Perceived Stress, Coping, and Cortisol Reactivity in Daily Life:
A Study of Adolescents during the First Year of College

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Abstract

Adolescents change how they cope with stress across different situations, but also differ from one another in their general capacity to cope. The current study examined whether cortisol reactivity to perceived daily stress varies with both situational (within-person) and individual (between-person) differences in coping. First-year college students ($N=63$; $M_{\text{age}}=18.85$) provided 15 stress-coping diaries and 15 corresponding saliva samples across 3 weekdays. Results from hierarchical linear growth models revealed that perceiving greater stress than usual in the last hour was significantly associated with elevations in cortisol (relative to diurnal patterning) only during situations characterized by greater than usual diary-reported engagement coping. Regarding individual differences, perceiving greater stress than usual was significantly associated with elevations in cortisol only for adolescents below average on trait measures of engagement coping or belief in their ability to handle stress. Findings indicate that cortisol reactivity to daily stress varies with both situational variation and individual differences in coping.

Keywords: perceived stress, coping, cortisol, daily diaries, adolescents, first year of college

As they transition to adulthood, many adolescents face novel daily demands in the college environment. These daily stressors have been linked to poor physical and psychological health among college students (O'Neill, Cohen, Tolpin, & Gunthert, 2004), who report notably poor sleep (Lund, Reider, Whiting, & Prichard, 2010), increased alcohol use (Carter, Brandon, & Goldman, 2010), and concerning rates of suicidal ideation (Wilcox et al., 2011). Hypothalamic-pituitary-adrenal (HPA) axis reactivity is one mechanism through which stress can impact health and well-being across development (Gunnar & Quevedo, 2007). Adolescents' psychological responses to stress (e.g., coping skills) influence physiological stress reactivity and also predict well-being (Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001).

The impact of daily stress on HPA reactivity likely depends on how adolescents both cope with specific stressful situations (measured through diary reports) and how they typically respond to stress (measured through traditional surveys). Developmental scientists have started collecting salivary biomarkers (e.g., cortisol) in conjunction with diary reports to measure adolescents' physiological responses to daily stress outside of the laboratory (e.g., Adam, 2006), yet little is known about how coping influences cortisol reactivity among adolescents as they navigate the college context. The goals of this study were to examine whether within-person situational and individual differences in coping account for variation in adolescents' cortisol responses to perceptions of daily stress. This research can potentially inform first-year transition programs aimed at improving how adolescents manage daily stress when starting college (see Barefoot, 2005).

Perceived Daily Stress

As they begin the transition to adulthood, many adolescents face demands across multiple domains (e.g., school, work, relationships; Arnett, 2000). Even relatively minor stressful events

can contribute to psychological problems. These “daily hassles” predict symptoms of depression and anxiety over and above major life events (Kanner, Coyne, Schaefer, & Lazarus, 1981). In a study of adolescents transitioning from high school to college, daily hassles mediated the relation between major negative events and psychological symptoms (Wagner, Compas, & Howell, 1988). Adolescents who are unable to handle stress during this transition may be particularly vulnerable to adjustment problems (Masten et al., 2004). Thus, it is important to examine mechanisms that might explain *why* perceptions of stress in daily life negatively influence the physical and mental health of first-year college students.

Cortisol Reactivity to Perceived Daily Stress

The HPA axis recruits resources to react to stressors and stimulates release of the hormone cortisol (de Kloet, 2004). When timing is carefully measured in a controlled lab environment, cortisol peaks in saliva approximately 20-25 minutes following a discrete stressor but may take up to one hour to return to baseline (Nicolson, 2008). In coordination with other biological systems, the production of cortisol allows for adaptive behavioral responses during stressful situations, but chronic activation of this response can be harmful to physical and mental health (McEwen, 2004).

Cortisol is released throughout the day in a pattern characterized by a dramatic increase 30 minutes after waking (cortisol awakening response, CAR) and then a general decrease across the waking day (Adam & Kumari, 2009; Pruessner et al., 1997). By modeling this diurnal cortisol pattern and utilizing corresponding diary reports of daily experiences, researchers can estimate real-world cortisol responses to stress. Past research has found situational elevations in cortisol from adolescents’ typical diurnal rhythms in relation to more worry/stress than usual (Adam, 2006), more loneliness than usual (Doane & Adam, 2010), and more negative affect than

usual (Doane & Zeiders, 2014). College students' cortisol levels increased in anticipation of a real-life multiple-choice exam (Nicolson, 1992), were higher the day of an exam compared to a control day (Verschoor & Markus, 2011), and were higher when students were alone compared to when they were not (Matias, Nicolson, & Freire, 2011). Thus, characteristic college stressors have been linked to changes in cortisol. Yet it is unclear how these cortisol changes in daily life might vary with changes in coping in response to specific stressful situations or differences in general coping capacity between students.

Coping with Perceived Daily Stress

Coping can be defined as, "conscious volitional efforts to regulate emotion, cognition, behavior, physiology, and the environment in response to stressful events or circumstances" (Compas et al., 2001, pp. 89). There is evidence for two dimensions of adolescents' voluntary coping responses: engagement (directed towards stress or reactions to stress; e.g., problem-solving) and disengagement (oriented away from stress; e.g., avoidance; Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000). Although the utility of engagement coping fundamentally varies with situational factors, this active style is generally linked with adolescents' positive adjustment (Compas et al., 2001).

Given that uncontrollable stressors produce the most pronounced cortisol response (Dickerson & Kemeny, 2004), college students' active coping efforts that enhance their perceived sense of control over stressful situations may attenuate cortisol reactivity. For example, college students who are more likely to adopt problem-focused or engagement coping have exhibited lower cortisol levels in response to psychological stress tasks (Matheson & Anisman, 2009; Rohrmann, Hennig, & Netter, 2002). Similarly, coping by gaining a sense of control has contributed to reduced cortisol reactivity to a pharmacological stress induction and

engagement coping style has been associated with lower daily cortisol output in samples of adults (Abelson, Khan, Liberzon, Erickson, & Young, 2008; O'Donnell, Badrick, Kumari, & Steptoe, 2008).

In addition, coping efficacy (the *belief* that one can deal with demands of a stressful situation; Sandler, Tein, Mehta, Wolchik, & Ayers, 2000) has been associated with successful adaptation to various stressors (e.g., Massey, Garnefski, Gebhardt, & van der Leeden, 2009). In our prior work, adolescents who reported increased loneliness from high school to college and also low coping efficacy exhibited poor average diurnal cortisol regulation (flatter slopes) in college, compared to those with high coping efficacy (Drake, Sladek, & Doane, in press). A logical extension of this work is to move beyond average diurnal cortisol patterns and consider whether situational (within-person) changes in cortisol in response to perceived daily stress differ for college students at varying levels of coping efficacy.

The Present Study

In order to extend available laboratory evidence, we examined stress, coping, and cortisol reactivity in the daily lives of adolescents during their first year of college. The current goals built upon our work from earlier waves of a longitudinal study, which focused on predicting individual differences in adolescents' average diurnal cortisol patterns as they transitioned from high school to college (Drake et al., in press). Using 15 pairs of diary reports and corresponding saliva samples across 3 days, we estimated the concurrent relation between situational (within-person, moment-to-moment) changes in perceived stress and deviations in salivary cortisol from adolescents' typical diurnal profiles (e.g., Adam, 2006). We then examined whether these cortisol responses to daily perceived stress varied with diary-reported engagement coping. We anticipated that perceiving more stress than usual (i.e., within-person increase) would be

associated with elevations in cortisol relative to the diurnal rhythm, unless adolescents also used more engagement coping than usual in response to the stressful situation. Finally, we examined whether individual differences in engagement coping and coping efficacy measured via standard surveys accounted for between-person variation in the cortisol response to daily perceived stress. We expected that perceiving more stress than usual would be associated with elevations in cortisol to a lesser extent for adolescents who generally used more engagement coping or reported greater coping efficacy.

Method

Participants

Eighty-two adolescents were recruited for a longitudinal study of the transition from high school to college (e.g., Taylor, Doane, & Eisenberg, 2014). Students in their final year of high school (T1) were contacted through psychology department orientations and email. Participants were required to live within 35 miles of the university and plan to attend in the fall (T2). Present analyses focus on 71 adolescents (23% male; 17-19 years old; $M_{\text{age}}=18.85$, $SD=0.54$) who participated a third time in the spring of their first year of college (T3; 87% retention). Participants reflected the university's diversity (52% non-Hispanic White, 25% Latino/Hispanic, 6% African American, 4% Asian American/Pacific Islander, 13% multiracial; 4% of parents completed some high school, 28% high school diploma, 25% some college, 13% associate's degree, 17% bachelor's degree, 13% graduate degree). Participants lost to attrition from T1 to T3 ($n=11$) had parents who completed more education ($M=4.55$, $SD=1.44$) than parents of participants who remained in the study ($M=3.32$, $SD=1.44$), $t(80)=-2.58$, $p=.01$, but did not differ significantly on focal or other demographic variables at T1.

One participant who did not provide diary data was not included in analyses. Data from seven participants were excluded for not correctly adhering to saliva sampling procedures (analytic $N=63$; see below). Participants excluded for compliance reasons did not differ from the included sample on focal or demographic variables.

Procedure

Participants completed a self-report questionnaire including measures of individual differences in coping and health information related to stress physiology. Participants selected 3 typical consecutive weekdays to complete a modified ecological momentary assessment during the spring semester of their first year of college. For these 3 days, participants completed diary reports and provided saliva samples via passive drool 5 times a day: waking, 30 minutes after waking, 2 other times (approximately 3 and 8 hours after waking), and bedtime. Participants were instructed to complete each diary entry immediately following the provision of each saliva sample. In each diary entry, participants described and rated the severity of any stressful events that occurred in the last hour and reported their coping responses to these events. Participants also reported sampling time and recent caffeine, nicotine, and medication use. In total, participants provided 15 diary entries ($M=14.74$, $SD=0.76$) and 15 saliva samples ($M=14.76$, $SD=0.71$), resulting in 1048 total data points.

Participants were instructed not to eat, drink, or brush their teeth 30 minutes prior to providing saliva. Straws for saliva samples were kept in a MEMS 6TM (Aardex) track cap, which electronically recorded times when opened. Participants wore the Actiwatch Score (Phillips Respironics, Inc.), a wrist-based accelerometer that objectively measured wake times and alerted participants when to complete diary entries and saliva samples approximately 3 and 8 hours after waking (see Doane & Zeiders, 2014). Study personnel went to dormitories/homes to explain

procedures and obtain informed consent. Study personnel called participants the night before they began the protocol, picked up completed materials, and paid participants \$75. Arizona State University's Institutional Review Board approved procedures.

Measures

Salivary cortisol. Saliva samples were stored at -20C until sent on dry ice to Biochemisches Labor (University of Trier, Germany) for duplicate assay using a solid phase time-resolved fluorescence immunoassay with fluorometric endpoint detection (DELFI; Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992). The intra-assay coefficients of variation ranged from 4.0% to 6.7% and the inter-assay coefficients of variation ranged from 7.1% to 9.0%. One cortisol outlier was winsorized at 1.81 µg/dl (50 nmol/L; Nicolson, 2008). Cortisol values were transformed using the natural log function to correct for positive skew. Waking samples were considered compliant if the track cap time was within 15 minutes of actigraph wake time and second samples were considered compliant if the track cap time was between 23 and 37 minutes after waking samples (DeSantis, Adam, Mendelsohn, & Doane, 2010). Based on these criteria, data from seven participants were excluded from analyses because no compliant waking samples were available. An additional 46 waking and 35 second samples from other participants were noncompliant and excluded (analytic $N=842$ data points).

Situational perceived stress. Immediately after providing each saliva sample, participants described the most stressful event of the last hour and rated its severity (0=*not at all stressful* to 3=*very stressful*). Participants completed these reports 5 times a day for 3 days.

Situational coping responses. Participants then indicated how much their response to recent stressful events included engagement coping (0=*not at all* to 3=*very*), again 5 times a day for 3 days. Eight items were modified from validated self-report questionnaires (Carver, 1997;

Connor-Smith et al., 2000; e.g., “doing something to solve the situation,” “thinking of a solution or gathering information”). Cronbach’s alphas at different times of day ranged from .70 to .78.

Engagement coping. In one sitting, participants completed the Brief COPE (Carver, 1997), which measures how frequently individuals typically use coping strategies to deal with stress (1=*I haven’t been doing this* to 4=*I’ve been doing this a lot*). Five items assessed voluntary engagement coping ($\alpha=.85$; e.g., “I’ve been trying to come up with a strategy about what to do”).

Coping efficacy. In one sitting, participants rated eight items that measured belief in their ability to handle stressors and novel situations (e.g., “Overall, how good do you think you will be at making things better when problems come up in the future?” 1=*not at all good* to 4=*very good*; Sandler et al., 2000; $\alpha=.92$).

Covariates. Given prior associations with cortisol activity, we evaluated several potential covariates: sex (1=male), race/ethnicity (1=non-Hispanic White), parents’ average level of education (1=*some high school* to 6=*graduate school*), oral contraceptive use (1=using contraception; all males coded 0), day-to-day differences in wake time and negative affect, and caffeine and nicotine use in the hour prior to saliva sampling.

Analytic Strategy

To account for nested data (saliva samples nested within days and persons), three-level hierarchical linear growth models were estimated in HLM 6.8 using full maximum likelihood estimation with robust standard errors to model situational-, daily-, and person-level changes in cortisol (Raudenbush & Bryk, 2002). This analytic strategy allows for the modeling of multiple cortisol parameters simultaneously, including cortisol levels at waking as the intercept, diurnal slope as a linear growth pattern estimated at waking, cortisol awakening response (CAR) as the deviation in cortisol from this linear pattern 30 minutes after waking, and “reactivity” as

situational deviations in cortisol from this average pattern in relation to perceptions of stress (Adam, 2006; Doane & Zeiders, 2014; Hruschka, Kohrt, & Worthman, 2005). Importantly, this approach has the ability to explore both time-varying state (e.g., situational coping) and non-time-varying trait (e.g., general coping efficacy) influences on cortisol parameters (Adam, 2006). Diurnal cortisol patterns were first modeled at Level 1 (L1). The diurnal cortisol slope was represented by including a situation-, day-, and person-specific time variable (growth parameter) indicating how long after waking each saliva sample was provided (0=wake time).¹ The CAR was represented by a dummy variable for the second saliva sample of the day (0=not second sample, 1=second sample). Diary-reported situational perceived stress level was then included as a L1 predictor of cortisol. Person-specific parameters that accounted for between-person differences in waking cortisol, CAR, and diurnal cortisol slope were included at L3. L1 parameters were centered within-person (i.e., situational scores subtracted from an individual's average of available scores) and L3 parameters were grand-mean centered (Enders & Tofighi, 2007). Exceptions were the linear growth parameter (diurnal cortisol slope) and dummy variables (CAR, race/ethnicity, contraceptive use). Separate chi-square likelihood ratio tests (nested model tests) revealed that the associations between the linear growth parameter and cortisol, $\chi^2(2)=72.46, p<.001$, and between perceived stress and cortisol, $\chi^2(2)=5.27, p=.04$, varied across persons. Thus, two random slope terms were included in all models to account for individual variation in these within-person relations.

Significant two-way interactions were investigated using simple slopes techniques for hierarchical linear modeling (Preacher, Curran, & Bauer, 2006). Simple slopes were estimated for associations between stress and cortisol at the mean of coping and ± 1 SD (Aiken & West,

¹ A quadratic growth function (time since waking²) did not significantly contribute to prediction of cortisol over and above the linear growth function ($\gamma_{300} = 0.0001, p = .91$).

1991). We also assessed the range of coping for which the within-person relations were significant.

Results

Preliminary Analyses

Table 1 presents descriptive statistics and correlations. Nested data were aggregated for descriptive purposes only. Participants exhibited the expected diurnal cortisol profile with relatively high waking cortisol (0.24 µg/dl or 6.69 nmol/L), an approximate 75% increase 30 minutes after waking (cortisol awakening response, CAR),² and an approximate 12% decline in cortisol per hour at waking (Table 2, Model 1). Race/ethnicity, oral contraceptive use, and parents' education level accounted for significant variance in the intercept (average waking cortisol), CAR, and/or diurnal cortisol slope; thus, the appropriate between-person covariates were included in all subsequent models (Table 2, Model 2).

Situational Analyses

Accounting for the diurnal cortisol pattern and these covariates, within-person changes in situational perceived stress were not significantly associated with situational deviations in cortisol on average (Table 2, Model 2). Adjusting for perceived stress, within-person increases in situational engagement coping were associated with lower cortisol relative to the diurnal rhythm; there was also a significant interaction between situational perceived stress and coping (Table 2, Model 3). Within-person increases in perceived stress were associated with increases in cortisol during situations when adolescents endorsed coping 1 *SD* above their own mean ($\beta=0.13$, $p<.01$) but not at their mean ($\beta=0.06$, $p=.06$) or 1 *SD* below their mean ($\beta=-0.01$, *ns*; Figure 1); this association was

² Because cortisol values were log transformed, the effect sizes can be interpreted as a percent change per 1 unit change in the predictor after using the formula: $\beta\% \text{ change} = [(e^{\beta}) - 1]$.

Table 1

Descriptive statistics and zero-order correlations among person-level averages of cortisol, stress, coping, and covariates

Variables	1	2	3	4	5	6	7	8	9	10	11	<i>M(SD)</i> ^a	Range
1. Waking cortisol	--											.24(.66)	.04-1.26
2. Cortisol awakening response	-.68**	--										.55(.56)	-.79-1.83
3. Cortisol diurnal slope	-.18	-.02	--									-.11(.05)	-.21-.02
4. Situational perceived stress	-.01	-.01	-.24†	--								1.16(.46)	.27-2.73
5. Situational coping	-.17	-.01	-.22†	.54**	--							.48(.32)	.00-1.38
6. Engagement coping	.16	-.12	-.17	.12	.38**	--						2.77(.74)	1.20-4.00
7. Coping efficacy	-.07	.03	-.16	-.03	-.01	.44**	--					25.41(4.85)	10.00-32.00
8. Non-Hispanic White	-.01	.06	-.40**	.26*	.11	.04	-.01	--				47.6	--
9. Parent education	-.20	.28*	-.27*	.12	.15	.23†	.17	.22†	--			3.28(1.42)	1.00-6.00
10. Oral contraceptive use	-.18	-.13	-.06	-.02	-.13	.01	.15	.34**	.29*	--		33.0	--
11. Sex (1=male)	.08	.09	.09	.11	.04	.09	.21	-.13	-.01	-.38**	--	22.2	--

Note. *N*=63. Waking cortisol and cortisol awakening response in µg/dl. Cortisol diurnal slope is regression-based estimate of linear change in cortisol from waking to bedtime. Parent education (average of mother's and father's): 1=completed some high school to 6=graduate degree.

†*p*<.10. **p*<.05. ***p*<.01.

^aPercentages for dichotomous variables.

Table 2

Hierarchical linear growth model fixed effects estimates predicting cortisol from situational perceived stress and coping

	Model 1		Model 2		Model 3	
	Est.	SE	Est.	SE	Est.	SE
Intercept: waking cortisol, γ_{000}	-1.42**	.05	-1.41**	.04	-1.45**	.05
White race/ethnicity, γ_{001}			.21*	.09	.21*	.08
Oral contraceptive use, γ_{002}			-.15†	.08	-.14†	.08
Parent education, γ_{003}			-.10*	.05	-.11*	.05
Cortisol awakening response, γ_{100}	.56**	.06	.55**	.06	.57**	.06
Oral contraceptive use, γ_{101}			-.34**	.11	-.35**	.11
Parent education, γ_{102}			.20**	.05	.21**	.05
Time since waking: diurnal slope, γ_{200}	-.11**	.01	-.11**	.01	-.11**	.01
White race/ethnicity, γ_{201}			-.03**	.01	-.03**	.01
Parent education, γ_{202}			-.01*	.01	-.01*	.01
Situation perceived stress level, γ_{300}			.03	.02	.06†	.03
Situation coping, γ_{400}					-.07*	.04
Situation stress x Situation coping, γ_{500}					.07*	.03

Note. 842 situations nested within 63 individuals. Cortisol levels natural logarithmically transformed. Cortisol awakening response (1=sample 30 min after waking, 0 = not sample 30 min after waking). Time since waking: how long after waking sample was provided. Coefficients are standardized. Est.=regression coefficient estimate. SE=robust standard error.

† $p < .10$. * $p < .05$. ** $p < .01$.

Figure 1. Simple slope plots of situational cortisol by situational perceived stress level at the within-person mean and ± 1 SD from the within-person mean of situational engagement coping. † $p < .10$. * $p < .05$.

significant only for situations when adolescents scored at least 0.07 *SD* above their mean of coping (41% of situations).

Individual Difference Analyses

Between-person differences in engagement coping and coping efficacy accounted for significant individual variance in the within-person association between situational perceived stress and cortisol (i.e., cross-level interactions; Table 3, Models 1 and 2, respectively). The positive within-person association between perceived stress and cortisol was significant only for those scoring 1 *SD* below the sample mean of engagement coping ($\beta=0.09$, $p<.01$) and not at the mean ($\beta=0.03$, $p=.19$) or 1 *SD* above the mean ($\beta=-0.03$, *ns*; Figure 2); this association was significant only for those scoring 0.26 *SD* below the mean or lower on engagement coping (35% of sample). Similarly, the positive within-person association between perceived stress and cortisol was significant only for those scoring 1 *SD* below the sample mean of coping efficacy ($\beta=0.10$, $p<.01$) and not at the mean ($\beta=0.03$, $p=.16$) or 1 *SD* above the mean ($\beta=-0.04$, *ns*; Figure 3); this association was significant only for those scoring 0.20 *SD* below the mean or lower on coping efficacy (51% of sample). These presented results were highly similar when accounting for additional covariates often considered in cortisol research, including caffeine and nicotine use at L1, wake time and negative affect at L2, and sex at L3.

Discussion

Dysregulation of the HPA axis may help to explain why stress can lead to poor health as adolescents transition to college. Few have studied physiological reactivity outside the laboratory, which is critical to approximate how stress responses operate in settings relevant to adolescents' daily lives. In the present study, we used ecological momentary assessment to examine cortisol reactivity to perceptions of daily stress during adolescents' first year of college,

Table 3

Hierarchical linear growth model fixed effects estimates predicting cortisol from situational perceived stress and individual differences in coping

	Model 1		Model 2	
	Engagement coping		Coping efficacy	
	Est.	SE	Est.	SE
Intercept: waking cortisol, γ_{000}	-1.41**	.04	-1.41**	.04
White race/ethnicity, γ_{001}	.20*	.08	.21*	.08
Oral contraceptive use, γ_{002}	-.14†	.08	-.14†	.08
Parental education, γ_{003}	-.12*	.05	-.10*	.05
Engagement coping, γ_{004}	.05	.04		
Coping efficacy, γ_{004}			-.07	.04
Cortisol awakening response, γ_{100}	.55**	.06	.55**	.06
Oral contraceptive use, γ_{101}	-.35**	.11	-.36**	.11
Parental education, γ_{102}	.20**	.05	.21**	.05
Time since waking: diurnal slope, γ_{200}	-.11**	.01	-.11**	.01
White race/ethnicity, γ_{201}	-.03**	.01	-.03**	.01
Parent education, γ_{202}	-.01*	.01	-.01†	.01
Situation perceived stress level, γ_{300}	.03	.02	.03	.02
Stress x Engagement coping, γ_{301}	-.06*	.03		
Stress x Coping efficacy, γ_{301}			-.07**	.02

Note. 842 situations nested within 63 individuals. Cortisol levels natural logarithmically transformed. Cortisol awakening response (1=sample 30 min after waking, 0=not sample 30 min after waking). Time since waking: how long after waking sample was provided. Coefficients are standardized. Est.=regression coefficient estimate. SE=robust standard error.

† $p < .10$. * $p < .05$. ** $p < .01$.

Figure 2. Simple slope plots of situational cortisol by situational perceived stress level at the sample mean and ± 1 SD from the mean of person-level engagement coping. $*p < .05$.

Figure 3. Simple slope plots of situational cortisol by situational perceived stress level at the sample mean and ± 1 SD from the mean of person-level coping efficacy. $*p < .05$.

with a focus on whether these cortisol responses varied with situational and individual differences in coping. Accounting for the diurnal cortisol pattern, perceiving greater stress than usual in the last hour was associated with elevations in cortisol only during situations characterized by *greater than usual* engagement coping. A different pattern emerged when considering individual differences; perceiving greater stress than usual was associated with elevations in cortisol only for adolescents who were *below average* on engagement coping or coping efficacy.

On average, perceiving more stress than usual in the last hour was not directly associated with situational elevations in cortisol. Given that cortisol peaks 20-25 minutes following a discrete stressor when measured in a controlled lab environment, our approach to modeling situational changes in cortisol in daily life likely underestimates true “reactivity.” However, a significant interaction between stress and coping indicated that cortisol responses to perceived stress must be interpreted in light of situation-specific coping efforts. Contrary to expectations, perceiving greater stress than usual was associated with higher cortisol (compared to situations of average or less stress) only when adolescents used *more* engagement coping than usual.

According to Lazarus and Folkman (1984), stress occurs when perceived environmental demands exceed one’s ability to cope with them. In our study, it is likely that adolescents felt compelled to use more active coping strategies in response to particularly demanding situations. Indeed, previous research has demonstrated that *how* one copes with stress predicts adaptation, whereas *how much* one copes actually reflects distress (Forsythe & Compas, 1987). Situations characterized by greater perceptions of stress and greater engagement coping than usual may have been the most uncontrollable, which produce the most robust cortisol response in lab settings (Dickerson & Kemeny, 2004). Although we anticipated that coping more than usual in

response to stress might attenuate cortisol reactivity, our results support models that emphasize the adaptive nature of changes in cortisol (Shirtcliff, Peres, Dismukes, Lee, & Phan, 2014). Engaging with recent stressors by actively coping may have facilitated HPA activation that was necessary to recruit physiological and psychological resources – the primary function of the stress response.

Assessed via traditional survey measures, individual differences in coping accounted for individual variation in the cortisol response to daily stress. Consistent with related laboratory research (Abelson et al., 2008; Matheson & Anisman, 2009; Rohrmann et al., 2002), our results demonstrated that adolescents who generally use more engagement coping strategies did not exhibit higher cortisol during particularly stressful situations in daily life. Rather, adolescents who were below average on engagement coping exhibited higher cortisol when they perceived greater stress (compared to average or less stress) than usual. The same pattern emerged for individual differences in coping efficacy. During secondary appraisal, individuals evaluate whether they can manage stress in order to adapt (Lazarus & Folkman, 1984). Adolescents who have greater confidence in their ability to handle stress are likely at an advantage during secondary appraisal and thus benefit from enhanced self-regulation when under stress. This finding builds upon our prior work focused on individual differences in coping efficacy and average diurnal cortisol patterns as these adolescents transitioned from high school to college (Drake et al., in press). Together, our results suggest that adolescents who have developed generally effective coping patterns (high engagement or high efficacy) have the capacity to regulate cortisol responsivity to daily stress in college. This is consistent with prior research that has demonstrated an inverse relation between engagement coping style and daily cortisol output among older adults (O'Donnell et al., 2008).

Notably, both situational *and* individual differences in engagement coping (assessed with different measurement approaches) accounted for variation in the cortisol response to daily stress, yet the patterns of findings were opposite. When adolescents reported using greater engagement coping than usual in response to stressful situations in daily life, greater stress than usual was associated with higher cortisol; for adolescents who scored above average on a traditional survey of engagement coping, however, greater stress than usual was not associated with higher cortisol. These differential findings underscore the importance of multiple levels of analysis in the study of coping, particularly because measures of “coping style” do not necessarily predict actual coping strategies in real life (Smith, Leffingwell, & Ptacek, 1999). Clinicians and university administrators invested in improving the first-year college experience should consider how coping functions differently across situations but also between students. For instance, college transition programs might consider highlighting diverse coping skills that students can use to manage different stressors, while also generally encouraging all students’ belief in their ability to handle daily demands of college life.

Limitations

Our sample of 63 first-year college students was modest in size, disproportionately female, and lived close to the university during high school. We did not assess perceived controllability of the stressors and did not explore how these relations may vary with type of stressor (e.g., academic, interpersonal). Due to available measures, we focused solely on engagement coping in the diary reports of this study. Future diary research should consider various coping dimensions, while balancing the need for brevity when using such methods. We are not able to suggest whether higher cortisol than usual should be considered adaptive or maladaptive, but future research might consider how these seemingly small changes in cortisol

contribute to the physical and psychological health of normative and clinical populations.

Conclusion

This study used ecological momentary assessment to examine how the cortisol response to perceived daily stress varies with situational and individual differences in coping among adolescents in their first year of college. Our results indicated that perceiving greater stress than usual was associated with situational elevations in cortisol only when adolescents responded by engaging *more than usual* with the source of stress. Yet in terms of individual differences, perceiving greater stress than usual was associated with elevations in cortisol only for adolescents who were *below average* on engagement coping or coping efficacy. Our findings extend previous literature by identifying within-person and between-person differences in adolescents' coping that separately account for variation in the HPA response to daily stress. It is critical to better understand how adolescents cope with this stress while they adjust to college demands in order to improve adaptation to their new academic and social environment.

Acknowledgments: This work was supported by Arizona State University's Institute for Social Science Research to LDD and by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-1311230 to MRS. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. Portions of this work are from the master's thesis of MRS completed at ASU. Portions of these findings were presented at the 2015 biennial meeting of the Society for Research in Child Development. Thanks to the Adolescent Stress and Emotion Lab and Andrea Gierens at the University of Trier for technical assistance with salivary assays.

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Figure 1

Figure 2

Figure 3