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Los Angeles

Emotional and Physiological Responses to Mild Stress in Daily Life

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Psychology

by

Sunhye Bai

2017

ABSTRACT OF THE DISSERTATION

Emotional and Physiological Responses to Mild Stress in Daily Life

by

Sunhye Bai

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2017

Professor Rena L. Repetti, Chair

Chronic exposure to high levels of stress in childhood pose risk for mental health problems. However, the effects of mild daily stress on youth psychological functioning is poorly understood. The three studies in this dissertation utilize intensive repeated data (e.g., daily diaries) to examine how children react to and recover from minor negative events on the same day or the next day. The first study examined children's emotion reactivity to and recovery from school problems, and assessed their cross-sectional associations with internalizing and externalizing problems in 83 5th and 6th graders. Study used repeated ratings of school problems and positive and negative emotion completed several times a day over five consecutive weekdays. Youths reported more negative emotion and less positive emotion at school and at bedtime on days when they experienced more problems at school. Youths who tended to report more negative emotion on stressful days at school had more symptoms of depression, even after controlling for average levels of exposure to school problems. Youths who tended to recover by bedtime had fewer internalizing problems. The second study examined same day and next day

mood responses to school problems over the course of 40 consecutive weekdays in a sample of 47 8-13-year-old youths. On average, youths reported more negative mood and less positive mood on days that they experienced more school problems. School problems were not linked to mood on the next day. Children who tended to report more negative mood or less positive mood on days when they experienced more school problems showed more internalizing problems three years later when they were 11-17 years old. The third study used data from the same sample of 47 children to test the within-and between-person effects of daily negative events – peer problems, academic problems and interparental conflict – on diurnal cortisol, a physiological indicator of stress reactivity. Three indices of diurnal cortisol were derived from saliva samples collected four times a day across eight days: same day diurnal cortisol slope, same day bedtime cortisol, and cortisol at wakeup the next morning. On average, children who reported more peer problems showed flatter slopes of cortisol decline from wakeup to bedtime. However, children secreted more cortisol at wakeup following days when they reported more peer or academic problems than usual. Interparental conflict was not significantly associated with diurnal cortisol. In sum, this dissertation showcases a novel application of intensive repeated methods in developmental psychopathology research. Using this methodology, studies found individual differences in reactivity to and recovery from daily problems, which in turn were associated with youth internalizing problems.

The dissertation of Sunhye Bai is approved.

Tara S. Peris

Andrew J. Fuligni

Theodore F. Robles

Rena L. Repetti, Committee Chair

University of California, Los Angeles

2017

DEDICATION

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ACKNOWLEDGMENTS

VITA

EDUCATION

2010   M.P.H. in Public Health, **UC Berkeley**

2008   B.S. with College Honors in Physiological Sciences, **UCLA**

HONORS and AWARDS

2017   JCCAP Future Directions Launch Award

2015 – 2016   Dissertation Year Fellowship, UCLA

2013 – 2015   NIMH Health Psychology Training Grant, UCLA

2012 – 2013   Graduate Summer Research Mentorship Award, UCLA

2012 – 2013   Dr. Ursula Mandel Fellowship, UCLA

2011 – 2012   Distinguished University Fellowship, UCLA

2008   Maternal and Child Health Bureau Fellowship, UC Berkeley

SELECTED CLINICAL, TEACHING and RESEARCH EXPERIENCE

2016 – 2017   **Clinical Psychology Internship,** UCLA Semel Institute

2016   **Teacher Assistant**, UCLA Department of Psychology

2015 – 2016   **Therapist,** Alhambra Unified School District

2012 – 2016   **Therapist, Assessor and Student Supervisor,** UCLA Psychology Clinic

2011 – 2016   **Research Assistant**, UCLA Families and Health Study

2014 – 2015   **Therapist**, UCLA Student Counseling and Psychological Services

2013 – 2015   **Therapist and Assessor**, UCLA Childhood OCD, Anxiety & Tic Disorders Program

2012 – 2013   **Teacher Assistant**, UCLA Department of Psychology

2011 – 2013   **Research Assistant**, UCLA Center for the Everyday Lives of Families

PUBLICATIONS

Fuligni, A.J., **Bai, S**., Krull, J.L., & Gonzales, N.A. (under review). Individual Differences in Optimum Sleep for Daily Mood during Adolescence.

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Introduction

Learning how to navigate the ups and downs of daily life is an essential part of growing up. Children commonly encounter put downs by peers, difficult questions of school exams, and arguments between their parents during school years. While chronic exposure to high levels of stress exposure in childhood is detrimental to child mental health, mildly negative experiences of daily life are hard to avoid. Exposure to mild stress, such as peer or academic problems, likely provokes negative emotions and activates the hypothalamic-pituitary-adrenal axis, a physiological stress response system. However, such experiences may also create opportunities for children to practice regulation and recovery (Repetti & Robles, 2016). Whereas poor recovery of emotional and physiological regulatory systems in between stressful experiences lead to the accumulation of allostatic load (the wear and tear of regulatory systems), quickly recovering from a stressful event may prevent the stressful event from having a lasting negative impact on the child, increase the child's sense of mastery over challenging events, and reinforce effective coping skills (McEwen, 1998; Rutter, 2012). A close investigation of children's emotional and physiological responses to mildly stressful events during the hours to days that follow can inform our understanding of how such experiences influence psychological adjustment over the long term (Repetti, Robles, & Reynolds, 2011). The three studies that make up this dissertation use intensive repeated measures to examine how school-age children emotionally and physiologically respond to mild problems that arise in their daily lives. Studies apply daily diary methods to assess individual differences in how youths respond to mild problems in daily life, and examine their links to child mental health.

The differentiation between reactivity and recovery is a prominent feature in all three papers of this dissertation. The lingering effects of mild daily problems on mood and stress

physiology may reflect youths' ability to mobilize positive coping strategies in response to a negative event (Drake, Sladek & Doane, 2016). Children who tend to ruminate or express negative emotions by acting out may continue to report poor mood or secrete higher levels of cortisol. Although recovery has been studied in the laboratory setting wherein researchers observe and monitor a participant's affective and physiological responses to an acute stressor (e.g., public speaking in front of confederates), it has not been a prominent feature of diary research. This dissertation investigates reactivity and recovery using children's ratings of mood and diurnal cortisol secretion in daily life to extend our understanding of emotion regulation and its links to psychological adjustment.

Studies using intensive repeated methods have often focused primarily on within-person processes. Investigations of within-person processes, such as the daily effect of a school problem on parent-child interaction shed light on how the challenges of daily life may affect children's social and emotional development. However, the process by which short-term responses to stressful events accumulate to individual differences in psychological adjustment remains unclear. The knowledge gained from within-person analyses can be made more meaningful by examining their implications on youth psychological problems. This dissertation applies advanced multilevel statistical methods to relate within-person associations to between-person differences. Studies examine short-term reactivity to and recovery from naturally occurring stressors, and relate them to between-person differences in patterns of emotional or diurnal cortisol regulation as well as youth psychological functioning.

This dissertation consists of three studies. Study 1 utilizes data from the UCLA Family Development Study, for which 5th and 6th grade children completed five diary reports per day across consecutive days. No biological samples were collected from this sample. Studies 2 and 3

use data from the UCLA Families and Health Study. Children in this study completed daily diaries once per day across 56 consecutive days, and provided 4 saliva samples per day on 8 of those days (Saturday to Tuesday) for cortisol assays when they were between 8 to 13 years old. Youths returned for follow up assessments three years later. Study 1 examines daily associations between problems at school, and child positive and negative emotion at school and at bedtime on the same day. It derives individual measures of emotion reactivity and recovery, and examines their links to measures of child internalizing and externalizing problems. Study 2 extends the findings of Study 1. It assesses same-day and next-day associations between problems at school and child positive and negative mood, and derives individual measures of mood regulation based on within-person patterns. Then, it evaluates the prospective links between individual measures of mood regulation to youth internalizing and externalizing symptoms three years later. Study 3 examines children's diurnal cortisol responses to three specific negative events that can occur in daily life: academic problems, peer problems and interparental conflict. It studies stress regulation by examining links between each stressor type and several indices of diurnal cortisol at the within- and between-person levels of analyses.

Together, this dissertation looks to children's daily lives to understand how children react to and recover from minor problems at school and at home. Studies contribute to the current understanding of allostatic processes by examining short-term responses to stress, and relating them to between-person differences in emotion regulation, diurnal cortisol rhythm and psychological adjustment.

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STUDY 1

NEGATIVE AND POSITIVE EMOTION RESPONSES TO DAILY SCHOOL PROBLEMS:

LINKS TO INTERNALIZING AND EXTERNALIZING SYMPTOMS

Abstract

Objective: Examining emotion reactivity and recovery following minor problems in daily life can deepen our understanding of how stress affects child mental health. This study assessed children's immediate and delayed emotion responses to daily problems at school, and examined their correlations with psychological symptoms. **Method:** On five consecutive weekdays**,** 83 fifth graders (M=10.91 years, SD=0.53, 51% female) completed brief diary forms five times per day, providing repeated ratings of school problems and emotions. They also completed a one-time questionnaire about symptoms of depression, and parents and teachers rated child internalizing and externalizing problems. Using multilevel modeling techniques, we assessed within-person associations between school problems and negative and positive emotion at school and again at bedtime. Individual-level indices of emotion responses derived from multilevel models were correlated with youth psychological symptoms. **Results:** On days when children experienced more school problems, they reported more negative emotion and less positive emotion at school, and at bedtime. There were reliable individual differences in emotion reactivity and recovery. Children who showed more negative emotion reactivity reported more depressive symptoms. Multiple informants described fewer internalizing problems among children who showed better recovery, even after controlling for children's average levels of exposure to school problems. **Conclusion:** Diary methods can extend our understanding of the links between daily stress, emotions and child mental health. Recovery following stressful events may be an important target of research and intervention for child internalizing problems.

Keywords: emotion reactivity; emotion recovery; positive emotion; internalizing problems; daily diary; school problems

Negative and Positive Emotion Responses to Daily School Problems: Links to Internalizing and Externalizing Symptoms

The adverse effects of psychosocial stress on child mental health are often mediated by difficulties with effectively managing emotions (Crowell, Puzia, & Yaptangco, 2015; Repetti, Taylor, & Seeman, 2002). School is one source of such stress; negative events such as making a mistake on a test or arguing with a peer are common in the daily lives of school-aged youth. If chronic or severe, problems at school may adversely affect child mental health. For example, children who are bullied are at increased risk for internalizing (i.e., anxiety, depression) and externalizing (i.e., disruptive behaviors, aggression) problems (Reijntjes et al., 2011; Reijntjes, Kamphuis, Prinzie, & Telch, 2010). However, some children demonstrate positive development despite exposure to such adversities (Luthar, Cicchetti, & Becker, 2000).

One approach to further understanding the link between exposure to negative events at school and youth mental health is to investigate same-day emotion responses to these problems (Repetti, Robles, & Reynolds, 2011). Emotions are defined as affective responses to specific events; they often give rise to behaviors, and can be modulated through the use of various coping strategies (Gross, 2015). Using intensive repeated ratings of school problems and emotions from 83 fifth graders, this study assessed children's emotion responses to daily school problems, and examined how between-person differences in emotion responses were associated with youth psychological symptoms. We focus on fifth graders because early adolescence is characterized by increases in academic demands and in the salience of peer relationships (Graber & Brooks-Gunn, 1996). The prevalence of psychological problems also dramatically increases in adolescence (Zahn-Waxler, Shirtcliff, & Marceau, 2008). In the context of these developmental changes, assessing child risk factors associated with psychological symptoms using externally valid naturalistic measures that minimize recall and response bias is an important priority.

The current study uses daily repeated measures of school problems and negative and positive emotions to differentiate between *emotion reactivity* and *recovery*. *Emotion reactivity* is operationalized as a significant within-person association between school problems and emotion measured at school. Separate from emotion reactivity is *recovery*, which is represented by a child's within-person association between problems rated at school and emotion rated at bedtime. Complete recovery is marked by the absence of a significant link between problems at school and emotion at bedtime. Daily diary studies have traditionally examined spillover, defined as the short-term process by which stressful experiences in one setting negatively influence experiences in another setting. Accordingly, emotions triggered by negative events at school often influence interactions at home (Flook & Fuligni, 2008; Lehman & Repetti, 2007). This study uniquely focuses on emotion recovery from negative events at school, and examines between-person variability in the daily link between school problems and emotion at home.

Emotion reactivity to daily school problems

School-age children react to school problems with concurrent elevations in negative emotion (Morrow, Hubbard, Barhight, & Thomson, 2014; Schneiders et al., 2006) and decreases in positive emotion (Flook, 2011; Kiang & Buchanan, 2014; Schneiders et al., 2006). For example, in an eight-day diary study, fifth grade children reported more negative emotion on days when they experienced any type of peer victimization (Morrow et al., 2014). Likewise, stressful events were linked to low positive emotion, in an experiential sampling study of young European adolescents (Schneiders et al., 2006). Negative and positive emotion uniquely affect child functioning in both the short- and the long-term. In the short-term, negative emotion may spill over from the school to the home and generate more stressful events (e.g., parent-child conflict) that day (Lehman & Repetti, 2007). In contrast, positive emotion promotes action,

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social connectedness, motivation and cognitive flexibility – attributes needed for learning, problem solving, and support seeking (Fredrickson, 2001). A decrease in positive emotion may lead children to withdraw from possibly helpful interactions with teachers.

At the trait level, poor negative and positive emotion regulation is closely linked to child psychopathology (Gilbert, 2012; Repetti et al., 2002; Southam-Gerow & Kendall, 2002). In particular, poor regulation of positive emotion has been linked to bipolar disorder and externalizing disorders (Gilbert, 2012), whereas low positive emotion uniquely differentiates child depression from other internalizing disorders (Chorpita & Daleiden, 2002). Given their unique effects on child psychological functioning and development, negative and positive emotion are important targets of research investigation. The current study attempts to replicate previous findings of negative emotion reactivity and build on the emerging evidence of positive emotion reactivity to school problems, using diary data.

We focus on individual differences in children's negative and positive emotion responses to negative events. Although many studies have used intensive repeated methods to describe within-person associations between school problems and emotion, few have explored individual differences in the strength of that association. Two studies examining how child psychological functioning moderates same-day links between negative events and emotion indicate that emotional reactions to spontaneously occurring negative events vary between individuals (Schneiders et al., 2006; Timmons & Margolin, 2015). However, we know of only one diary study that derived individual measures of negative and positive emotion reactivity in children; Robles and colleagues (2016) obtained individual measures of emotion reactivity to interparental conflict and related them to biological markers of aging. This represents a significant gap in the research literature inasmuch as individual differences in emotion reactivity to everyday stress

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may represent an important component of child mental health.

Emotion recovery from daily school problems

As with emotion reactivity, negative and positive emotion recovery may vary significantly between individuals. Studies of emotion recovery based on laboratory analogs of peer rejection often monitor changes in child emotion over several minutes (Adrian, Zeman, & Veits, 2011; Reijntjes, Stegge, Terwogt, Kamphuis, & Telch, 2006). These studies have focused on behavioral responses that are expected to modulate children's emotion expressions over brief periods of time (e.g., distraction, problem solving). However, the time course of emotion recovery, separate from emotion reactivity is not well understood.

Diary methods can complement laboratory observational methods by assessing the lingering effects of everyday stress on child emotion over several hours and across the school and home contexts. A lack of recovery would suggest that problems at school negatively affects emotions across contexts, whereas recovery may reflect successful emotion regulation. Successfully modulating an emotional response to minor stressors such as problems at school may help children gain self-efficacy and resilience against the detrimental effects of subsequent stressors (Rutter, 2012). Despite their unique contributions, diary studies of recovery are rare and limited to the examination of the effects of stressors on next day mood (Chung, Flook, & Fuligni, 2011; Kiang & Buchanan, 2014). Although these studies control for various day-level covariates, it is not possible to accurately account for all that can happen to influence emotion over 24 hours.

Emotion response to stress and youth psychological symptoms

Emotion reactivity and recovery may be key processes that link school-related stress to child psychological problems (Crowell et al., 2015; Reijntjes et al., 2011, 2010). The association between emotion regulation and internalizing problems has been established through a number of

studies (Hastings, Zahn-Waxler, & Usher, 2007; McLaughlin, Hatzenbuehler, & Hilt, 2009; Zeman, Shipman, & Suveg, 2002). However, analyses of the link between emotion regulation and externalizing problems have not been as consistent (Cooley & Fite, 2015; Hastings et al., 2007; Herts, McLaughlin, & Hatzenbuehler, 2012). For instance, although most investigations suggest that better emotion regulation is linked to fewer externalizing problems or aggression, Hastings and colleagues (2007) found that greater positive affect during a socially challenging laboratory task was associated with more externalizing problems.

In addition, while there is abundant research differentiating adaptive coping strategies (e.g., cognitive reappraisal) from maladaptive ones (e.g, rumination) (Aldao, Nolen-Hoeksema, & Schweizer, 2010), we know little about how these strategies actually help children recover from stressful events in the throughout the course of a day. Observational methods improve on questionnaire ratings, by directly assessing children's immediate emotional and behavioral responses to specific events (e.g., Morris et al., 2011). Still, few assessments of child emotion responses to stressful events examine how the intensity of the emotion changes over several hours. Even fewer studies have assessed the links between naturalistically occurring problems at school, emotional responses to these events, and child psychological functioning.

Although higher levels of daily stress are typically associated with poorer psychological functioning, mild negative events such as doing poorly on a test or arguing with a friend may also afford children the opportunity to practice coping and promote positive development (Repetti & Robles, 2016). An empirical study of recovery may help to differentiate possible gains associated with exposure to mild stress from detrimental effects. Studies using experience sampling method or daily diaries suggest that child emotion reactivity to and recovery from daily stress are concurrently associated with child adjustment (Neumann, van Lier, Frijns, Meeus, &

Koot, 2011; Silk et al., 2003). Silk and colleges (2003) examined declines in negative emotions over one hour time periods following negative events during a one-week long experiential sampling methods study. They found that children who were more likely to react to a negative event with negative emotion and not recover within an hour had more psychological problems than those who reacted and then recovered. The current study extends past research by using multilevel modeling methods to derive continuous between-person measures of reactivity and recovery. We examine how between-person differences in reactivity and recovery are associated with psychological symptoms, over and above average levels of exposure to school problems.

Current study

Children in the current study completed self-reports of school events and emotion, several times per day, for five consecutive weekdays. Using these intensive repeated data, we examined children's negative and positive emotion reactivity to problems at school, and recovery by bedtime. Self-reports of negative and positive emotion taken at school and at bedtime were used as indices of reactivity and recovery. We derived individual-level measures of reactivity to school problems and examined their cross-sectional links to youth-reported depression symptoms, and parent- and teacher-reported internalizing and externalizing problems. We hypothesized that higher levels of reactivity would be associated with more youth symptoms across reporters, even when controlling for the level of exposure to school problems. We also derived individual-level estimates of negative emotion and positive emotion recovery, and examined their cross-sectional associations with youth-, parent- and teacher-ratings of psychological symptoms. We expected that poor emotion recovery would be associated with more psychological symptoms, over and above average levels of problems at school.

Methods

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Participants

Data were collected as part of a larger three-year study of stress and family development. Children and parents were recruited through one parochial and two public schools in the greater Los Angeles area. To be eligible, parents living with the child had to be employed at least part-time. The current study examined data from 83 children (51% girls) who were recruited from a sample of 112 eligible participants in the larger study. Of the 83 children in the current study, the majority (n=71) of the students completed the diary in Spring of 5th grade; a small minority (n=12) completed it during Fall of 6th grade. Mean child age during the diary phase was 10.91 years (SD=0.53). Of the 83 children, 79% were White, and 21% had at least one parent who was not White. Sixty percent of the families reported annual incomes greater than $80,000 USD in years 1993 to 1996. Of the 83 children, 65% lived with both two parents (mother and father) and 35% lived with one parent. In addition to child participants, 70 mothers, 55 fathers and 73 teachers completed one-time questionnaires about youth symptomatology during the diary year.

Procedures

The 83 children in the current study completed five diaries each day for five consecutive weekdays (Mon to Fri). Parental consent was obtained via mail. In addition to the diary surveys about emotion, school events, and family interactions, children completed group and individual interviews at school. Parents and teachers completed questionnaires about youth psychological symptoms. The university's institutional review board approved all study procedures.

Diary procedures. Research staff provided instructions to children about daily diary procedures during home visits. On each of the five weekdays, children completed brief paper-and-pencil diary forms 5 times per day: morning, just before lunch, end of the school day, early evening and bedtime. Lunch and end-of-school-day diaries were completed at school, while all

others were completed at home. Children received beeper watches that reminded them to complete the two forms at school. At home, they were reminded by parents. Research staff called families during the week to check compliance. Children optionally received preaddressed and stamped envelopes to return their reports at the end of the day, each day, but most children opted to return all the diaries together at the end of the week. Compliance was high, with the average child completing 24.5 (SD =1.93), out of the 25 expected diaries.

Measures

Youth daily diary. *School problems*. Twice daily (just before lunch and at the end of the school day), the children completed the Youth Everyday Social Interaction and Emotion measure (YES I AM), which asked about ten school problems. Five items assessed academic problems (e.g., "I made a mistake in class today", "I had trouble finishing my schoolwork today") and five assessed peer problems (e.g., "Another kid teased me today", "I felt that my friends didn't want to be around me today") (Lehman & Repetti, 2007; Repetti, 1996). The response options for the 10-item school problems scale ranged from 1 (definitely false) to 4 (definitely true). Responses were averaged across 10 items at each assessment, then again across the two assessments each day to create a daily school problems score. Between-person reliability (R_{KF}=.95) and within-person reliability (R_C=.62) were adequate for the total school problems scale; Cronbach's alphas across the five days ranged from .75 to .87. The intraclass coefficient (ICC), an index of the proportion of the variance attributable to between-individual differences as opposed to within-person differences was .65. Descriptive statistics are shown in Table 1. School problems were grand mean centered in all within-subject analyses.

Negative and positive emotion. Children rated ten items assessing negative emotion (e.g., tense, confused, scared, sad, alone, angry) and seven items related to positive emotion (e.g.,

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proud, happy, excited, confident) from the YES-I-AM scales (Lehman & Repetti, 2007; Repetti, 1996). Items were rated four times each day - morning, just before lunch, end of school day, and bedtime - on a four-point scale, with options ranging from 1 (definitely false) to 4 (definitively true). Item scores were averaged to create negative emotion and positive emotion scale scores at each assessment. Between- and within-person reliability estimates for negative emotion were adequate (R_{KF}=.96, R_C=.67); Cronbach's alpha ranged from .75 to .91 across assessments. Between- and within-person reliability estimates for positive emotion were adequate as well (R_{KF}=.97, R_C=.52); Cronbach's alpha ranged from .81 to .92.

The current study uses negative emotion and positive emotion scale scores from the just before lunch, end-of-school-day and bedtime assessments. Emotion scores from the lunch and end-of-school-day assessments were averaged for each day to create daily measures of school negative emotion and school positive emotion, and used in the analyses of reactivity. Bedtime negative emotion and positive emotion scale scores were used in analyses of emotion recovery. ICC estimates for negative emotion at school and at bedtime were .55 and .53, respectively. For positive emotion, ICC was .71 at school and .64 at bedtime. Three children were excluded from all analyses involving positive emotion due to a high frequency of errors in their item responses.

Questionnaire measures. ***Parent report of youth internalizing and externalizing problems.*** The *Child Behavior Checklist* is a widely used 113-item parent measure of child emotional and behavioral functioning (CBCL; Achenbach, 2009). It shows good psychometric properties, including high test-retest reliability and high external validity (Achenbach, 2009). The current study uses the internalizing problems (31 items; withdrawn, somatic complaints and anxious/depressed subscales) and externalizing problems (33 items; aggressive and delinquent behaviors subscales) broad-band scales. Mothers and fathers independently rated items on a 0

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(not true) to 2 (very true or often true) scale. Items were averaged for each rater, with higher scores indicating more internalizing or externalizing problems. In the current study, internal consistency of the broad-band scales ranged from .89 to 91. Because of the high correlation between mother and father CBCL scores (r(40) = 0.53 and 0.60 for internalizing problems and externalizing problems, respectively), mother- and father-reports were averaged whenever both scores were available. Descriptive statistics for combined parent scores are shown in Table 1.

 Teacher report of youth internalizing and externalizing problems. *Teacher Report Form* (TRF; Achenbach, 2009) is a widely used 113-item teacher questionnaire that parallels the CBCL. It has been shown to be a reliable, stable, and valid measure of child psychological adjustment (Achenbach, 2009; Edelbrock & Achenbach, 1984). Consistent with parent reports, the current study uses the internalizing problems (36 items) and externalizing problems (34 items) broad-band scales. All items are rated on a 0 (not true) to 2 (mostly true) scale, and averaged, with higher scores indicating higher levels of symptoms. Internal consistency for internalizing problems and externalizing problems were high (α = .81 and .92, respectively).

 Depressive symptoms. *Children's Depression Inventory* (CDI; Kovacs, 1985) is a 27-item questionnaire that assesses children's self-reports of affective, behavioral, somatic and cognitive symptoms of depression. Children responded to each item by indicating which of three sentences best describe how they have felt during the last two weeks (e.g., "I am sad once in a while, I am sad many times, I am sad all the time"). Each statement was linked to a score (0, 1 or 2) and scores from 27 questions were averaged. Higher average scores indicated more symptoms of depression. The CDI shows strong psychometric properties, including high test-retest reliability, concurrent validity and predictive validity for depression (Carey, Faulstich, Gresham, Ruggiero, & Enyart, 1987). In the current study, Cronbach's alpha was .78.

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Data analysis

First, we conducted multilevel linear regression analyses (PROC MIXED in SAS), to evaluate emotion reactivity to and recovery from daily school problems. School problems ratings from the lunch and end-of-school-day assessments were averaged to create one score for each day. Likewise, emotion ratings from the two school assessments were averaged to create daily scores for negative and positive emotion at school, and used in the analyses of emotion reactivity. Bedtime emotion ratings were used in the analyses of emotion recovery.

Multilevel models (MLM) accounted for the two-level structure of our data, in which days (Level 1) are nested in children (Level 2). MLMs tested the within-person effect of school problems on emotion while allowing the intercept and slope to randomly vary between individuals (Raudenbush & Bryk, 2002). This approach excluded observations with missing data using listwise deletion. A first order autoregressive structure was specified for residuals to correct for time dependencies across days, and school problem was grand mean centered. The four measures of emotion (negative or positive; at school or at bedtime) were tested as outcomes in four separate analyses. Equations 1, 2 and 3 further describe this two-level approach:

$$\text{Level 1: } \text{Emotion}_{ij} = \beta_{0j} + \beta_{1j} \text{ Problem}_{ij} + e_{ij} \quad (1)$$
$$\text{Level 2: } \beta_{0j} = \gamma_{00} + u_{0j} \quad \quad \quad \quad (2)$$
$$\beta_{1j} = \gamma_{10} + u_{1j} \quad \quad \quad \quad (3)$$

As described in Equation 1, emotion for child j on day i is a function of the intercept for child j and school problems for child j on day i. Child j's intercept, β_{0j}, is the sum of γ_{00}, the average level of emotion across all days and all children, and u_{0j}, child j's deviation from this average (see Equation 2). β_{1j}, represents the within-person association between school problems and emotion for child j. As shown in Equation 3, it is the sum of γ_{10}, the average linear effect of school problem on emotion, and u_{1j}, child j's deviation from this average slope, over and above

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the child's average level of emotion across all diary days (β_{0j}), and correcting for time dependencies of residuals across days.

The random slope effect, or the between-person variance in slopes (u_{1j}), indicates the extent to which the within-person association between school problems and emotion varies between children. In each of the four analysis, we examined this variance estimate to determine the level of between-person variability in emotion reactivity or recovery. When the variance estimate (i.e., random slope effect) was different from 0 at a cutoff of $p < .10$, we derived empirical Bayes (EB) estimates of the slope for each child, in our second step of data analysis.

The Bayesian estimation method allows us to derive adjusted individual slopes (centered to the average slope, γ_{10}) to use as predictors (see Mohr et al., 2013 as an example). The estimation accounts for fixed effects at Level 1 (i.e., intercept) and the size of each child's sample, by "borrowing" strength from children with more data points (Raudenbush & Bryk, 2002). We derived EB estimates of the slope of the association between school problems and emotion at school as a between-person measure of emotion reactivity (Robles et al., 2016). Likewise, the individual EB estimates of the association between school problems and emotion at bedtime was used as a between-person measure of recovery.

Third, we evaluated the associations between the individual-level measures of reactivity, recovery and youth symptoms. Child sex differences were assessed in multiple linear regression analyses, through interactions between child sex and the reactivity/recovery variable. We further tested the incremental validity of reactivity and recovery by examining their links to youth symptoms while controlling for average levels of school problems, in multiple linear regression analyses. For each child, daily ratings of problems at school were averaged across the five days of data to create an individual score for average level of school problems. All outliers at the

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individual level of analyses (> +2.5xSD or < -2.5xSD) were winsorized. Data analyses were conducted on SAS 9.4 software or Stata 13.1 software.

Results

First, we examined how the average child reacts to and recovers from school problems on the same day and created between-person measures of reactivity and recovery. Second, we assessed cross-sectional associations between the indicators of emotion response and youth psychological symptoms. We tested for moderation by child sex.

Emotion reactivity and recovery

Reactivity. Negative emotion and positive emotion at school were separately examined as the dependent variable in two MLMs; school problems was the predictor in both models.

For the average child, more school problems were associated with higher levels of negative emotion at school that day (γ_{10}=0.46, SE=0.06, t=7.46, p<.001). The random slope effect was significant (Variance=0.07, SE=0.04, z=1.73, p=.042), suggesting that individuals differed in the intensity of their negative emotion reactivity to those daily stressors. Figure 1 depicts the individual slopes using raw day-level scores for school problems and emotion. As shown in Table 1, the EB estimates of negative emotion reactivity ranged from 0.21 to 1.04, with higher values representing higher levels of reactivity.

Likewise, the average child reported lower levels of positive emotion at school on days with school problems (γ_{10}=-0.27, SE=0.07, t=-3.91, p<.001). Although the average child showed positive emotion reactivity to school problems, the random effect on this slope was not significant (Variance=0.02, SE=0.04, z=-1.48, p=.336), suggesting that individuals did not vary in the intensity of their positive emotion responses to school problems (see Figure 1). Thus, we did not derive individual-level estimates of positive emotion reactivity.

Recovery. Next, we examined whether daily school problems predicted same-day emotion at bedtime, with negative and positive emotion tested in separate MLMs. All other model specifications were consistent with the reactivity models.

For the average child, more problems at school were associated with higher levels of negative emotion at bedtime that night (γ_{10}=0.39, SE=0.07, t=5.57, p<.001), which suggests that the he or she experienced negative emotion spillover rather than recovery. The strength of this association varied quite a bit across individuals (see Figure 1), as demonstrated by a statistically significant random effect of school problems on bedtime negative emotion (Variance=0.10, SE=0.05, z=2.20, p=.014). When deriving individual-level estimates of negative emotion recovery, EB estimates were reverse coded (multiplied by -1) for ease of interpretation: higher values represented greater recovery (i.e., less positive associations between school problems and bedtime negative emotion). As shown in Table 1, the mean negative emotion recovery score was equal to the unstandardized coefficient (γ_{10}) in magnitude but reversed in direction.

As with negative emotion recovery patterns, more school problems also predicted lower levels of positive emotion that night for the average child (γ_{10}=-0.32, SE=0.11, t=-3.02, p=.003). The random slope effect was marginally significant (Variance=0.18, SE=0.12, z=1.45, p=.074) suggesting that the strength of the association between school problems and bedtime positive emotion differed between children (see Figure 1). Mean positive emotion recovery score was consistent with the unstandardized coefficient in the MLM (γ_{10}) and ranged from -0.99 to 0.11 across individuals. Higher values indicated better recovery, defined as a weaker association between school problems and that night's positive emotion.

Associations between reactivity, recovery, and youth symptoms

Next, we used the individual-level estimates of negative emotion reactivity and negative

and positive emotion recovery, to assess how daily emotion responses to school problems were linked to five measures of youth symptoms. First, we describe correlations between individual-level measures of reactivity and recovery, and among the measures of psychological symptoms.

As shown in Table 2, three correlations tested the associations between one measure of reactivity and two measures of recovery. Negative emotion recovery and positive emotion recovery were positively correlated. Higher scores of negative emotion reactivity were correlated with lower scores for both negative emotion recovery and positive emotion recovery. The correlations among the five different youth symptom scores showed that child ratings of depression symptoms were correlated with both parent- and teacher-ratings of internalizing problems. Parents and teachers' reports of internalizing problems were not correlated, although they agreed on ratings of child externalizing problems. Within each reporter, internalizing problems were positively correlated with externalizing problems.

Negative emotion reactivity and youth symptoms. Out of the five cross-sectional correlations between negative emotion reactivity and five measures of youth symptoms, only one was statistically significant (Table 2). More negative emotion reactivity was associated with more child self-reported symptoms of depression. Of the five tests of child sex differences, only one of the interaction terms was statistically significant; the association between negative emotion reactivity and teacher-rated externalizing problems differed for boys and girls (b=-0.50, SE=0.17, t=-2.89, p=.005). Negative emotion reactivity was correlated with more teacher-rated externalizing problems in boys (r(33)=0.45, p=.007), but not in girls (r(36)=-0.10, p=.556).

Next, we tested five linear regression models to examine the associations between negative emotion reactivity and youth symptoms, controlling for average levels of school problems. As shown in Table 3, the association between negative emotion reactivity and child

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self-reported symptoms of depression held, even when controlling for average school problems. Consistent with correlation findings, negative emotion reactivity was not associated with parent- and teacher-reports of internalizing problems (see Table 3), or parent-ratings of externalizing problems (b=0.06, SE=0.12, t=0.50, p=.616). For teacher-ratings of externalizing problems, the interaction between negative emotion reactivity and child sex was significant (b=-0.47, SE =0.18, t=-2.72, p=.008), controlling for average school problems. Higher levels of negative emotion reactivity were associated with more externalizing problems for boys (b=0.42, SE=0.15, 95% CI [0.11, 0.72]), but not for girls (b=-0.06, SE=.10, 95% CI [-0.25, 0.13]).

Negative emotion recovery and youth symptoms. As shown in Table 2, three out of five correlations between negative emotion recovery and youth psychological problems were statistically significant. A higher level of negative emotion recovery was associated with fewer parent-reported internalizing problems, fewer teacher-reported internalizing problems and fewer child self-reported depression symptoms. There were no child sex differences in any of the associations between emotion recovery scores and youth symptoms.

Five multiple linear regressions tested the association between negative emotion recovery and youth symptoms, over and above average levels of problems at school. As shown in Table 3, negative emotion recovery was associated with parent-report and teacher-report of child internalizing problems (p < .10), and child self-reported depression symptoms (p < .05), controlling for average school problems. Consistent with results shown in Table 2, negative emotion recovery was not associated with parent- or teacher-ratings of child externalizing problems (b=0.02, SE=0.08, t=0.23, p=.821; b=0.04, SE=0.06, t=0.64, p=.523, respectively).

Positive emotion recovery and youth symptoms. For positive emotion recovery, two out of five correlations were significant (see Table 2). Better positive emotion recovery

following difficult days at school was associated with fewer teacher-reported internalizing problems and fewer child-reported depression symptoms. These correlations did not differ by child sex. Follow-up analyses using regressions showed that these associations held even when controlling for average school problems. However, positive emotion recovery was not associated with child externalizing problems reported by parents (b<0.01, SE=0.11, t=-0.01, p=.996) and teachers (b=0.09, SE=0.07, t=1.25, p=.217), over and above average school problems.

Discussion

The current study used a unique diary approach to investigate children's emotional responses to daily school problems, and examine their links to youth psychological symptoms. We evaluated individual differences in negative and positive emotion responses to problems at school. On days when the average child reported more school problems, he or she endorsed more negative and less positive emotion at school, and more negative and less positive emotion at bedtime. We found between-person differences in measures of negative emotion reactivity, negative emotion recovery, and positive emotion recovery. However, the intensity of positive emotion reactivity did not differ between children. Individual-level measures of negative emotion reactivity, negative emotion recovery and positive emotion recovery were associated with depression, even when controlling for average levels of problems at school. Children who reported more negative emotion in conjunction with school problems endorsed more symptoms of depression. Children who showed better negative and positive emotion recovery at bedtime had fewer teacher-reports of internalizing problems and self-reports of depression symptoms.

Emotion responses to daily stressors

The current study took advantage of intensive repeated ratings of child emotion to examine how problems at school affect child emotional states throughout the day. Consistent

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with past diary studies, we found that children reacted to school problems with more negative emotion and less positive emotion at school (Flook, 2011; Kiang & Buchanan, 2014; Morrow et al., 2014; Schneiders et al., 2006). Separate from emotion reactivity, problems at school affected emotion at bedtime. As previously reported (Lehman & Repetti, 2007), children reported more negative emotion and less positive emotion at bedtime on more stressful days at school.

Underlying many laboratory studies of emotion responses to stress is the common assumption that recovery occur over minutes (e.g., Morris et al., 2011). However, our measure of recovery uncovered the extent to which a child's emotion at home later at night is correlated with earlier events at school. Our data indicate that children experience more negative emotion and less positive emotion for hours after following a stressful event, even after changing contexts. Rather than recovering, spillover appears to be the norm in the daily lives of fifth graders.

Theories and investigations of the same-day links between experiences at school and experiences at home propose that negative events at school trigger a cascade of emotional and behavioral reactions in the child, which may generate more stress in the home. For example, children report more negative emotions and perceive more conflict and less warmth with parents at home, following difficult days at school (Bai, Reynolds, Robles & Repetti, 2016; Chung et al., 2011; Lehman & Repetti, 2007; Timmons & Margolin, 2015). Children may also withdraw from family members, especially when experiencing less positive emotion (Ramsey & Gentzler, 2015). These strained family interactions may contribute to the maintenance of low positive emotion and high negative emotion, and thus, signs of poor recovery at bedtime.

Although the average youth showed more negative emotion and less positive emotion at school and at bedtime on more stressful school days, there was significant variability between individuals. Children differed in the extent with which they reacted with negative emotion at

school. Children also differed in their within-person associations between school problems and negative and positive emotion at bedtime. Positive emotion reactivity did not vary significantly between individuals. In fact, positive emotion at school appeared to be more trait-dependent rather than state-dependent, and thus less amenable to an analysis of within-subjects variance.

Emotion reactivity, recovery and youth symptoms

Using intensive repeated ratings of negative and positive emotion obtained several times a day for five consecutive days, we derived three individual-level indices of emotion responses to mild stressors: negative emotion reactivity, negative emotion recovery and positive emotion recovery. Consistent with past research on the link between emotion dysregulation and child internalizing problems, we found that negative emotion reactivity to school problems were correlated with more symptoms of depression (Eisenberg et al., 2005; Repetti et al., 2002; Suveg & Zeman, 2004). Only one child sex difference emerged. Higher levels of negative emotion reactivity were correlated with more teacher-rated externalizing problems for boys but not girls. This moderation effect may reflect child sex differences in the identification and prevalence of externalizing problems in the school setting (Silver, Measelle, Armstrong, & Essex, 2005). Externalizing problems are more likely to be identified in boys, than girls, due to the overt symptoms such as hyperactivity and impulsivity that are observed more frequently in boys (Gershon, 2002). Boys with higher levels of negative emotion reactivity may express negative affect outwardly when frustrated and also show more externalizing problems in the classroom.

We assessed recovery and reactivity separately, to test whether these two aspects of stress response are differentially associated with youth symptoms. As expected, indices of recovery were also correlated with youth psychological symptoms. Better negative emotion recovery by bedtime (weaker association between school events and negative emotion) was associated with

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with fewer child-reported depression symptoms. It was also associated with fewer parent- and teacher-reported internalizing problems at trend level. Likewise, better positive emotion recovery was correlated with fewer teacher-rated internalizing problems and child-reports of depression symptoms. Although recovery is considered an important component of emotion regulation conceptually (Eisenberg & Spinrad, 2004), it is rarely examined in research. Child- and parent-rated questionnaires on emotion regulation more often assess emotional reactivity only and the use of adaptive and maladaptive coping strategies (e.g., Shields & Cicchetti, 1997; Zeman et al., 2001). Observational studies directly assess child emotions and behaviors in response to stress; however, they focus on overt signs of recovery over several minutes. In contrast, diary studies show that stressful events continue to affect child emotion and behaviors in the hours to days that follow (Chung et al., 2011). By using diary measures to examine emotion reactivity and recovery, our findings begin to address a significant gap in the research on emotion dysregulation, and its links to child mental health.

Naturalistic assessment of emotion responses to stress

The current study uniquely integrates literatures on daily stress reactivity and temperamental correlates of psychological problems in youth. Although these literatures are complementary, they are rarely considered together. On one hand, several past diary studies have documented children's short-term responses to mild daily stressors, while the implications of emotion responses on child mental health remain unknown. On the other hand, prior studies of emotion reactivity and child mental health have prioritized the use of standardized questionnaires and laboratory tasks, over measures that can help increase real-life relevance of study findings.

The few published studies that have integrated these literatures show mixed results (Salamon, Johnson, & Swendsen, 2011; Schneiders et al., 2006; Timmons & Margolin, 2015).

For example, Timmons & Margolin (2015) found that the within-person association between parent-adolescent conflict and same-day negative emotion was stronger among adolescents with more symptoms of depression and anxiety. However, Salamon and colleagues (2011) reported that internalizing symptoms did not influence the likelihood of a negative event in one domain (e.g., family) predicting that another negative event occur in a different domain (e.g., academic) on the same day. The current study improved upon past analyses by using daily diaries to derive individual-level indices of emotion reactivity and recovery. We found that more negative emotion reactivity is associated with more internalizing problems in children, whereas better negative and positive emotion recovery is correlated with fewer internalizing problems.

These findings extend our understanding of how short-term emotion responses to minor daily events relate to child psychological functioning. For instance, our data suggest that emotion recovery and average levels of exposure to minor problems at school are inversely linked to child self-report of depressive symptoms. Whereas higher levels of school problems may be associated with more symptoms of depression, better emotion recovery from these stressors may help to compensate for this detrimental effect. These results begin to shed light on the interplay of short-term stress and resilience processes (Bai & Repetti, 2015; Repetti & Robles, 2016).

Limitations and future directions

Several limitations must be considered when interpreting our findings. First, the sample size and limited age range constrained our statistical power to test the effects of moderators, such as child age, cumulative stress, and family characteristics. Future research with larger and more heterogeneous samples should explore how individual differences in levels of early stress exposure moderate same-day emotion responses to daily negative events. Second, school problems were relatively rare in this sample. Longer diary duration can help increase variability

in both academic and peer problems and more reliably assess child emotion responses to different types of problems. Nonetheless, multiple ratings of emotion within each day across a relatively brief diary period allowed us to assess both reactivity and recovery processes within the same day. Third, we cannot ascertain the temporal order of the within-person association between problems and emotions at school. However, the consistency of our findings with prior study's results (e.g., Lehman & Repetti, 2007), as well as our statistical controls offer additional support for our interpretations. Fourth, we cannot evaluate the extent to which the cross-sectional associations reported here represent an effect that emotion dysregulation has on psychological functioning, versus emotion dysregulation as a symptom of child internalizing problems. However, the use of reports from multiple informants reduce the possibility that shared method variance inflated the correlations reported in the study. Future studies using longitudinal data can examine the predictive validity of these measures of emotional reactivity and recovery.

Despite several limitations, the current study represents an important step in applying intensive repeated methodology to assess individual differences in emotion responses to stress to more precisely identify targets of interventions for child internalizing problems. We found that negative emotion reactivity to school problems is correlated with more symptoms of depression. In contrast, children who showed better negative and positive emotion recovery by bedtime displayed fewer depression symptoms. Emotion recovery may be a logical target of clinical interventions for childhood depression and anxiety. Future research could examine factors that increase emotion recovery (e.g., parental involvement), and cognitive and behavioral processes that inhibit emotion recovery (e.g., rumination) during hours following the stressful event. More importantly, future clinical intervention efforts related to decrease internalizing problems may consider the importance of promoting emotion recovery in the hours that follow.

Table 1-1

Descriptive statistics for reactivity, recovery and youth psychological symptoms

	N	Mean	SD	Min	Max
AGGREGATED DAILY VARIABLES					
Average school problems	83	1.50	0.44	1.00	3.23
Negative school emotion	83	1.37	0.43	1.00	2.87
Positive school emotion	80	3.30	0.53	2.04	4.00
Negative bedtime emotion	83	1.38	0.45	1.00	3.10
Positive bedtime emotion	80	3.24	0.58	1.82	4.00
EMOTION RESPONSE TO PROBLEMS					
Negative emotion reactivity	83	0.46	0.18	0.21	1.04
Negative emotion recovery [a]	83	-0.39	0.28	-1.63	-0.06
Positive emotion recovery [a, b]	80	-0.32	0.20	-0.99	0.11
YOUTH PSYCHOLOGICAL SYMPTOMS					
Parent – Internalizing	76	0.20	0.18	0	0.94
Parent – Externalizing	76	0.22	0.19	0	0.94
Teacher – Internalizing	73	0.08	0.11	0	0.44
Teacher – Externalizing	73	0.09	0.15	0	0.82
Child – CDI	82	0.16	0.16	0	0.70

[a] Higher scores indicate higher levels of recovery; [b] Values were reverse coded (multiplied by -1) for ease of interpretation.

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Table 1-2

Correlation matrix of bivariate associations between school problem reactivity, recovery, and youth psychological symptoms

	1	2	3	4	5	6	7	8	9	10	11	12
AGGREGATE DAILY VARIABLES												
1 Average school problems												
2 Negative school emotion	.77***											
3 Positive school emotion	-.47***	-.48										
4 Negative bedtime emotion	.77***	.90***	-.43***									
5 Positive bedtime emotion	-.36	-.35***	.81***	-.38***								
EMOTION RESPONSE TO PROBLEMS												
6 Negative emotion reactivity	.38***	.84***	-.33**	.72***	-.24*							
7 Negative emotion recovery	-.40***	-.74***	.34**	-.85***	.37***	-.78***						
8 Positive emotion recovery	-.13	-.28*	.38***	-.27*	.45***	-.22*	.37***					
YOUTH PSYCHOLOGICAL SYMPTOMS												
9 Parent - Internalizing	.15	.18	-.27*	.17	-.31**	.14	-.24*	-.13				
10 Parent - Externalizing	.13	.10	-.20	.04	-.18	.10	-.02	-.03	.69***			
11 Teacher - Internalizing	.21	.28*	-.31**	.30*	-.32**	.22	-.29*	-.28*	.22	.04		
12 Teacher - Externalizing	.11	.06	-.15	.02	-.01	.10	.02	.13	.04	.35**	.29*	
13 Child - CDI	.48***	.50***	-.50***	.46***	-.49***	.36***	-.37***	-.31**	.32**	.16	.37**	-.05

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

Note: All variables winsorized to 2.5xSD above or below the mean.

Table 1-3

Multiple regression analyses testing associations between emotion responses to stress and parent-, teacher- and child self-report of youth internalizing symptoms, over and above average levels of school problems

PREDICTORS	OUTCOMES														
	Parent ratings					Teacher ratings					Child self-reported depression scores				
	b	SE	95% CI	β	t	b	SE	95% CI	β	t	b	SE	95% CI	β	t
Negative emotion reactivity models															
Reactivity	0.09	0.11	-0.13, 0.31	.10	0.79	0.10	0.07	-0.04, 0.25	.18	1.42	0.18	0.09	0.01, 0.35	.21	2.11[*]
School problems	0.04	0.05	-0.05, 0.14	.11	0.91	0.03	0.03	-0.03, 0.09	.13	1.09	0.16	0.04	0.08, 0.23	.43	4.29[***]
Negative emotion recovery models															
Recovery	-0.14	0.08	-0.29, 0.02	-.22	-1.77[t]	-0.10	0.05	-0.20, 0	-.25	-1.98[t]	-0.12	0.06	-0.24, 0	-.21	-2.01[*]
School problems	0.03	0.05	-0.07, 0.12	.07	0.54	0.02	0.03	-0.04, 0.09	.09	0.75	0.15	0.04	0.08, 0.23	.43	4.17[***]
Positive emotion recovery models															
Recovery	-0.09	0.10	-0.29, 0.11	-.11	-0.89	-0.13	0.06	-0.25, -0.01	-.25	-2.19[*]	-0.18	0.08	-0.34, -0.03	-.23	-2.38[*]
School problems	0.06	0.04	-0.03. 0.14	.16	1.34	0.05	0.03	-0.01, 0.10	.21	1.78[t]	0.17	0.03	0.11, 0.24	.48	5.05[***]

[t] p <.10; * p < .05, ** p < .01, *** p < .001; b=unstandardized coefficient; SE=standard error; CI=confidence interval; β=standardized coefficient.
Note: All variables winsorized to 2.5xSD above or below the mean; N ranged from 70 to 82.

Figure 1-1

Within-person associations between school problems and negative and positive emotion at school and at bedtime
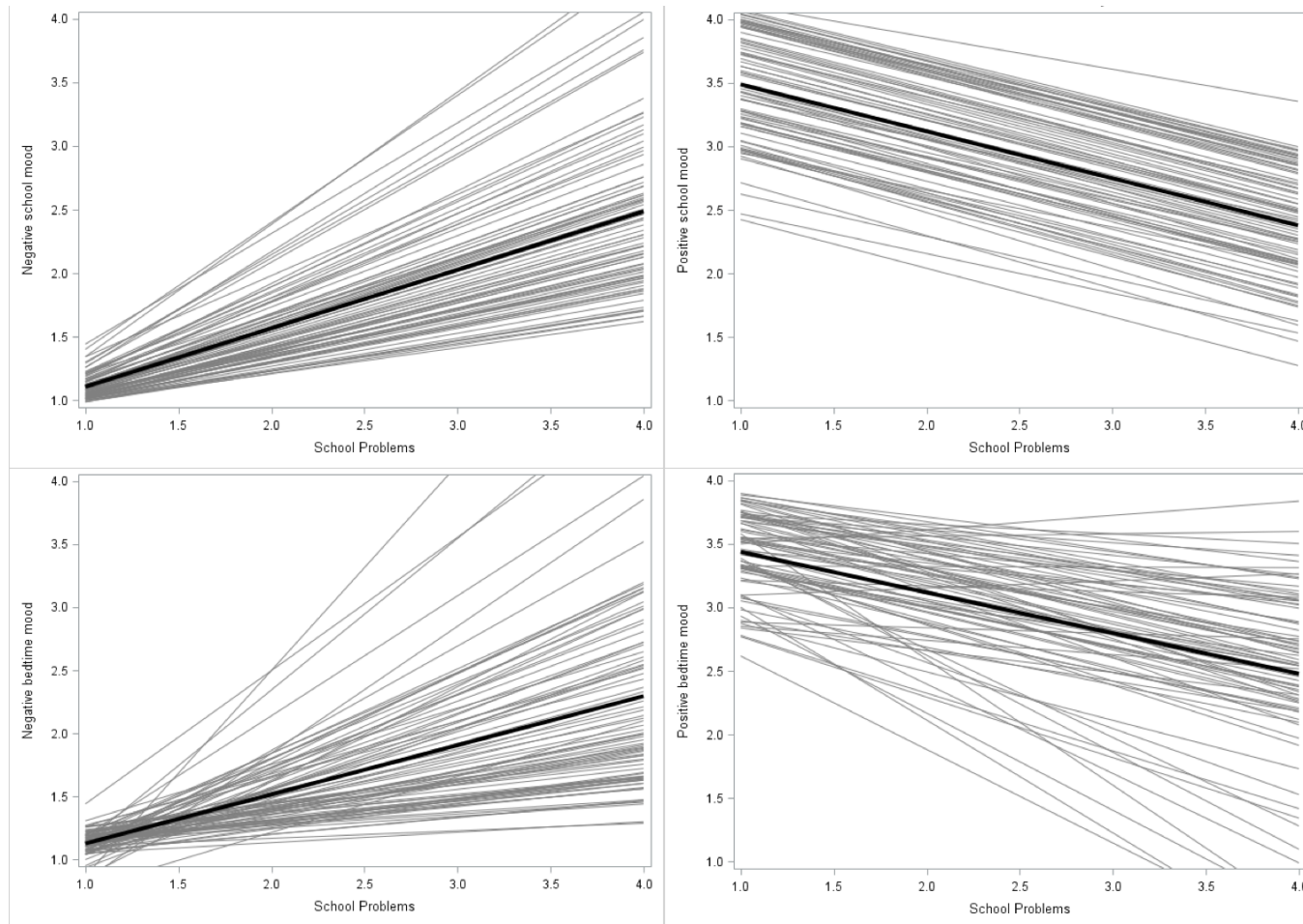
Average within-person slope
Individual EB estimates of within-person slope

Appendix 1-1

Child Diary School Event Scales

Scale scores are means; Response Options: 1 = *definitely false*, 2 = *mostly false*, 3 = *mostly true*, 4 = *definitely true*

PEER PROBLEMS AT SCHOOL (5 items)
1. I felt that my friends didn't want to be around me.
2. Another kid teased me.
3. I felt that that my friends were talking about me behind my back.
4. I got into a fight with another kid.
5. One of my friends was mad at me.

ACADEMIC PROBLEMS AT SCHOOL (5 items)
1. My schoolwork was too hard.
2. I made a mistake in class.
3. I had trouble finishing my schoolwork.
4. I had trouble learning something new.
5. I received a bad grade on a test or paper.

Appendix 1-2

Child Diary Positive and Negative Mood Scales

Scale scores are means; Response Options: 1 = *definitely false*, 2 = *mostly false*, 3 = *mostly true*, 4 = *definitely true*

CHILD POSITIVE MOOD   (7 items)
1. I felt proud
2. I was happy
3. I was loved
4. I was excited
5. I felt confident
6. I was smiling
7. I was acting cheerful

CHILD NEGATIVE MOOD (10 items)
1. I felt tense
2. I felt confused
3. I felt worried, distracted or preoccupied
4. I was scared
5. I felt that others were pressuring me
6. I felt that others were expecting too much from me
7. I was sad
8. I felt alone
9. I felt ashamed
10. I was angry

STUDY 2

DAILY MOOD REGULATION IN MIDDLE CHILDHOOD PREDICTS INTERNALIZING

PROBLEMS IN ADOLESCENCE

Abstract

Using daily diary methodology, this study examined individual differences in mood

regulation, and evaluated their prospective associations with youth psychological problems, three

years later. At baseline, 47 children ages 8 to 13, reported on problems at school and mood daily,

across 8 weeks. Children and parents also completed one-time questionnaires about youth

psychological symptoms at baseline and three years later when youths were 11 to 17 years old.

There were individual differences in the within-person associations between school problems

and same day and next day mood. A greater tendency to react to school problems with more

negative mood or less positive mood on the same day predicted more psychological symptoms

three years later, relative to baseline levels of symptoms.

Keywords: mood regulation; positive emotion; internalizing problems; daily diary; school
problems

Daily Mood Regulation in Middle Childhood Predicts Internalizing Problems in Adolescence

The transition from middle childhood to adolescence is marked by several important changes in social and emotional development, including greater salience of peers and more academic demands. At the same time, the prevalence of mental disorders, including depression, anxiety, later-onset conduct problems and substance use dramatically increases (Lee et al., 2014; Patrick & Schulenberg, 2014; Zahn-Waxler, Shirtcliff, & Marceau, 2008). Given the emergence of psychological problems in adolescence, it is important to identify and assess key precursors in childhood. One such precursor may be children's reactivity to and recovery from stressful events (Repetti, Robles, & Reynolds, 2011). A careful investigation of mood regulation in the context of everyday life can inform our understanding of how responses to stressful events influence youth psychological functioning. We evaluated how mood regulation in response to problems at school predict *change* in internalizing and externalizing problems across a three-year period, as children enter adolescence.

Naturalistic assessment of mood regulation

Intensive repeated methods such as daily diaries offer a unique approach to the assessment of mood responses to specific stressful events (i.e., school problems) as they arise in everyday life. In this study, we operationalize *daily mood dysregulation* as higher levels of negative mood or lower levels of positive mood, in association with more school problems at school that day. *Mood dysregulation* for a particular child is represented by the overall strength of the day-to-day association between school problems and negative or positive mood. For example, some children's daily fluctuations in mood may be closely tied to events at school, while others show little association between events at school and mood that day. Study 1 of this dissertation showed that 5th and 6th graders who tended to report more negative emotion in

response to a stressful event at school have more internalizing problems. Likewise, children who continued to report more negative mood and less positive mood at bedtime following stressful days at school had more internalizing problems (see Study 1). The current study improves on the short diary period and cross sectional design of Study 1. In this study, eight consecutive weeks of daily diaries captured multiple instances of school problems and short-term emotional responses to school problems. We examined the link between problems at school and mood at two different time points, to capture the lingering effects of school problems on child mood: mood on the same day as the school problem, and mood on the next day. Moreover, with follow-up assessments conducted three years after the completion of daily diaries, this study examines prospective associations between mood regulation and youth psychological functioning.

Negative and positive mood represent separate assessment targets, as their effects on subsequent social interactions and psychological functioning differ. A short-term increase in negative mood caused by school problems may spill over to the home environment, leading to more stressful interactions from the perspective of the child (Lehman & Repetti, 2007; Bai, Reynolds, Robles & Repetti, 2016). In contrast, positive mood is theorized to promote action, social connectedness, motivation and cognitive flexibility (Fredrickson, 2001). Thus, a short-term decline in positive mood may lead to withdrawal from social interactions and less support-seeking behavior. Moreover, poor regulation of positive emotion is an important component of depression, bipolar disorders and other externalizing disorders (Gilbert, 2012). Thus, we assess negative and positive mood responses separately, and test negative and positive mood dysregulation as predictors of psychological functioning in adolescence.

The within-person association between school problems and mood on the same day has been established through a number of studies. School-age children and adolescents tend to report

higher levels of negative mood on days when they experience more peer or academic problems at school (Morrow, Hubbard, Barhight, & Thomson, 2014; Nishina & Juvonen, 2005; Schneiders et al., 2006; Timmons & Margolin, 2015). Studies have also indicated that the average child responds to problems at school with lower levels of positive mood on the same day (Flook, 2011; Kiang & Buchanan, 2014; Schneiders et al., 2006). For example, Reavis and colleagues (2015) found that fifth grade students reported more negative mood and less positive mood on days when they experienced a social problem at school in the absence of bystander help.

School problems may continue to affect mood on the next day as well. However, few studies have considered this possibility in youth, and the available tests provide inconsistent results. In one study, peer conflict did not predict emotional distress the next day in a diverse sample of 9th graders (Chung, Flook, & Fuligni, 2011). In another, academic and peer problems did not predict next day negative mood or happiness in 9th and 10th grade Asian-American adolescents (Kiang & Buchanan, 2014). In contrast, Timmons & Margolin (2015) found that academic problems predicted higher negative mood the next day in a sample of 13-17 year old adolescents. There may be considerable individual variability in the extent to which a stressful day at school continues to affect mood on the following day. Although the average child may show no carry over, it is possible that a subset of children – particularly those with poor emotion regulation – do experience high levels of negative mood and low levels of positive mood on the next day.

Few daily diary studies have explored the between-person variability in the strength of the daily association between stressful events and mood. Furthermore, this exploration has been limited to the study of individual-level moderators of the within-person association. For instance, a five-day study of young European adolescents showed that the same day association between

academic problems and anxious mood is strongest among those with more internalizing and externalizing problems (Schneider et al., 2006). The current study took advantage of the between-person variability in the strength of the within-person effect, to derive four individual level indices of mood response: same day negative mood, same day positive mood, next day negative mood and next day positive mood responses to daily problems at school. Using these naturalistic indices, we tested whether mood regulation prospectively predict change in psychological functioning from middle childhood to adolescence.

Prospective links between mood regulation and psychological problems

Social and academic problems at school may detrimentally affect youth mental health. Evidence for the negative influence of peer problems on youth psychological functioning is particularly robust. For example, a teacher's perceptions of a child's acceptance among his or her peers was linked to child psychological symptoms two years later, such that lower ratings of peer acceptance predicted increases in internalizing and externalizing problems (Klima & Repetti, 2008). Academic functioning also predicts youth psychological problems (Obradović, Burt, & Masten, 2009; Shochet, Dadds, Ham, & Montague, 2006). One longitudinal study of pre-adolescents indicated that students' beliefs that they are accepted, valued and respected at school were linked to their psychological adjustment. Poor school connectedness predicted internalizing problems (Shochet et al., 2006). The current study builds on this literature by first examining the within-person links between daily school problems and child mood across 56 consecutive days.

Emotion dysregulation is considered to be a key explanatory process underlying prospective links between exposure to stress in childhood and youth psychological functioning. It consistently predicts internalizing problems, and to a lesser degree, externalizing problems (Hastings, Zahn-Waxler, & Usher, 2007; McLaughlin et al., 2009; Zeman, Shipman, & Suveg,

2002). However, past research has mostly relied self- or parent-report questionnaires about emotion regulation strategies and laboratory paradigms that elicit emotional or physiological responses from children. In contrast, this study utilizes diary methods to assess mood regulation over the course of two months. Diary methods offer several advantages over questionnaires and laboratory paradigms (Bolger, Davis, & Rafaeli, 2003). First, recall biases are minimized by asking participants to report on negative events and mood each day. Second, intensive repeated measures can be used to examine both within and between-individual variability in mood responses because multiple reports are obtained over several days from each participant. Using intensive repeated measures of school problems and mood, we derived individual measures of negative and positive mood dysregulation, and tested their prospective associations to internalizing and externalizing problems three years later.

Current Study

Using data from eight consecutive weeks of daily diaries completed by 47 children between the ages of 8 and 13, we assessed the same day and next day associations between negative school events and child mood. Daily reports of negative and positive mood were examined separately at each time point, resulting in four individual-level indices of mood dysregulation. Youth psychological problems were measured at baseline when the diaries were completed, and three years later. We hypothesized that children who show greater increases in negative mood or decreases in positive mood on days when they experience more school stressors would have more psychological problems at baseline and at the three-year follow-up. As with same day associations, we also predicted that children who continue to report elevated level of negative more or decreased level of positive mood the next day exhibit more psychological problems at baseline and follow-up.

Methods

Participants

Two-parent families with at least one child between the ages of 8 and 13 were recruited in the Los Angeles area through newspaper advertisements, flyers distributed in schools, community centers, medical clinics, and direct mailings. Because the larger study focused on daily family life and susceptibility to upper respiratory infections, at least one parent and the target child were screened for mental and physical health problems, yielding a generally healthy sample free of major chronic illness. Baseline data were collected in three yearly cohorts between the months of September and May (2009-2012). At baseline, 47 target children (19 boys, 28 girls; M age=11.28, SD=1.50) participated, along with all 47 mothers (M age=43.29, SD=6.31) and 39 fathers (M age=43.67, SD=8.10). The sample was ethnically diverse; parents self-identified as 45% non-Hispanic white, 22% Latino/Hispanic, 17.5% African-American, 12.5% Asian, 1.5% Native American and 1.5% "Other". They reported a median personal income within a $31,850 - $82,400 bracket, at baseline.

Three years later, 33 of the 47 youth (15 boys, 18 girls) returned to complete the follow-up assessment when they were between 11 to 17 years old (M age=14.88, SD=1.61). Mothers and fathers had the option of completing a one-time questionnaire about youth psychological problems at the follow-up assessment. For 23 adolescents, parent surveys were completed by mothers only. For 7 adolescents, they were completed by fathers only. Finally, 3 of the adolescents had surveys completed by both mothers and fathers. Each parent received $20 for completing the questionnaire.

The retention rate from baseline to follow up was 70.2%. Youths who completed the follow-up assessment (N=33) did not differ from those lost to follow up (N=14), with respect to

age ($t(23.9)$=-1.02, p=.315), sex ($\chi^2(1)$=1.16, p=.281), maternal race-ethnicity ($\chi^2(4)$=3.20, p=.525), as well as the number of mother-rated internalizing and externalizing problems ($t(36.5)$= -.85, p=.401; $t(28.6)$=-.55, p=.589, respectively).

Procedures

Baseline. The study included extensive data collection procedures, most of which are described elsewhere (Reynolds, Robles, & Repetti, 2016; Sears, Repetti, Reynolds, Robles, & Krull, 2016). During an initial visit that typically occurred in the family's home, researchers discussed study procedures with the family and obtained informed parent consent and youth assent. During a second visit, typically within a week of the first, participants were trained on diary procedures. The eight-week daily diary began on the Saturday following the second visit. Children completed daily diaries every weekday and weekend day, as close to bedtime as possible by using unique usernames and passwords to log into our study web portal. Personalized "home" pages provided a link to the current-day online diary (blocks of items were randomly ordered across days of the week). Paper diaries were available in case of technical difficulties. Child and parent participants also used the study web portal to complete one-time questionnaires about youth psychological symptoms at their convenience during the diary phase. Each child earned up to $300, and each parent, $350 for their participation.

Follow-up. Approximately three years after the baseline assessment, families were contacted to participate in a follow-up assessment. Follow-up procedures were similar to those at baseline, but only involved youth participation and a shorter diary phase. During an initial home visit, researchers obtained parent consent and youth assessment, and reviewed study procedures. Youths completed one-time questionnaires about psychological problems online, within 4 weeks of the home visit. Like the baseline assessment, the follow-up assessment was complex and

included several other procedures for data not included in this study. Each youth earned up to $210 for participation in the follow-up assessment. The university Institutional Review Board (IRB) approved all study procedures at both assessments.

Measures

The current study uses youth daily reports of school problems and mood from the baseline assessment, and youth and parent questionnaire reports of youth psychological problems from the baseline and follow-up assessments. Table 1 presents summary statistics.

Youth daily diary. The 47 children in the study completed a total of 2449 diaries. The average child completed 94% of the 56 diaries (M=52.77, SD=6.64). The current study utilized the weekday subset of daily diaries; youths completed a total of 1,879 diaries on weekdays.

School problems. Daily school problems were assessed using the Youth Everyday Social Interaction and Mood scales (YES-I-AM; Repetti, 1996). On days when they reported having gone to school, children responded to five items about academic problems (e.g., "I made a mistake in class today", "I had trouble finishing my schoolwork today") and five items about peer problems that might have occurred that day (e.g., "Another kid teased me today", "I felt that my friends didn't want to be around me today"). Responses (1=*yes*, 0=*no*) were summed across all 10 items to create a daily school problems score. The school problems score was coded as missing if there were missing responses on one or more of the school problem items that day (n_{obs}=1418). Between-person reliability was high (R_{KF}=.99). Within-person reliability, defined as the ability to reliably detect changes within individuals was acceptable (R_c=.65). The intraclass coefficient (ICC), which indicates the proportion of variance that is attributable to between-individuals differences, was .59.

Negative and positive mood. Measures of daily positive and negative mood used adjectives drawn from prior diary studies (Cohen, Alper, Doyle, Treanor, & Turner, 2006; Doyle, Gentile, & Cohen, 2006; Repetti, 1996). Daily negative mood was assessed with six items (sad, mean, unhappy, tense, angry, worried) and positive mood was assessed with eight items (lively, happy, relaxed, full of energy, cheerful, calm, proud and loved). For each item, children were instructed to rate how they felt or were that day on a four-point response scale, ranging from 1 (*not at all*) to 4 (*all day*). Item responses were averaged each day to create two scale scores reflecting daily negative mood and daily positive mood (n_{obs}=2449). Between-person reliability and within-person reliability for negative mood was 1.00 and 0.72, respectively. Between-person reliability and within-person reliability for positive mood was 1.00 and 0.82, respectively. ICC estimates for negative and positive mood were .56 and .82, respectively.

Questionnaire measures. ***Parent report of youth internalizing and externalizing symptoms***. The Child Behavior Checklist is a widely used 113-item parent questionnaire that assesses parents' report of child emotional and behavioral functioning *(CBCL;* Achenbach, 2009*)*. It shows good psychometric properties, including high test-retest reliability and high external validity (Achenbach, 2009). The current study used the Internalizing Problems (31 items; withdrawn, somatic complaints and anxious/depressed subscales) and Externalizing Problems (33 items; aggressive and delinquent behaviors subscales) broad-band scales. At baseline and at the follow-up assessment, mothers and fathers independently rated items on a 0 (not true) to 2 (very true or often true) scale. Items were averaged for each rater with higher scores indicating more internalizing or externalizing problems. In the current study, internal consistency of the broad-band scales at baseline and follow-up for mothers and fathers ranged from .81 to .93. Because of the strong correlation between mother and father CBCL scores at

baseline ($r(37)$ = .67 and .68 for internalizing problems and externalizing problems, respectively), we averaged mother and father reports whenever both reports were available at baseline and follow-up.

Depressive symptoms. Child Depression Inventory – Short Form (CDI; Kovacs, 1985, 1992) is a 10-item questionnaire that assesses children's self-reports of affective, behavioral, somatic and cognitive symptoms of depression. At baseline and at the follow-up assessment, children responded to each item by indicating which of three sentences best describe how they have felt during the last two weeks (e.g., "I am sad once in a while, I am sad many times, I am sad all the time"). Response options ranged from 0 to 2, and items were averaged. The CDI shows strong psychometric properties, including high test-retest reliability, concurrent validity and predictive validity for depression (Carey, Faulstich, Gresham, Ruggiero, & Enyart, 1987). In the current study, Cronbach's alpha values for this measure were .81 at baseline and .88 at follow-up.

Data Analysis

Data analysis was conducted in three steps. First, we conducted multilevel linear regression analyses (PROC MIXED in SAS), to derive individual-level estimates of same day and next day associations between school problems and negative and positive mood. Second, we evaluated the bivariate associations between same day and next day mood dysregulation and youth psychological problems at baseline and follow-up. Third, we conducted multiple linear regression analyses to test whether same day and next day mood dysregulation separately predict three-year change in youth psychological problems, over and above demographic variables and baseline symptoms levels. All analyses were conducted on SAS 9.4 software or Stata 13.1 software.

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Results

Deriving indices of mood dysregulation

First, we tested four multilevel models (MLM) examining the within-person associations between school problems and four mood outcomes: negative and positive mood on the same day and next day. School problems were grand mean centered and a first order autoregressive structure was specified for residuals to correct for time dependencies in the daily reports. In each MLM, the intercept and slope of school problems were allowed to randomly vary between individuals, making it possible to extract individual-level empirical Bayes (EB) estimates of the intercept and slope. Each EB slope represented the unique association between school problems and mood for that child (Mohr et al., 2013; Nezlek, 2012; Robles et al., 2016). In order to extract EB slopes as predictors, the random effect of school problems on mood had to be statistically different from zero using a cut-off level of $p=.10$. Table 1 presents descriptive statistics for the four indices of mood dysregulation. We use the term "same day mood dysregulation" to refer to the daily association between school problems and mood observed in a child's data collected over 8 weeks. The term "next day mood dysregulation" refers to the association between a child's exposure to school problems and his or her mood on the following day.

Same day negative mood and positive mood were separately examined as the dependent variable in two MLMs. For the average child, more school problems was associated with higher levels of negative mood on the same day ($B=0.06$, $SE=.01$, $t=5.24$, $p<.001$, 95% CI [0.04, 0.08]). The random effect was significant, suggesting that there was considerable between-person variability on the magnitude of that association (Variance$=0.002$, $SE=0.001$, $z=1.92$, $p=.027$) (see Figure 1). Mean same day negative mood dysregulation across the 47 children was equivalent to the average within-person effect ($M=0.06$). Children's scores ranged from 0.01 to

0.12, indicating that some children showed no link between reports of school problems and negative mood on the same day, while other children evidenced a strong association between stressors at school and mood that day.

Likewise, for the average child, more school problems was associated with lower levels of positive mood on the same day (B=-0.08, SE=0.02, t=-4.76, p<.001, 95% CI [-0.11, -0.05]). As shown in Figure 1, the random effect on this slope was also significant (Variance=0.005 SE=0.002, z=2.28, p=.011), suggesting significant between-person variability. When deriving individual-level measures of same day positive mood dysregulation, EB estimates were reverse coded (multiplied by -1) for ease of interpretation. Higher values indicate a greater decrease in positive mood in association with more school problems. Thus, mean same day positive mood dysregulation was equal in magnitude but reversed in direction, relative to the average within-person effect of school problems on positive mood (M=0.08). Same day positive mood dysregulation ranged from 0 to 0.20 across 47 children. As was the case for negative mood, there was no association between daily exposure to school problems and positive mood that day for some children. However, for other children, school problems were linked to less positive more and more negative mood the next day

Next, two MLMs separately tested the within-person association between school problems and negative and positive mood on the next day. We conservatively controlled for next day school problems in order to assess next day mood dysregulation over and above the effect of any new or persisting school problems. For the average child, more school problems did not significantly predict next day negative mood (B=0.01, SE=0.01, t=0.79, p=0.431, 95% CI [-0.02, 0.04]) controlling for next day school problems. Although the average child did not show an association between school problems and next day negative mood, the random slope effect was

marginally significant (Variance= 0.003, SE=0.002, Z=1.49, p=.068), suggesting considerable between-person variability on the strength of this association (see Figure 1). Mean next day negative mood dysregulation was equivalent to the unstandardized B coefficient (M=0.01) and ranged from -0.12 to 0.09. Thus, for some children in this study, there was an inverse association between reports of school problems and negative mood ratings the following day. A higher next day negative mood dysregulation score indicates that that child's daily data showed a strong positive link between school problems and next day negative mood.

Likewise, the within-person association between school problems and next day positive mood was not significant (B=0.003, SE=0.02, t=0.19, p=.846, 95% CI [-0.03, 0.04]), when controlling for next day school problems. However, the random slope effect was marginally significant (Variance=0.004, SE=0.003, Z=1.46, p=.072), suggesting considerable between-person variability in next day positive mood dysregulation (see Figure 1). EB estimates of the within-person association between school problems and next day positive mood were reverse coded (multiplied by -1) for ease of interpretation. Higher values indicate a greater decline in positive mood in association with more school problems the previous day. The average next day positive mood dysregulation score was -0.003, and the range across all children in the study was -0.11 to 0.05.

Correlations between mood dysregulation and youth psychological problems

Next, we examined Pearson correlations between four indices of mood dysregulation, three measures of youth psychological problems at baseline, and three measures of youth psychological problems at follow-up (see Table 2). First, we describe the correlations between same day and next day indicators of mood dysregulation. Then, we report the cross-informant correlations for measures of youth psychological problems across the two assessments. Third, we

report the cross-sectional and prospective links among the four indices of mood dysregulation and youth psychological problems at baseline and follow-up. Prior to conducting these correlations, all outliers were winsorized to 2.5 x SD.

Four correlations tested the associations between two individual-level measures of same day mood dysregulation and two individual-level measures of next day mood dysregulation (See Table 2). Higher same day negative mood dysregulation scores were correlated with higher same day positive mood dysregulation scores. The children who tended to report more negative mood on high-stress school days were the same children who tended to report less positive mood on those days. Likewise, higher next day negative mood dysregulation scores were correlated with higher next day positive mood dysregulation scores. Children who continued to show more negative mood on the day following stressful events at school also tended to show lower levels of positive mood the day after exposure to minor school stressors. Same day mood dysregulation scores were not correlated with next day mood dysregulation scores for either positive or negative mood dysregulation. Notably, the average level of daily school problems that a child reported over the course of the study was not correlated with any of the same day or next day mood dysregulation scores.

The correlations among ratings of youth psychological problems are also reported in Table 2. Children's reports of depressive symptoms were not correlated with parent ratings of internalizing problems or externalizing problems at baseline. However, at follow-up, the parents of children who self-reported more symptoms of depression also reported that their children displayed more internalizing problems. Child ratings of depression symptoms at baseline were not correlated with self-reported depression at follow-up. Parents who reported more internalizing problems also reported more externalizing problems at both assessments. Unlike

child ratings of depressive symptoms, parent ratings of internalizing and externalizing problems were highly stable across the three-year period.

Next, we tested Pearson correlations between the two measures of same day mood dysregulation and three baseline measures of youth psychological problems (internalizing problems, externalizing problems, depression). As displayed in Table 2, only one out of six correlations was statistically significant. Same day negative mood dysregulation was not correlated with any measure of youth psychological problems at baseline. However, greater same day positive mood dysregulation was correlated with fewer child depression symptoms.

We also examined the prospective links between two measures of same day mood dysregulation at baseline, and three measures of youth psychological problems at follow-up. Out of six correlations, three were statistically significant. As shown in Table 2, higher levels of same day negative mood in response to school problems predicted more internalizing problems and externalizing problems three years later. It did not predict depression symptoms. Higher levels of same day positive mood dysregulation predicted more externalizing problems at the three year follow up, but not internalizing problems or depression.

Next, we tested the correlations between two measures of next day mood dysregulation to school problems and three measures of youth psychological functioning at baseline. As shown in Table 2, none of the six correlation tests were statistically significant. Next day negative mood and positive mood dysregulation to school problems were not linked to internalizing problems, externalizing problems or depression symptoms at baseline. Finally, we evaluated the prospective links between the two measures of next day mood dysregulation at baseline and three measures of youth psychological problems at follow-up. Only one out of six correlations was significant (see Table 2). Children who showed weaker next day associations between school

problems and positive mood at baseline had more externalizing problems three years later. Average level of school problems at baseline was not correlated with any measure of psychological problems at follow-up.

Mood dysregulation predicting three-year change in youth psychological problems

A final set of multiple linear regression analyses tested the hypothesis that same day and next day mood dysregulation scores would predict changes in youth psychological problems over a three-year period. Six regression models tested same day mood dysregulation, and six others tested a next day mood dysregulation score as the main predictor variable. All predictor variables were grand mean centered and all outliers winsorized to 2.5 x SD. With respect to covariates, the model controlled for child sex (male = 0, female = 1), grand mean centered age in years at baseline, and the baseline symptom score that corresponded to the outcome of interest at follow-up (e.g., controlled for baseline depressive symptoms in the prediction of depressive symptoms at follow-up). Finally, we tested whether child sex moderated the main effect of mood dysregulation in all models.

Same day negative mood and positive mood dysregulation were separately examined as predictors of internalizing problems, externalizing problems and depression symptoms in six separate linear regression models. As displayed in Table 3, three of the six tests were statistically significant. Greater same day negative mood dysregulation predicted increases in internalizing problems and externalizing problems three years later (See Figures 2 and 3), but did not predict depressive symptoms at follow-up. Same day positive mood did not predict change in internalizing or externalizing problems three years later. However, greater positive mood dysregulation predicted increases in depression symptoms, over and above baseline symptom levels (See Figure 4). None of these patterns was moderated by child sex.

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We also tested the prospective association between next day negative mood and positive mood dysregulation at baseline and youth psychological problems three years later. Next day negative mood and positive mood dysregulation were separately examined as predictors of internalizing problems, externalizing problems and depression symptoms, as shown in Table 4. Greater next day negative mood dysregulation did not predict future internalizing problems, externalizing problems or depression symptoms three years later, over and above baseline scores, child sex and age. Lower levels of next day positive mood dysregulation predicted *increases* in externalizing problems, but not internalizing problems or depression symptoms. As in the previous models, there were no child sex differences in the pattern of results.

Discussion

Using longitudinal daily diary data, the current study took a unique approach to assess mood regulation in 8 to 13 year-old children, and examined its prospective links to psychological problems in adolescence. We used 40 school days of daily diaries completed by 47 youths to assess how problems at school are associated with negative and positive mood that day, and on the next day. The strength of the same day and next day association between problems at school and mood varied significantly between children. Based on this variability, we derived four individual-level indices of mood regulation: negative and positive mood on the same day and next day following reports of negative events at school. We found that the children who reported greater negative mood on days when they experienced more school problems had higher levels of parent-reported internalizing and externalizing symptoms three years later, over and above baseline symptom levels. The children who described less positive mood on days when they experienced more problems at school showed increases in self-reported depressive symptoms from childhood to adolescence. Next day mood response was not consistently linked to

psychological problems in adolescence. Our results suggest that a child's daily mood dysregulation in response to naturally arising problems at school may be a risk factor for psychological maladjustment in adolescence.

Naturalistic assessment of mood regulation

As previously reported, children reported higher negative mood and lower positive mood on days when they experience more problems at school (Bai et al., 2016). However, for the average child, the effect of school problems on mood did not linger to the next day, over and above the effect of new stressful events. The current study extends prior research by focusing on individual differences in the magnitude of these daily associations. Our data show that the strength of the within-person associations between problems at school and mood on the same day or next day differs between individuals. Whereas school problems may be linked to higher levels of negative mood or lower levels of positive mood on the next day for some children, other youth report less negative mood or more positive mood on the next day when controlling for the effect of any new school problems. Such differences in mood regulation may underlie between-person variability in the magnitude of the associations between school problems and mood. For example, a child who shows a strong association between school problems and negative mood on the same day and next day may be more reactive and have greater difficulty modulating the duration of his or her negative emotional states.

We derived four measures of mood dysregulation using intensive repeated measures of school problems and mood: same day negative and positive mood, and next day negative and positive mood. By deriving these measures and testing their predictive validities, we demonstrated a novel approach to measuring emotion regulation in youth. Youth emotion regulation is typically measured using parent- or child-rated questionnaires, or laboratory

paradigms that provoke emotional reactions. Although these approaches have been critical to our understanding of emotion regulation, they are not without limitations. For instance, questionnaires that assess children's emotional reactions to stressful events place the burden of recall on the respondent. Although laboratory assessments of emotion regulation eliminate respondent biases, they prioritize standardization across individuals, and may present stressful situations that youths do not typically encounter in their daily lives. The daily diary approach complements existing methodologies. Because children report on school events and mood daily, our approach minimizes the cognitive burden of recall. More importantly, this approach measures mood responses to real problems that arise in the context of everyday life. Thus, our approach contributes a unique, ecologically valid perspective on emotion regulation.

Prospective links to psychological functioning in adolescence

The daily diary-based measures of mood regulation prospectively predicted three-year growth in parent-reported internalizing and externalizing problems and youth-rated depression symptoms, with the control of baseline symptomatology, age, and child sex. Specifically, higher same day negative mood dysregulation scores predicted increases in parent-reported internalizing problems and externalizing problems. Higher levels of same day positive mood dysregulation (less positive mood on more stressful days) predicted increases in youth self-reported depressive symptoms three years later. These findings are in line with existing research, which suggest that poor emotion regulation in childhood is prospectively linked to more psychological symptomatology, such as depressive symptoms and externalizing problems, in adolescence (Eisenberg et al., 2001; Silk, Steinberg, & Morris, 2003; Zeman et al., 2002).

Findings contribute to a limited evidence base on the role that positive mood regulation plays in psychological adjustment. Youths who reported less positive mood on high-stress days

at school showed increases in depressive symptoms three years later, over and above baseline levels of depressive symptoms. However, youths who tended to report higher levels of positive mood on the day after a stressful school day were described by their parents as displaying more externalizing problems at the three-year follow-up. Recent research suggests that difficulty up-regulating positive emotions and an excess of positive emotion can underlie several psychological problems (Carl, Soskin, Kerns, & Barlow, 2013; Gilbert, 2012). In adults, difficulties engaging in positive experiences, sustaining positive mood, and using reappraisal to increase positive mood, are observed in depressed individuals (Carl et al., 2013). The role of positive emotion in externalizing problems is less consistent. However, in younger children, more extraversion, characterized as assertiveness, high energy and talkativeness, is associated with more externalizing problems (Malouff, Thorsteinsson, & Schutte, 2005). Extraversion may underlie the tendency among some children in our study to report higher than expected levels of positive mood on the days following stressful days at school.

Notably, a child's average number of school problems (computed over 40 days) at baseline was not correlated with mood dysregulation at baseline, or psychological functioning at follow-up. Mood dysregulation in response to problems at school, but not average exposure to school problems, predicted internalizing and externalizing symptoms in adolescence. This finding may reflect the low rate of school problems for most of the children in our sample. Peer and academic problems may negatively shape mental health at higher intensities or frequencies than those experienced by the majority of children in this study.

It is striking that, even though problems were relatively infrequent in our sample, individual differences in the daily association between school problems and same day mood predicted psychological functioning in adolescence. These individual difference scores, which

we treat as indicators of one aspect of emotion regulation, may reflect trait-like precursors to psychological problems. They may also reflect cumulative dysfunction in the emotion regulation system that results from its repeated reactions to stressful events outside of the school.

Limitations and future directions

There are several characteristics of this study that limit generalizability of findings. First, our small sample was composed of relatively healthy children from two-parent homes in a large metropolitan city. The size and characteristics of our sample constrained our statistical power to assess important moderators, such as quality of the parent-child relationship and average exposure to stress. Second, peer and academic problems were infrequently endorsed by our sample. However, the long diary duration (40 weekdays) helped to increase variability within and between individuals, and to more reliably assess individual differences in the link between school problems and mood. Third, children were instructed to complete one diary each day; also to reduce burden of participation in light of the 8-week diary period. Thus, it is possible that the within-person association between school problems and mood are confounded by the effects of state-dependent recall. Moreover, we cannot ascertain the direction of the within-person association, and youths may report more problems on days that they are experiencing more negative mood. However, the consistency between current findings and findings in Study 1 provide further credence to the assumption that school problems influence mood.

Despite these limitations, this study is one of the first to use naturalistic methods to examine the developmental sequela of daily mood responses to stressful events. We found that youths who reported more negative mood on days that they experienced problems at school show increases in internalizing problems and externalizing problems from childhood to adolescence. Likewise, children who reported less positive mood on high stress school days, showed an

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increase in symptoms of depression in adolescence. Mood responses to negative events –

however minor – may be an important predictor of psychological problems in adolescence.

Researchers should continue to explore the use of intensive repeated methods to naturalistically

assess emotion regulation and examine its stability over time, as well as its effects on

development.

Table 2-1

Descriptive statistics for same day and next day mood dysregulation at baseline and youth psychological symptoms at baseline and follow-up

	N	Mean	SD	Min	Max
AGGREGATED DAILY VARIABLES					
School problems	47	0.62	1.14	0	7.37
Negative mood	47	1.27	0.29	1.01	2.28
Positive mood	47	2.97	0.70	1.64	3.99
SAME DAY MOOD DYSREGULATION					
Negative mood	47	0.06	0.03	0.01	0.12
Positive mood [a]	47	0.08	0.04	0	0.20
NEXT DAY MOOD DYSREGULATION					
Negative mood	47	0.01	0.03	-0.12	0.09
Positive mood [a]	47	-0.003	0.04	-0.11	0.05
BASELINE PSYCHOLOGICAL SYMPTOM SCORES					
Parent – Internalizing	47	0.11	0.12	0	0.56
Parent – Externalizing	47	0.13	0.13	0	0.47
Child – CDI	47	0.20	0.26	0	1.20
FOLLOW-UP PSYCHOLOGICAL SYMPTOM SCORES					
Parent – Internalizing	33	0.13	0.16	0	0.58
Parent – Externalizing	33	0.13	0.16	0	0.58
Child – CDI	33	0.37	0.39	0	1.40

[a] Values were reverse coded (multiplied by -1) for ease of interpretation; Higher scores indicate children showed greater decrease in positive mood in association with school problems.

Table 2-2

Correlation matrix of same day and next day mood dysregulation scores and youth symptoms at baseline and follow-up

	1	2	3	4	5	6	7	8	9	10	11	12	13
AGGREGATE DAILY VARIABLES													
1 School problems	1												
2 Negative mood	.65***	1											
3 Positive mood	-.23	-.37*	1										
SAME DAY MOOD DYSREGULATION													
4 Negative mood	.27	.30*	-.04	1									
5 Positive mood	-.14	-.04	.46**	.43**	1								
NEXT DAY MOOD DYSREGULATION													
6 Negative mood	.17	-.19	-.04	.22	-.2	1							
7 Positive mood	.13	-.02	.31*	-.01	-.05	.45***	1						
BASELINE SYMPTOM SCORES													
8 Parent – Internalizing	.13	.09	-.11	.03	.04	-.13	-.1	1					
9 Parent – Externalizing	-.05	-.04	.03	.25	.26	-.05	-.04	.70***	1				
10 Child – CDI	.53***	.50***	-.45**	-.12	-.48***	.07	.25	.13	-.17	1			
FOLLOW-UP SYMPTOM SCORES													
11 Parent – Internalizing	.05	.24	-.11	.44*	.22	-.1	-.1	.66***	.60***	-.05	1		
12 Parent – Externalizing	.08	.23	-.07	.51**	.47**	-.21	-.35*	.41*	.62***	-.24	.66***	1	
13 Child – CDI	.30	.36*	-.13	.26	.21	.23	.29	.29	.42*	.29	.34*	.27	1

* $p < .05$, ** $p < .01$, *** $p < .001$; All variables winsorized to 2.5xSD above the mean

Table 2-3

Results of six multiple regression models, each separately testing the prospective association between same day mood dysregulation to school problems and youth psychological symptoms at follow-up

	OUTCOME VARIABLES AT FOLLOW-UP								
	Internalizing problems			Externalizing problems			Depression sx		
PREDICTOR	Beta	t	p	Beta	t	p	Beta	t	p
Same day negative mood dysregulation	0.39	3.07	.005	0.41	2.85	.008	0.20	1.18	.247
F Statistic	$F_{(4, 28)}=10.31$, p<.001			$F_{(4, 28)}=8.23$, p<.001			$F_{(4,28)}=2.75$, p=.047		
R^2	.60			.54			.28		
Same day positive mood dysregulation	0.16	1.11	.276	0.26	1.63	.115	0.46	2.75	.010
F Statistic	$f_{(4, 28)}=6.52$, p=.001			$F_{(4, 28)}=5.91$, p=.001			$F_{(4, 28)}=4.80$, p=.005		
R^2	.48			.46			.41		

*p<.05; Models control for child sex (male=0, female=1), baseline age (centered), and baseline symptom levels of outcome variable; primary predictor variable and ratings of youth psychological symptoms were winsorized to 2.5xSD above the mean.

Table 2-4

Results of six multiple regression models, each separately testing the prospective association between next day mood dysregulation to school problems and youth psychological problems at follow-up

	OUTCOME VARIABLES AT FOLLOW-UP								
	Internalizing problems			Externalizing problems			Depression sx		
PREDICTOR	Beta	t	p	Beta	t	p	Beta	t	p
Next day negative mood dysregulation	-.12	-0.86	.399	-.19	-1.36	.184	.11	0.63	.533
F Statistic	$F_{(4, 28)}=6.28$, p=.001			$F_{(4, 28)}=5.58$, p=.002			$F_{(4, 28)}=2.42$, p=.072		
R^2	.47			.44			.30		
Next day positive mood dysregulation	-.04	-0.33	.746	-.36	-2.76	.010	.24	1.47	.152
F Statistic	$F_{(4, 28)}=5.99$, p=.001			$F_{(4, 28)}=7.99$, $p < .001$			$F_{(4, 28)}=3.01$, p=.035		
R^2	.46			.53			.30		

*p<.05; Models control for child sex (male=0, female=1), baseline age (centered), and baseline symptom levels of outcome variable; primary predictor variable and ratings of youth psychological adjustment were winsorized to 2.5xSD above the mean.

Figure 2-1

Within-person associations between school problems and negative and positive mood on the same day and next day

Average within-person slope
Individual EB estimates of within-person slope

Figure 2-2

Scatterplot of the prospective association between same day negative mood dysregulation and parent report of internalizing problems at follow-up

Figure 2-3

Scatterplot of the prospective association between same day negative mood dysregulation and parent report of externalizing problems at follow-up
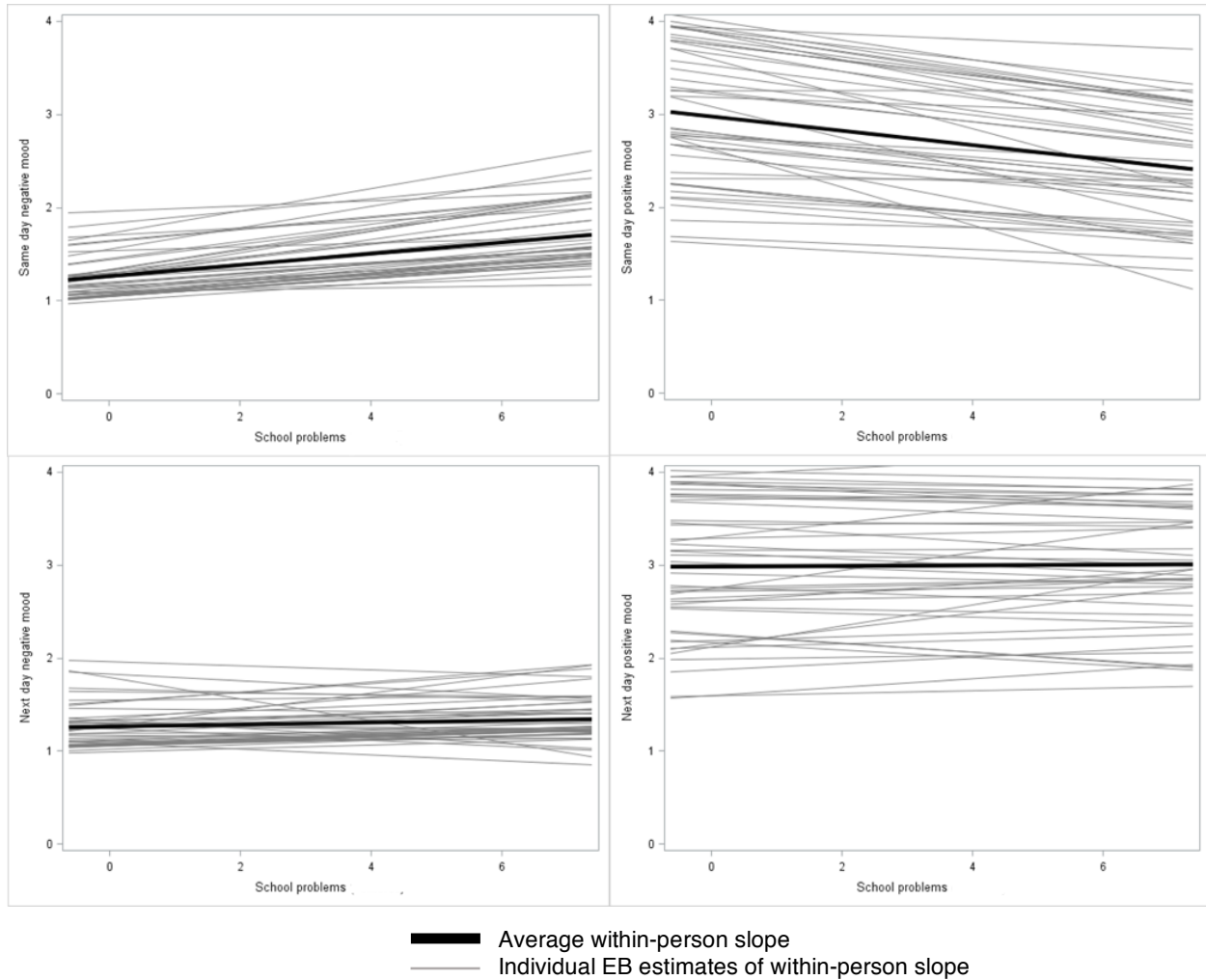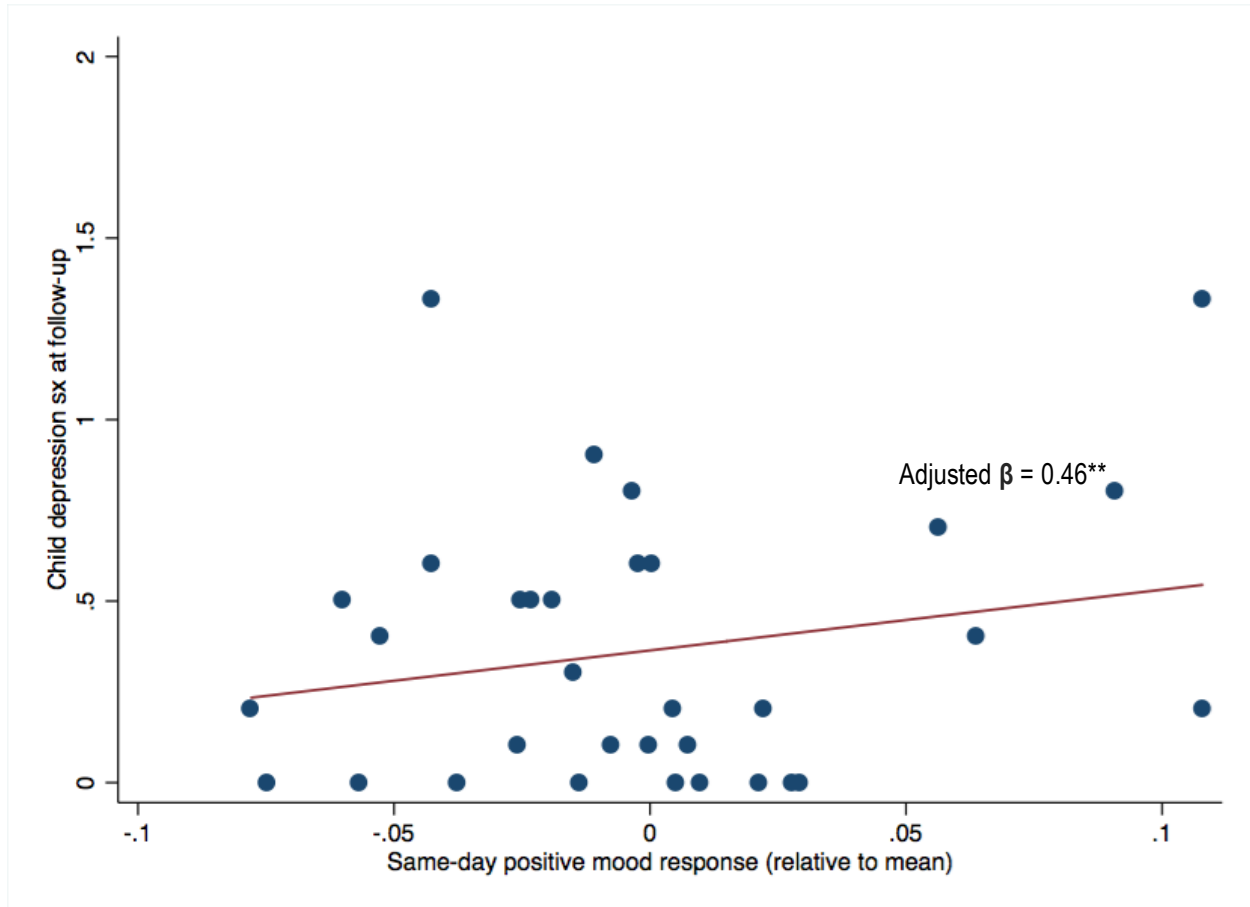
Figure 2-4

Scatterplot of the prospective association between same day positive mood dysregulation and child depression symptoms at follow-up

Appendix 2-1

Child Daily Diary School Event Scales

All scale scores are sums; Response Options: 0 = *no*, 1 = *yes*

PEER PROBLEMS AT SCHOOL (5 items)
1. I felt that my friends didn't want to be around me today.
2. Another kid teased me today.
3. I felt that that my friends were talking about me behind my back today.
4. I got into a fight with another kid today.
5. One of my friends was mad at me today.

ACADEMIC PROBLEMS AT SCHOOL (5 items)
1. My schoolwork was too hard today.
2. I made a mistake in class today.
3. I had trouble finishing my schoolwork today.
4. I had trouble learning something new today.
5. I received a bad grade on a test or paper today.

Appendix 2-2

Child Daily Diary Positive and Negative Mood Scales

All scale scores are means; Response Options: 1 = *not at all*, 2 = *some of the day*, 3 = *most of the day*, 4 = *all day*

CHILD POSITIVE MOOD   (8 items)
1. Lively
2. Happy
3. Relaxed
4. Full of energy
5. Cheerful
6. Calm
7. Proud
8. Loved

CHILD NEGATIVE MOOD (6 items)
1. Sad
2. Mean
3. Unhappy
4. Tense
5. Angry
6. Worried

STUDY 3

CHILDREN'S DIURNAL CORTISOL RESPONSES TO NEGATIVE EVENTS AT SCHOOL

AND HOME

Abstract

This study examined the within-and between-person effects of daily negative events –
peer problems, academic problems and interparental conflict – on diurnal cortisol in school-age
children. Salivary cortisol levels were assessed four times per day (at wakeup, 30 minutes later,
just before dinner and at bedtime) across eight days in 47 youths ages 8 to 13 years old (60%
female; M age=11.28, SD=1.50). The relative influences of within- and between-person
variances in each stressor were tested with three indices of diurnal cortisol: same-day diurnal
cortisol slope, bedtime cortisol, and next morning wakeup cortisol. Children who reported more
peer problems on average showed flatter slopes of cortisol decline from wakeup to bedtime.
However, children secreted more cortisol at wakeup following days when they reported more
peer or academic problems than usual. Interparental conflict was not significantly associated
with diurnal cortisol. Findings from this study extend our understanding of short-term cortisol
responses to naturally occurring problems in daily life, and help to differentiate these daily
processes from the cumulative effects of chronic stress.

Keywords: diurnal cortisol; daily diary methods; peer problems; academic problems;
interparental conflict; hypothalamic-pituitary-adrenal axis

Children's Diurnal Cortisol Responses to Negative Events at School and Home

Daily life presents children an assortment of challenges, with some days being more stressful than others. Early exposure to high levels of chronic psychosocial stress can negatively affect mental health, in part through its impact on one physiological stress response system, the hypothalamic-pituitary-adrenal (HPA) axis (Repetti, Taylor, & Seeman, 2002). This research has focused on the individual as the primary unit of analysis, examining between-person differences in stress exposure and stress reactivity (Miller, Chen, & Zhou, 2007; Peters, Riksen-Walraven, Cillessen, & de Weerth, 2011; Repetti et al., 2002). Few studies, however, have examined how the ups-and-downs of daily life affect children's cortisol on the same day or on the next day.

The HPA axis secretes cortisol in a strong circadian rhythm, such that cortisol peaks during the first 30 minutes after wakeup (cortisol awakening response; CAR) and then declines throughout the day (Adam & Kumari, 2009). According to the concept of allostatic load, repeated exposure to stress leads to wear-and-tear on physiological stress response systems and thereby contributes to negative health consequences and psychiatric disorders (McEwen, 1998; Repetti, Robles, & Reynolds, 2011). Naturalistic studies suggest that the HPA axis responds to daily fluctuations in psychosocial experiences in the lives of youths (Lippold, Davis, McHale, Buxton, & Almeida, 2016; Sladek & Doane, 2014). However, the relative influence of within-person and between-person variance in everyday problems on cortisol has rarely been evaluated in children. The current study focuses on three types of common negative events – problems with peers, academic difficulties and interparental conflict – to examine how their daily fluctuations, as opposed to average levels, relate to diurnal cortisol patterns.

Negative events and diurnal cortisol in middle childhood

Middle childhood is characterized by increasing salience of peers, more academic

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demands, and greater emotional awareness and social perception (Roeser, Eccles, & Sameroff, 2000). These changes can be stressful, and together with the onset of puberty, may impact HPA axis functioning (Marceau, Ruttle, Shirtcliff, Essex, & Susman, 2015). Investigations of the short-term effects that minor negative events have on diurnal cortisol may help us understand a longer-term process of biological adaptation to social demands in middle childhood.

Past studies have revealed between-person associations between diurnal cortisol and stressors in the peer, academic and family arenas. School-age children and adolescents who experience more peer problems show flatter diurnal slopes and lower levels of morning cortisol (Peters et al., 2011; Vaillancourt et al., 2008). Children in non-supportive classrooms and those with more conflictual relationships with their teachers have flatter slopes of cortisol decline than do those in more supportive school environments (Ahnert, Harwardt-Heinecke, Kappler, Eckstein-Madry, & Milatz, 2012). Likewise, children who are more frequently exposed to interparental conflict show more dysregulated HPA axis functioning, indicated by higher average levels of cortisol at rest and flatter diurnal cortisol slopes across the day (Lucas-Thompson, 2012; Lucas-Thompson & Hostinar, 2013). Despite evidence of between-person links between cortisol indices and problems at home and school, few studies have investigated the daily influence of such problems by studying these associations at the within-person level of analysis.

Daily links between negative events and diurnal cortisol

The diurnal cortisol rhythm is sensitive to daily psychological experiences, over and above individual differences. Over fifty percent of the total variability in cortisol is attributable to within-person variance (Ross, Murphy, Adam, Chen, & Miller, 2014; Rotenberg, McGrath, Roy-Gagnon, & Tu, 2012). Comparing the relative influences of within-person and between-person differences in daily problems will help differentiate adaptive short-term responses to

acute stress from more trait-like consequences of repeated stress exposure.

To our knowledge, only three published studies have tested links between daily experiences and diurnal cortisol in children (Lippold, Davis, et al., 2016; Lippold, McHale, Davis, Almeida, & King, 2016; McHale et al., 2012). Lippold and colleagues collected saliva samples four times per day and conducted daily telephone interviews with 9- to 17-year-old youths (Lippold, Davis, et al., 2016; Lippold, McHale, et al., 2016). Their studies showed that more daily stress, including more negative parent-child interactions, is connected to higher bedtime levels of cortisol and flatter slopes of cortisol decline from evening to bedtime on the same day, over and above average levels of stress (Lippold, Davis, et al., 2016; Lippold, McHale, et al., 2016). In a different study of 10-18 year olds, McHale and colleagues (2012) found that more time spent on schoolwork, on average, was linked to generally lower levels of cortisol. However, spending more time on schoolwork than usual was linked to more cortisol secretion on that day (McHale et al., 2012). These naturalistic studies suggest that diurnal cortisol may be sensitive to daily fluctuations in the psychosocial experiences during middle childhood and adolescence. However, the evidence base is very limited, and no studies have examined the effects of negative events on cortisol the next morning in children. Examining the within-person link between negative events and next morning cortisol will contribute to our understanding of HPA axis recovery from acute problems in daily life (Doane & Adam, 2010; Saxbe, Repetti, & Nishina, 2008; Sladek & Doane, 2014).

Current Study

We examined within-and between-person effects of three daily stressors – peer problems, academic problems and interparental conflict – on the diurnal cortisol of 47 8-13-year-old children. Cortisol was assayed from saliva sampled four times per day on eight days. We tested

associations between daily reports of each type of stressor and diurnal cortisol slope, as well as cortisol levels both at bedtime and at wakeup the next morning.

Methods

Participants

Two-parent families with at least one child between the ages of 8 and 13 were recruited from the Los Angeles area through newspaper advertisements, flyers distributed in schools, community centers, medical clinics, and direct mailings. Because the larger study focused on daily family life and susceptibility to upper respiratory infections, youths were screened for mental and physical health problems, yielding a generally healthy sample free of major chronic illness. Forty-seven children (19 boys, 28 girls; M age=11.28 years, SD=1.50) participated in the study. The sample was ethnically diverse; parents of youth participants self-identified as 45% non-Hispanic white, 22% Latino/Hispanic, 17.5% African-American, 12.5% Asian, 1.5% Native American and 1.5% "Other". They reported a median personal income within a $31,850 - $82,400 bracket. 57% of mothers (59% of fathers) attained at least a bachelor's degree or higher.

Procedures

The study included extensive data collection procedures, most of which are described elsewhere (Kuhlman, Repetti, Reynolds, & Robles, 2016; Reynolds, Robles, & Repetti, 2016). During an initial visit in the family's home, researchers described study procedures and obtained informed parent consent and youth assent. During a second visit, within a week of the first, participants were trained on diary and saliva collection procedures. An eight-week (56 consecutive days) daily diary phase began on the Saturday following the second visit. From Saturday to Tuesday during weeks 3 and 6 of the daily diary phase (study days 15-18 and 36-39), participants provided samples of passive drool saliva four times daily. Each child could earn up

to $300 for completing all data collection procedures across 56 days. In the current study, we used diary data collected from study days 14 to 18 and 35 to 39 (10 total days of child diaries) in correspondence with saliva sampling procedures. See Figure 1 for more information on the study timeline. The university Institutional Review Board (IRB) approved all study procedures.

Daily diaries. Children completed online daily diaries, as close to bedtime as possible, using unique usernames and passwords to log into our study web portal. Personalized "home" pages provided a link to the current-day online diary, which randomly ordered blocks of items across days of the week. Paper diaries were available in case of technical difficulties. A diary was considered compliant if completed before 9am the next day. On average, children completed 94% of all assigned diaries (M=52.77, SD=6.64), for a total of 2449 diaries completed by youths.

Cortisol collection. Saliva samples were collected in cryogenic vials four times each day: wakeup, 30 minutes post-wake, before dinner and before bedtime. Across eight days, each child provided up to 32 samples. Participants were given twist-cap bottles containing 4-inch straws to aid in the passive drool technique. Although only 29% of the participating children received an actual MEMS 6 Track Cap, every participant was informed that the twist-caps had a device to track bottle openings to increase compliance with study procedures (Kudielka, Broderick, & Kirschbaum, 2003). Fidelity in sample timing for this subsample was 97.6% (Kuhlman et al., 2016). Participants recorded sample timing with an electronic date-time stamp on a paper form to further confirm compliance. In addition, we pre-assigned each vial to a specific day and sample time (e.g., "saliva day 4, wakeup sample") and assigned randomly generated numbers to each pre-labeled vial. Participants recorded the number of the vial that they used, as they provided each saliva sample. Participants also recorded whether they took medication, ate, brushed teeth, consumed caffeine, or exercised vigorously 30 minutes prior to each sample. Samples were

stored in the family freezer until retrieval by research staff for storage in a -20° Celsius freezer. Cortisol was assayed using chemiluminescent immunoassay by the Biological Psychology Laboratory at the Technical University of Dresden, under the direction of Dr. Clemens Kirschbaum. This procedure had a lower limit sensitivity of .003 μg/dL and samples that were below this limit or above 60 μg/dL were excluded from analyses. Cortisol values were natural log transformed prior to analysis to control for positive skew in the data.

Measures

See Table 1 for descriptive statistics for all variables. Intraclass coefficients, which index the proportion of variance in repeated measures data that is attributable to between-person differences, are also presented.

Peer and academic problems. Peer and academic problems were assessed using items from the Youth Everyday Social Interaction and Mood scales (Repetti, 1996). On days when children reported having gone to school, they completed 5 items assessing peer problems (e.g., "Another kid teased me today", "I felt that my friends didn't want to be around me today") and 5 items assessing academic problems (e.g., "I made a mistake in class today", "I had trouble finishing my schoolwork today"). Responses (1=yes, 0=no) were summed to create a daily peer problems score and a daily academic problems score. Mean Cronbach's alphas across the 6 daily ratings used in this study were .61 (Range = .47 - .69) for peer problems and .69 (Range = .42 - .90) for academic problems. Across all 40 school days of data, between-person reliability for peer problems was high (R_{KF}=.99) and within-person reliability, defined as the ability to reliably detect changes within individuals, was adequate (R_C=.66). For academic problems, between-person reliability was high (R_{KF}=.99) and within-person reliability was adequate (R_C=.65).

Interparental conflict. Diary items assessing daily interparental conflict were adapted

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from the Child Home Data Questionnaire (Margolin, 1990). Each day youths responded to two items assessing interparental conflict ("My mom and dad seemed angry with each other today," "My mom and dad argued today") on a three-point scale: 1=*not at all*, 2=*some*, 3=*a lot*. Responses were averaged to create a daily interparental conflict scale. Items were coded as missing if a youth reported having no contact with his or her mother or father that day. Reliability was high, with a mean Cronbach's alpha of .92 (Range = .54-.99) across the 10 days of data in the current analysis. Across all 56 days of the larger study, between-person reliability (R_{KF}=.99) and within-person reliability (R_C=.89) were high.

Cortisol. In total, 1332 saliva samples were collected for cortisol assays. On average, each target child provided 87.5% of the expected 32 saliva samples (M=28, SD=4.98). The proportion of missing data did not significantly differ between sample times ($X^2(3)$=1.90, p=.594) or between day of the week ($X^2(3)$=2.04, p=.564). Mean collection times for the four samples were 7:47 a.m., 8:17a.m., 6:20 p.m., and 9:15 p.m. Collection times varied most for the bedtime sample (SD=144 min), and least for the 30 min post-wake sample (SD=111 min). Time was recorded to the nearest minute in accordance with the 24-hour clock, converted to hour units, rounded to the hundredth decimal place, and centered to wake time. Of the 1332 samples, 1270 had a valid cortisol value and collection time. Raw concentrations of cortisol in nmol/L units are described in Table 1.

For each sample, we coded the presence or absence of any presample confounds (e.g., eating 30 min prior to sample, vigorously exercising within 30 minutes; 0=no confound, 1=any confound). Youths endorsed presample confounds in 8.27% out of 1270 valid saliva samples. We also coded each sample's level of fidelity to sample timing instructions, based on the correspondence between randomly assigned tracking numbers on saliva vials and researchers'

record forms. Researcher confidence in a sample's fidelity to instructions was coded as 0 (no deviation from protocol) or 1 (possible deviation from protocol). Across 1270 saliva samples with valid cortisol values and times, only 5.12% were possibly deviant on sample timing.

Data analysis procedures

All data were analyzed using multilevel regression models. Multilevel modeling (MLM) is ideal for cortisol analyses because it accounts for both two-level data structures (in which data are nested within individuals), and three-level data structures (in which samples are nested within days, which are nested within individuals). Thus, MLM can test the effects of daily levels (within-person variance) and average levels (between-person variance) of peer, academic or interparental problems on diurnal cortisol. Analyses were conducted using SAS 9.4 software (PROC MIXED).

Deriving daily estimates of diurnal slope. In order to extract daily estimates of diurnal slope, cortisol was modeled using a three-level growth curve, in which samples (Level 1) are nested in days (Level 2), which are nested in individuals (Level 3; (Adam, Hawkley, Kudielka, & Cacioppo, 2006; Doane & Adam, 2010). Table 2 shows the results of the following three-level growth curve model, in which time of day predicts natural log transformed cortisol level at sample occasion t, on day j, for child k. This model is comprised of equations at three levels of data (Equations 1, 2 and 3). First, the following Level 1 equation depicts the estimation of *Cortisol* at sample occasion t, on day j, for child k:

Level 1:

$$Cortisol_{tjk} = \pi_{0jk} + \pi_{1ik}(Time_{tik}) + \pi_{2ik}(Time_{tik}^2) + \pi_{3ik}(CAR_{tik}) \qquad (1)$$
$$+ \pi_{4jk}(PreSampleConfound_{tjk}) + \pi_{5jk}(Accuracy_{tjk}) + e_{tjk}$$

In the above equation, the intercept π_{0jk}, represents natural log transformed cortisol level at wakeup for child k on day j. π_{1jk} and π_{2jk} are coefficients representing the effects of *Time* and

$Time^2$ on cortisol for at sample occasion t, on day j for child k. π_{3jk} is the coefficient that reflects the effect of a dummy variable representing the CAR sample (1=sample from 30 min post wakeup; 0=all other samples). π_{4jk} and π_{5jk} are coefficients reflecting the effects of the two sample-level covariates for child k on day j (presample confounds and confidence in the sample's fidelity to instructions).

Next, Level 2 equations depict the effect of *Wake Time*, a day-level variable, on cortisol, as well as between-day variance in the effects of sample-level variables (e.g., time, sample-level covariates) described in Level 1.

Level 2:

$$\pi_{0jk} = \beta_{00k} + \beta_{01k}(WakeTime_{jk}) + r_{0jk} \qquad \pi_{3jk} = \beta_{30k} + r_{3jk}$$
$$\pi_{1jk} = \beta_{10k} + r_{1jk} \qquad\qquad\qquad\qquad \pi_{4jk} = \beta_{40k} \qquad\qquad (2)$$
$$\pi_{2jk} = \beta_{20k} + r_{2jk} \qquad\qquad\qquad\qquad \pi_{5jk} = \beta_{50}$$

Cortisol at wakeup for child k on day j (π_{0jk}) is equal to sum of child k's average intercept across all days (β_{00k}), the effect of *Wake Time* on day j for child k (β_{01k}), and child k's deviation on day j from his or her own average intercept (r_{0jk}). Likewise, β_{10k}, β_{20k}, and β_{30k}, are coefficients representing the average effects of *Time*, *Time*^{2}, *CAR*, respectively, across all days for child k. r_{1jk}, r_{2jk} and r_{3jk} are corresponding random effects at the day level, representing child k's deviations on day j from his or her own average linear slope of *Time*, quadratic effect of *Time* and effect of *CAR*, respectively. Finally, β_{40k}, and β_{50k} reflect the fixed effects of sample-level covariates on cortisol for child k.

Variance in r_{1j} reflects the extent to which the linear effect of *Time* on *Cortisol* varies between days, within each child. Given high variance in r_{1j} we derived empirical Bayes (EB) estimates of the diurnal cortisol slope, on each day for each child. Next, Level 3 equations show how effects of key predictor variables (e.g., *Time*) vary between children:

Level 3:

$$\beta_{00k} = \gamma_{000} + u_{00k} \qquad\qquad \beta_{30k} = \gamma_{300} + u_{30k}$$
$$\beta_{01k} = \gamma_{010} \qquad\qquad\qquad \beta_{40k} = \gamma_{400} \qquad\qquad (3)$$
$$\beta_{10k} = \gamma_{100} + u_{10k} \qquad\qquad \beta_{50k} = \gamma_{500}$$
$$\beta_{20k} = \gamma_{200} + u_{20k}$$

β_{10k}, the effect of *Time* on cortisol for child k, is the sum of γ_{100}, the average slope of *Time* across all samples, days and youths, and u_{10k}, child k's unique deviation from the average slope. As shown in Table 2, cortisol significantly decreases with each passing hour from wakeup (γ_{100}), in the average child. Variance in u_{10k} reflects the extent to which the linear effect of *Time* on cortisol varies between individuals. Given the high level of variance in u_{10k}, we derived EB estimates of each child's deviance from the average *Time* slope.

Together, the unique effect of *Time* on *Cortisol* (i.e., diurnal cortisol slope) on each day for each child, adjusting for variations in sample size (Raudenbush & Bryk, 2002), was derived as the sum of (1) the average effect of *Time* (γ_{100}), (2) the EB estimate of the deviation in slope on day j, for child k (r_{1jk}), and (3) the EB estimate of the deviation in slope for child k (u_{10k}). Because the random effect of CAR at the day level (variance of r_{1jk}) was not statistically significant, we did not derive daily measures of CAR. Descriptive statistics for the derived estimates of diurnal cortisol slope, are reported in Table 1.

Associations between stressor and cortisol index. Nine separate two-level regression models tested the unique associations between the three daily stressor variables (i.e., peer problems, academic problems, interparental conflict) and three diurnal cortisol outcomes (i.e., same-day slope, same-day bedtime cortisol, and next-day wakeup cortisol). Diurnal slope was derived from the above described three-level growth curve model. All two-level equations, which adjusted for the nesting of days in individuals, included a random intercept at the child level.

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As shown in Figure 1, children provided saliva samples on two sets of four consecutive days (Sat to Tues). When assessing the same-day association between peer problems or academic problems, and diurnal slope or bedtime cortisol, we used diary and cortisol data from four weekdays. When testing the next-day association between peer or academic problems and wakeup cortisol, we used diary data from two Fridays and two Mondays to predict cortisol on Saturdays and Tuesdays. All eight days of cortisol data were used in the analyses involving interparental conflict, as children reported on interparental conflict each day. When testing next day waking cortisol as outcomes, we used reports of interparental conflict from Friday, Saturday, Sunday and Monday, which allowed us to use all available cortisol data.

We first tested effects of grand mean centered stressor variables on as predictors. Grand mean centering allows the examination of the combined influence of between-person and within-person variance on the cortisol index, while preserving degrees of freedom (Enders & Tofighi, 2007). When the effect of the grand mean centered stressor reached trend-level significance ($p < 0.10$), the within-person and between-person variance in the stressor were partitioned into their own components. This partitioning was achieved by child mean centering the stressor variable, and obtaining average levels of the stressor across the 6 or 10 days of data for each child (Enders & Tofighi, 2007). Averages were centered around the mean for ease of interpretation. The independent effects of between-person and within-person variance of a stressor were tested by simultaneously including child mean centered and average levels of the stressor as predictors in the two-level regression models.

Covariates. The presence or absence of any presample confounds (e.g., eating, vigorously exercising), level of researcher confidence in fidelity to sample timing instructions, and the time at which the sample was collected were included as covariates. Sample time was

recorded to the nearest minute according to the 24-hour clock, converted to hour units, rounded

to the hundredth decimal place. Of note, these covariates were not included in two-level models

examining diurnal cortisol slope as outcomes, as they were already accounted for when deriving

day-level estimates of diurnal cortisol slope (See Equation 1).

We controlled for weekend status (0=weekday, 1=weekend day) in analyses that used

cortisol data from both weekdays and weekend days. Due to the effect of physical development

on the diurnal cortisol rhythm (Marceau et al., 2015), child age (grand mean centered) was also

included as a covariate. Gender was tested as a covariate but not included in the final analyses

because it was not significantly associated with any of the cortisol variables.

Results

First, we evaluated between-person correlations among key variables of interest. Then,

we examined the daily associations between each stressor and cortisol outcome. If the estimate

of the daily stressor effect reached at least $p < 0.10$, we tested the unique contributions of within-

person and between-person variance in the stressor on the cortisol outcome.

Correlations between stressors and diurnal cortisol

Table 1 presents between-person correlations among three stressor variables, four

measures of cortisol secretion, and diurnal cortisol slope from wake to bedtime. Two of the

stressor variables were correlated with each other. Youths who reported more academic

problems also reported more peer problems. Interparental conflict was not linked to either type

of problem at school.

All four measures of cortisol secretion (wakeup, 30-min post wake, pre-dinner and

bedtime) were correlated with one another. Youths who secreted more cortisol at one point in the

day (e.g., wakeup) were also likely to secrete more cortisol at another point in the day (e.g.,

bedtime). The linear slope of decline from wake to bedtime, derived from a three-level growth curve, was significantly correlated with cortisol at wakeup and just before dinner. Youths who secreted more cortisol at wakeup tended to have steeper slopes of cortisol decline throughout the day. However, youths who secreted more cortisol in the evening tended to have flatter diurnal cortisol slopes. At the between-person level of analysis, peer problems, academic problems and interparental conflict were not correlated with any cortisol index. Likewise, child age and sex were not correlated with any measure of cortisol.

Peer problems and diurnal cortisol

Three models tested the association between peer problems and three measures of diurnal cortisol: that day's diurnal slope and bedtime levels and the next morning's waking cortisol level. As shown in Table 3, Model 1, more peer problems were associated, at a marginal level of statistical significance, with both a same-day flatter slope and higher cortisol secretion at waking the next morning. Peer problems were not associated with bedtime cortisol (γ_{10}=-0.10, SE=0.15, t=-0.71, p=.481).

Model 2 in Table 3 presents the results when the within-person and between-person variance in the peer problems was partitioned into separate components. That analysis showed that, after controlling for the effect of day-to-day fluctuations in peer problems, children with more peer problems on average had flatter diurnal slopes. In Model 2, age and within-person fluctuations in peer problems were not significantly associated with daily diurnal slopes. The analysis of next day waking cortisol produced a different pattern. As summarized in Table 3 Model 2, an individual's average level of peer problems did not predict his or her waking cortisol, over and above the effects of day-to-day variance. Rather, children showed higher waking cortisol following days when they had experienced more than their average number of

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peer problems. Older children secreted more cortisol at wakeup than did younger children.

Academic problems and diurnal cortisol

Three models tested the daily association between academic problems and cortisol. As shown in Table 3 Model 1, academic problems were associated with more cortisol at next day wakeup. However, daily academic problems were not associated with diurnal slope, nor were they significant predictors of bedtime cortisol level (γ_{10}=0.01, SE=0.10, t=0.09, p=.932).

Follow up analyses that partitioned the within-person and between-person variance indicated that day-to-day variance in academic problems drove the link between academic problems and next morning wakeup cortisol (Table 3 Model 2). Children secreted more cortisol at wakeup when they had experienced more academic problems than average the day before. Between-person variance in academic problems marginally contributed to higher levels of cortisol at wakeup. Age was a significant predictor, indicating that older children secreted more cortisol at wakeup than did younger children.

Interparental conflict and cortisol

Three models tested the association between interparental conflict and daily cortisol. The results summarized in Table 3 (Model 1) indicate that more conflict predicted a flatter diurnal cortisol slope at a marginal level of statistical significance. The follow-up analysis in Model 2 suggests that the association was explained by day-to-day variance in interparental conflict: more conflict was marginally associated with flatter slope of decline that day, controlling for average levels of conflict and child age. Interparental conflict was not linked to bedtime cortisol (γ_{10}=0.02, SE=0.08, t=0.24, p=.810) or next day wakeup levels (See Table 3).

Discussion

The current study used daily diaries and repeated saliva sampling methods to examine the

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effects of mild negative events on diurnal cortisol in 8- to 13-year-old children. Specifically, we assessed diurnal cortisol sensitivity to day-to-day fluctuations, as well as between-person differences in peer problems, academic problems and interparental conflict. Youths who reported more peer problems on average showed flatter slopes of cortisol decline from wakeup to bedtime. And daily fluctuations in peer and academic problems predicted next-day waking cortisol: children secreted more cortisol at wakeup following days when they reported more peer or academic problems than usual. In comparison to problems at school, interparental conflict had little impact on cortisol secretion. Our results demonstrate how acute and repeated exposure to daily problems may affect cortisol secretion in everyday life.

Effects of daily negative events on diurnal cortisol

The current study capitalized on daily diary methods to assess incremental contributions of within-person and between-person variance in mild stressors on diurnal cortisol. We examined three types of daily negative events and found that their effects on diurnal cortisol vary. More peer problems on average were linked to flatter diurnal slopes. This pattern is consistent with past research indicating that youth who report higher levels of peer victimization and trait loneliness have flatter diurnal slopes (Doane & Adam, 2010; Vaillancourt et al., 2008). Peer problems – even at seemingly low frequencies – may alter the diurnal cortisol rhythm over time. Daily fluctuations in peer problems also affected cortisol secretion in the short-term. When youths indicated that they had experienced more peer problems than they typically reported, they secreted more cortisol at wake the next day. A similar within-person effect on next day waking levels was observed for academic problems as well. Unlike peer problems, however, academic problems were not associated with between-person differences in diurnal cortisol. Although unpleasant, academic problems may not pose the same degree of social-evaluative threat as peer

problems, and thus not leave as lasting an imprint on the diurnal cortisol rhythm.

In contrast to peer and academic problems, daily elevations in interparental conflict was only marginally associated with a flatter diurnal slope. Between-child variance in interparental conflict was not linked to any measure of cortisol. Past research has shown that children's appraisals contribute to the link between interparental conflict and their HPA axis functioning (Lucas-Thompson & Hostinar, 2013). In particular, child self-blame is associated with a flatter diurnal cortisol slope and lower levels of cortisol at wakeup (Lucas-Thompson & Hostinar, 2013). Perhaps the infrequent incidents of interparental conflict captured by our daily diaries did not provoke self-blame in our sample, and thus, did not show a link with diurnal cortisol.

Diurnal cortisol rhythm

Our findings complement past research on HPA sensitivity, which has historically relied on experimental paradigms conducted in laboratories. Despite the external validity afforded by naturalistic methods, relatively few studies have tested the daily variation in children's diurnal cortisol rhythm. The current study addressed this gap by investigating the effects of three mild stressors on three indices: diurnal cortisol slope, bedtime cortisol, and next day waking cortisol.

Two indices of diurnal cortisol were associated with school problems. First, children who reported more peer problems on average had flatter diurnal cortisol slopes, but not lower wakeup levels or higher bedtime levels. The decline in cortisol from wakeup to evening is driven by the circadian rhythm, which is in turn, governed by the suprachiasmatic nucleus (SCN) in the hypothalamus and the negative feedback mechanism of HPA axis (Clow, Hucklebridge, Stalder, Evans, & Thorn, 2010). Studies of between-person differences in HPA axis functioning indicate that youths who were raised in socioeconomically disadvantaged families are more likely to show down-regulation of genes related to glucocorticoid receptors, which in turn modulate

cortisol secretion (Miller et al., 2009). Perhaps a different chronic stressor, repeated exposure to social difficulties at school, alters the body's ability to effectively down-regulate cortisol throughout the day. However, given the low rates of peer problems in this relatively healthy sample, another possibility is that a psychological characteristic correlated with reports of daily stressors contributes to the flatter diurnal slopes. For example, psychological symptoms, such as depression, are associated with flatter cortisol slopes (Doane et al., 2013; Shirtcliff & Essex, 2008). Perhaps emotional difficulties, such as symptoms of depression that are connected to disruptions in diurnal HPA activity also increase sensitivity to problems at school.

Second, children's cortisol secretion increased at awakening the morning after they had experienced more problems at school. Daily sleep quality may mediate the effects of stress on next day waking cortisol (Sladek & Doane, 2015). Waking cortisol reflects sleep quality, hippocampal activation, and adrenal sensitivity to ACTH (a pituitary hormone) during the pre-awakening period of sleep (Clow et al., 2010). Although adrenal sensitivity to ACTH is temporarily reduced through an extrapituitary pathway during the pre-awakening period in all individuals, poor sleep may further decrease its sensitivity. In addition, poor sleep quality may influence the activation/deactivation pattern of hippocampus during the pre-awakening period, which further modulates cortisol regulation at this time (Clow et al., 2010).

Interestingly, our results regarding waking cortisol contradict past research linking negative psychosocial experiences with lower waking cortisol at the within-person (Doane & Adam, 2010; Peters et al., 2011) and between-person (Peters et al., 2011) levels of analysis. Specifically, Doane and Adam (2010) found that prior day reports of nervousness and stress were linked to lower waking levels of cortisol in young adults ages 17 to 20. Peters and colleagues (2011) examined between-person effects of peer exclusion on waking cortisol in 4th

graders (i.e., age 9) and found that on average, youths who were excluded from peers showed lower levels of cortisol at wake. With participants ranging from 8 to 13 years in age, the current study captures early adolescence. Our unique findings may reflect the effects of age and pubertal development on morning cortisol secretion (Oskis, Loveday, Hucklebridge, Thorn, & Clow, 2009). Diurnal cortisol sensitivity to daily negative events may also change as a function of pubertal development, such that children become more sensitive to the social experiences with increasing age (Booth, Granger, & Shirtcliff, 2008).

Cortisol level at bedtime was not linked to average or daily levels of any of the stressors assessed in this study. To our knowledge, only two studies have examined the within-person link between negative events and bedtime cortisol in children and adolescents. These studies have reported some evidence for elevations in bedtime cortisol on high stress days (i.e., more interpersonal and work/school related problems) (Lippold, Davis, et al., 2016). Specifically, more negative parent-child experiences were associated with greater secretion of cortisol at bedtime among youths who reported low average levels of negative parent-child interactions (Lippold, McHale, et al., 2016). However the timing of the stressors assessed in the current study may explain the lack of association with bedtime cortisol. Peer and academic problems, in particular, are likely to have occurred outside of the bedtime context.

Together, findings suggest that waking levels of cortisol are sensitive to daily fluctuations in school experiences, whereas diurnal cortisol slope is more sensitive to between-person differences in the quality of peer interactions. Due to the limited number of studies exploring the effects of day-to-day variations in stress exposure on the diurnal cortisol rhythm in middle childhood, our findings must be interpreted with caution. Nonetheless, this study uniquely applied intensive repeated methods to help clarify the time course by which negative events

affect HPA axis functioning.

Limitations and Future Directions

Several limitations must be considered when interpreting our findings. The relatively small and homogenous sample constrained our power to test the effect of individual level moderators, such as puberty, and psychopathology. Larger and more heterogeneous samples of families would allow tests of these moderators and increase generalizability. The infrequency of stressors may have also influenced our results. Future studies would benefit from more nuanced approaches to assess both low and high intensity stressors. For example, more response options on diary questions or recording family interactions in the home would allow a more sensitive assessment of stressor intensity. Finally, our study offers a snapshot of children's diurnal cortisol sensitivity to naturalistic stressors during a month in their lives. Longitudinal designs can better investigate allostatic load processes by examining the stability of the within-person links between stress and diurnal cortisol rhythm over time.

Despite several limitations, the current study contributes to an emerging body of research that aims to elucidate the links between daily life stress and HPA axis functioning. Findings suggest that whereas average levels of peer problems are linked to diurnal slope, day-to-day fluctuations in peer and academic problems predict waking cortisol the next day. Future studies may use daily diaries and naturalistic methods to further differentiate adaptive stress responses in the short term, and physiological consequences of repeated exposure to stress over time.

Table 3-1

Means and standard deviations at the child and day levels of analysis and between-person correlations between study variables

	Child-level	Day-level		Correlations between cross-days average levels									
	M(SD)	M(SD)	ICC	1	2	3	4	5	6	7	8	10	11
DAILY STRESSORS													
1 Peer problems	0.16 (0.47)	0.10 (0.37)	0.39	1.00									
2 Academic problems	0.31 (0.84)	0.26 (0.76)	0.72	0.75***	1.00								
3 Interparental conflict	1.14 (0.21)	1.13 (0.35)	0.25	0.09	0.10	1.00							
CORTISOL MEASURE													
4 Wakeup	16.76 (5.70)	16.76 (8.52)	0.32	-0.10	0.07	-0.07	1.00						
5 30 min post wake	18.26 (6.99)	18.24 (10.46)	0.31	0.07	0.10	-0.09	0.73***	1.00					
6 Pre-dinner	3.19 (2.19)	2.15 (3.62)	0.26	0.14	0.13	0.00	0.36*	0.45**	1.00				
7 Bedtime	2.23 (2.59)	2.13 (4.35)	0.21	0.04	0.04	-0.07	0.32*	0.37**	0.70***	1.00			
8 Diurnal slope[a]	-0.16 (0.05)	-0.16 (0.06)	0.37	0.15	0.05	0.09	-0.46**	-0.23	0.48*	-0.01	1.00		
CHILD CHARACTERISTICS													
10 Age (years)	11.28 (1.50)	--	--	0.15	0.16	0.22	0.25	0.23	0.24	0.08	0.08	1.00	
11 Sex	60% female	--	--	0.02	0.13	-0.13	0.04	0.14	-0.12	-0.09	-0.23	0.04	1.00

* $p < 0.05$, ** $p < 0.10$, *** $p < 0.001$
M = Mean; SD = standard deviations; ICC = Intraclass correlation coefficient; [a] Day-level estimates of diurnal slope are derived using empirical Bayes estimates
Means and SD of cortisol at wakeup, 30-min post wake, pre-dinner and bedtime reflect untransformed concentrations in nmol/L.
These values were natural log transformed prior to conducting zero order correlations.

Table 3-2

Diurnal cortisol rhythm depicted by three-level regression model in which time of day predicts cortisol level (N_{child}=47, n_{sample}=1256)

	FIXED EFFECT			
PREDICTOR	Coef.	SE	t	p
Intercept, γ_{000}	3.759	0.108	34.73	<.001
Time, γ_{100}	-0.164	0.013	-12.17	<.001
Time^2, γ_{200}	0.002	0.001	2.46	.014
CAR, γ_{300}	0.118	0.036	3.25	.001
Presample confound, γ_{400}	-0.033	0.049	-0.67	.502
Sample accuracy, γ_{500}	-0.243	0.093	-2.60	.009
Wake time, γ_{010}	-0.128	0.013	-9.97	<.001

	RANDOM EFFECT			
VARIANCE COMPONENTS	Variance	SE	z	p
Child level				
Intercept, u_{00k}	0.074	0.021	3.51	<.001
Time, u_{10k}	0.003	0.002	1.81	.035
Time^2, u_{20k}	0.000	0.000	1.86	.032
CAR, u_{30k}	0.027	0.013	2.06	.020
Day level				
Intercept, r_{0jk}	0.060	0.022	2.69	.004
Time, r_{1jk}	0.007	0.004	1.78	.037
Time^2, r_{2jk}	0.000	0.000	1.62	.052
CAR, r_{3jk}	0.011	0.037	0.31	.379
Residual, e_{tjk}	0.108	0.017	6.38	<.001

Time was recorded to the nearest minute in accordance with the 24-hour clock, converted to hour units, rounded to the hundredth decimal place, and centered to wake time; cortisol was natural log transformed to account for positive skew

Table 3-3

Fixed effect of peer problems, academic problems and interparental conflict on diurnal cortisol slope and next morning wake level

PREDICTOR	PEER PROBLEMS				ACADEMIC PROBLEMS				INTERPARENTAL CONFLICT			
	Slope		Next day wake [a]		Slope		Next day wake [a]		Slope [a]		Next day wake [a]	
	γ (SE)	t	γ (SE)	t	γ (SE)	t	γ (SE)	t	γ (SE)	t	γ (SE)	t
1 Stress$_{gmc}$	0.02 (0.01)	1.67^t	0.31 (0.17)	1.84^t	0.01 (0.01)	0.92	0.19 (0.07)	2.70**	0.01 (0.01)	1.66^t	-0.04 (0.09)	-0.47
Age	0.005 (0.005)	0.88	0.10 (0.04)	2.72**	0.01 (0.01)	0.92	0.10 (0.04)	2.78**	0.004 (0.005)	0.89	0.05 (0.03)	1.70^t
2 Daily stress$_{cmc}$	-0.01 (0.01)	0.79	0.34 (0.17)	1.96*	--	--	0.18 (0.08)	2.30*	0.01 (0.01)	1.65^t	--	--
Avg stress	0.04 (0.02)	1.97*	0.11 (0.32)	0.34	--	--	0.20 (0.12)	1.68^t	0.02 (0.04)	0.65	--	--
Age	0.003 (0.01)	0.66	0.10 (0.04)	2.74**	--	--	0.10 (0.04)	2.75**	0.004 (0.01)	0.81	--	--

^{t} p < 0.10, * p < 0.05, ** p < 0.01
gmc = grand mean centered, cmc = child mean centered; ^{a} Models controlled for weekend/weekday.
All models included random intercept, and controlled for time of cortisol sample, presample confounds, and sample accuracy. Cortisol levels (nmol/L) were natural log transformed prior to all analyses. Model 2 was tested only when the association between grand mean centered stressor and cortisol outcome was significant at p <.10 in Model 1. Cortisol levels (nmol/L) were natural log transformed prior to all analyses.

Figure 3-1

Study timeline

Study timeline indicating days of saliva collection and assessments of child-report of stressors included in the present analyses. Saturdays and Sundays (days 15, 16, 36, 37) are shown in bold and underlined.

Appendix 3-1

Child Daily Diary Peer and Academic Problems Scales
All scale scores are sums; Response Options: 0 = *no*, 1 = *yes*

PEER PROBLEMS AT SCHOOL (5 items)
1. I felt that my friends didn't want to be around me today.
2. Another kid teased me today.
3. I felt that that my friends were talking about me behind my back today.
4. I got into a fight with another kid today.
5. One of my friends was mad at me today.

ACADEMIC PROBLEMS AT SCHOOL (5 items)
1. My schoolwork was too hard today.
2. I made a mistake in class today.
3. I had trouble finishing my schoolwork today.
4. I had trouble learning something new today.
5. I received a bad grade on a test or paper today.

Child Daily Diary Positive Involvement with Mothers or Fathers (3 items)
All family interaction scale scores are means; Response Options: 1 = *not at all*, 2 = *some*, 3 = *a lot*

1. My Mom and Dad seemed angry with each other today.
2. My Mom and Dad argued today.

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