curvilinearity (effect of Time^2) of the diurnal cortisol rhythm is meaningfully related to health outcomes (Adam & Kumari, 2009).

[3] We also conducted subsequent analyses to test associations with afternoon-evening cortisol slope, evening cortisol nadir, and area under the curve (AUCg and AUCi) and found no significant associations, meaning that EAR-assessed child conflict did not predict between-person differences in these other cortisol parameters over the 2 days of cortisol assessment. These analyses are described in the Supplementary online material (available online only) for this article.

Table 1
Time of Day, Daily Conflict (EAR-Measured), and Covariates Predicting Children's Cortisol in Everyday Life

Fixed effect (independent variable)	Coefficient (*SE*)	*t*-ratio	*p*	Effect size *r*
Model 1 (simple model with time of day and conflict)				
Intercept (average cortisol at wakeup), β00	0.864 (0.034)	25.52	<.001	
EAR-measured conflict, β01	−2.237 (0.816)	2.47	.009	.36
Average slope of time since waking, β10	−0.064 (0.010)	−6.19	<.001	
EAR-measured conflict, β11	0.593 (0.207)	2.86	.007	.40
Average slope of time since waking^2, β20	0.002 (0.001)	2.51	.016	
EAR-measured conflict, β21	−0.353 (0.015)	2.36	.023	.34
Average CAR, β30	−0.022 (0.041)	−0.53	.60	
EAR-measured conflict, β31	1.959 (1.640)	1.19	.24	.19
Model 2 (combined model including covariates)				
Intercept (average cortisol at wakeup), β00	0.999 (0.282)	3.54	<.001	
EAR-measured conflict, β01	−1.862 (0.829)	−2.25	.031	.34
Child sex, β02	0.030 (0.065)	0.47	.64	.08
Child age, β03	−0.002 (0.003)	−0.65	.52	.11
Wakeup time, β04	0.006 (0.026)	0.23	.82	.04
CBCL externalizing behavior, β04	−0.003 (0.004)	−0.75	.46	.12
Parents' daily reports of child conflict, β05	−0.075 (0.056)	−1.35	.19	.22
Average slope of time since waking, β10	0.008 (0.097)	0.08	.94	
EAR-measured conflict, β11	0.508 (0.229)	2.22	.033	.34
Child sex, β12	0.022 (0.018)	1.21	.24	.20
Child age, β13	−0.001 (0.001)	−0.78	.44	.13
Wakeup time, β14	−0.009 (0.009)	−0.94	.35	.15
CBCL externalizing behavior, β04	0.001 (0.001)	0.42	.68	.07
Parents' daily reports of child conflict, β05	0.014 (0.015)	0.97	.34	.15
Average slope of time since waking^2, β20	−0.004 (0.007)	−0.55	.58	
EAR-measured conflict, β21	−0.031 (0.017)	−1.77	.085	.28
Child sex, β22	−0.002 (0.001)	−1.60	.12	.25
Child age, β23	0.000 (0.000)	0.89	.38	.14
Wakeup time, β24	0.001 (0.001)	1.07	.29	.17
CBCL externalizing behavior, β24	−0.000 (0.000)	−0.48	.64	.08
Parents' daily reports of child conflict, β25	−0.001 (0.001)	−0.61	.54	.10
Average CAR, β30	0.779 (0.276)	2.82	.008	
EAR-measured conflict, β21	0.609 (1.596)	0.38	.70	.06
Child sex, β22	−0.197 (0.063)	−3.11	.004	.46
Child age, β23	−0.005 (0.004)	−1.27	.21	.20
Wakeup time, β24	−0.051 (0.034)	−1.49	.15	.24
CBCL externalizing behavior, β24	0.001 (0.006)	0.10	.92	.02
Parents' daily reports of child conflict, β25	0.013 (0.065)	0.20	.85	.03

Note. Intercepts indicate average cortisol values at wakeup; average slopes of time since waking indicate change in cortisol per 1-hr change in time; average slopes of time since waking^2 indicate change in cortisol per 1-hour change in time^2; CAR = Cortisol Awakening Response, indicating amount of change in cortisol during the 45 min after waking. For sex, Male = 0, Female = 1.

diurnal cortisol slopes. Further, these associations were independent of effects of parent reports of externalizing behavior, daily conflicts, and child age and sex.

Although previous work has demonstrated associations between children's externalizing behaviors and lower morning cortisol (Shirtcliff, Granger, Booth, & Johnson, 2005) and teacher reports of relationship conflict associated with cortisol increases during teacher–child interactions (Lisbonee, Mize, Payne, & Granger, 2008), this is the first study to our knowledge to suggest links between observed behaviors at home and diurnal cortisol patterns in children. Flatter diurnal cortisol slopes have been linked to negative health consequences in adulthood, including mortality (Kumari et al., 2011; Matthews, Schwartz, Cohen, & Seeman, 2006), and is a noted marker of allostatic load (McEwen, 2007). The findings reported here indicate that taking into consideration everyday conflicts at home may be critical to our understanding of stress-health links in normally developing young children. Conflict in families clearly lies across a continuum. These data, along with other data (e.g., Luecken, Kraft, & Hagan, 2009; Weidner, Hutt, Connor, & Mendell, 1992), suggest that gradations even in the low to middle end of the continuum may have implications for health.

Evaluating young children's at-risk social interactions at home has important implications for preventive intervention programs that aim to ameliorate the intergenerational transmission of psychopathology and its impact on physical health. Recent intervention research is encouraging, showing, for example, that atypical diurnal cortisol patterns of preschoolers in foster care can be altered (becoming comparable to nonfoster preschoolers) after a family based treatment intervention (Fisher, Stoolmiller, Gunnar, & Burraston, 2007). Our findings suggest that preschoolers' ev-

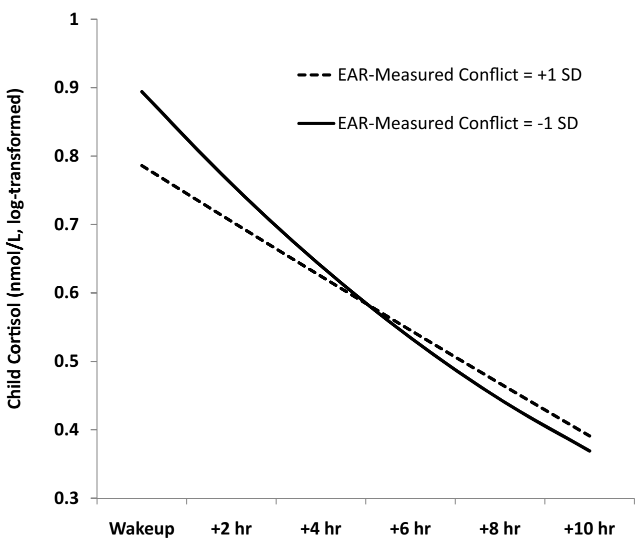

Figure 1. Effect of preschoolers' everyday conflict at home on their own diurnal cortisol rhythms. High values for EAR-measured conflict are plotted at 1 *SD* and low values plotted at −1 *SD* from the mean (Aiken & West, 1991).

eryday conflicts at home may be a key target for future intervention efforts.

Important trade-offs of the richness and ecological validity of this type of data include sampling limitations. Children in this study wore the EAR on only 1 day but provided saliva samples on 2 days, so that for some children, conflict behaviors predated half of the cortisol sampling (if the child wore the EAR on a Saturday), whereas for other children, half of the saliva sampling predated the conflict behaviors (if the child wore the EAR on a Sunday). We view the single day that children wore the EAR as a "snapshot" of each child's life during this period and treat it as a person-level variable, both theoretically and methodologically. This view is in line with other EAR research in which conflict coded from EAR data is aggregated and treated as a person-level variable and correlated with person-level factors (e.g., personality traits; Mehl, Gosling, & Pennebaker, 2006; Vazire & Mehl, 2008). The low base rate of conflict in everyday life effectively renders within-day analysis impossible without a considerably large sample size (noteably, conflict occurred in 1% of children's sound files in this study, more than twice the amount of conflict reported in adult EAR samples, e.g., Holtzman et al., 2010). Further, because the base rates of daily conflict reported in previous adult EAR studies have been very low, we made the decision at the outset of the coding process to create a single code for family conflict that taps into conflict between the target child and any family member (parents or siblings). Unpacking the nuances of the separate effects of daily parent–child conflict and conflict with siblings on child health and within-day analyses on the links between conflict and cortisol are key directions for future EAR research using larger samples and more days of EAR sampling. A second limitation of this study is the correlational nature of the data, which prevent firm causal inferences from being made. Additionally, the timing of our cortisol sampling and the number of sampling days (two) may not have optimally captured diurnal rhythm. Future work would benefit from including EAR and cortisol assessments over a greater number of time points, days, and waves, as well as electronic devices to monitor cortisol sampling compliance (e.g., MEMS caps). Finally, samples with greater diversity in cultural background, socioeconomic status, and family composition are essential to determine the generalizability of these findings.

Despite these limitations, this work represents a significant advance in generating an ecologically valid understanding of the links between everyday behaviors and health-related biological processes in young children. These findings indicate that preschoolers' everyday conflicts at home are predictive of less "healthy" diurnal cortisol rhythms, extending previous research demonstrating links between questionnaire reports of family relationship quality and child cortisol (Pendry & Adam, 2007). It should be noted that while diurnal cortisol dysregulation in childhood is hypothesized to be linked to poorer child health (Gunnar & Quevedo, 2007), the current empirical evidence for direct links between diurnal cortisol patterns and health outcomes is derived from adult samples (Kumari et al., 2011; Matthews et al., 2006).

This study is the first to our knowledge to show that young children's diurnal cortisol patterns are linked to discrete social behaviors in everyday life at home. Momentary and daily diary assessment is now a mainstay in studies of adults and adolescents (Conner, Tennen, Fleeson, & Barrett, 2009; Shiffman & Stone, 1998), but its use in studies of young children is comparatively much lower, undoubtedly in part because of young children's inability to complete self-report questionnaires. New methodological approaches such as the EAR may bring the number of health psychology studies of children's everyday lives more in line with that of adults, complementing other approaches to child health research.

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