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Emotion dysregulation, anticipatory cortisol, and substance use in urban adolescents

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Abstract

Anticipatory cortisol is associated with risk for substance use in adolescents. The present study extended prior literature by testing a model linking family emotional climate, emotion dysregulation, anticipatory cortisol, and substance use. Participants were 229 adolescents ($M = 11.94$ years, $SD = 1.55$; 41% male; 92% African American) enrolled in a 4-wave study of stressors, physiological stress responses, and substance use. Caregivers completed measures of family emotional climate at baseline and adolescents' emotion dysregulation one and two years later; adolescents reported on their substance use at baseline and three years later at Wave 4. Adolescents completed a stress task at Wave 4; saliva samples taken immediately prior to the task were analyzed for cortisol. Longitudinal path models revealed that a negative emotional climate at home was associated with elevated emotion dysregulation at subsequent waves for all youth. Emotional dysregulation was prospectively associated with blunted anticipatory cortisol, which in turn was associated with elevated substance use, controlling for baseline substance use and age. However, these associations only were observed for females. This study suggests that helping girls in particular manage their emotional responses to stress more effectively may impact their physiological responses and reduce risk for substance use.

Keywords

Family climate; Emotion dysregulation; Anticipatory cortisol; Substance use; Sex differences

1. Introduction

Rates of adolescent substance use, though on the decline overall, remain high (CDC, 2014). Although a substantial amount of research has focused on understanding the developmental precursors of substance use and other risky behaviors (Scheier, 2010), there is relatively less information regarding physiological correlates of substance use in adolescents.

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Ethical statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Researchers have linked physiological stress responses such as heart rate, skin conductance, and cortisol reactivity with externalizing behavior in adolescents (Evans et al., 2012; Moss, Vanyukov, Yao, & Kirillova, 1999). In one of the few studies examining physiological stress response and adolescent substance use, Evans et al. (2012) found that adolescents who reported regularly consuming moderate to high amounts of alcohol displayed lower heart rates during a stress task than those who reported consuming lower amounts; this finding was replicated with tobacco use. These studies confirm the hypo-arousal theory of risk behavior in adolescence, which suggests a low threshold for physiological arousal is related to engaging in more risky behaviors. Individuals with blunted physiological responses to stress or emotional stimuli may seek out more risk-taking behaviors in order to increase or regulate arousal levels, or because they simply lack fear or anxiety and a lack of concern for negative consequences (see van Goozen, Fairchild, Snoek, & Harold, 2007).

A developmental perspective on physiological hypo-arousal suggests that early exposure to adversity in childhood influences later physiological stress responses through repeated exposure or accumulated risk (Evans & Kim, 2007; Lovallo, 2013). In particular, environmental risk factors such as parental substance use (Evans, Greaves-Lord, Euser, Franken, & Huizink, 2013; Evans et al., 2012; Moss et al., 1999), childhood physical abuse (Carpenter, Shattuck, Tyrka, Geraciotti, & Price, 2011), and repeated exposure to violence (Aiyer, Heinze, Miller, Stoddard, & Zimmerman, 2014) are associated with blunted cortisol. Youth exposed to these environmental stressors may experience them chronically through a negative emotional climate that develops in the home and that is reflected in interactions characterized by irritation, anger, conflict, criticism, disrespect, blame, or threats.

The relation between experiencing stressors and blunted cortisol reactivity may, in part, be explained by difficulty with regulating emotions. Indeed individuals diagnosed with post-traumatic stress disorder have higher levels of emotion dysregulation (Tull, Barrett, McMillan, & Roemer, 2007). It is likely that youth who have ongoing exposure to a negative family emotional climate are at an increased risk for emotion dysregulation, which also may lead to substance use as a way of coping with the negative affect associated with these stressors.

Further, the regulation of emotional responses, along with other individual differences reflecting underlying temperament, may be linked to cortisol responses (Ayer et al., 2013; Shoal, Giancola, & Kirillova, 2003). Ayer et al. (2013) found that preadolescents from a Dutch longitudinal population study with a persistent dysregulated profile showed blunted levels of cortisol in response to stress. The results of the Ayer et al. (2013) study coupled with hypo-arousal theory provides evidence that individual differences in emotion dysregulation are influenced by contextual stressors and may affect HPA axis activation in several ways. First, youth with dysregulated emotional responses may experience a greater number of stressors as a consequence of their emotional reactivity. A transactional approach to development notes that children not only react to their environment, but actively contribute to it (Sroufe & Rutter, 1984). This stress exposure may contribute to a repeated cycle of HPA axis activation, and over time may alter or blunt the typical HPA axis response to threat (Tsigos & Chrousos, 2002). Second, youth with dysregulated emotional responses may have an underlying sensitivity to the stressors they encounter, which also may alter the

typical HPA axis response. However, more longitudinal research needs to be conducted in this area among diverse populations of youth. Research on HPA axis activation and externalizing behaviors during adolescence is equivocal. Most previous research on correlates of HPA axis activation has used baseline-resting measures or reactivity responses (c.f., Van de Wiel, Van Goozen, Matthys, Snoek, & Van Engeland, 2004). The activation of the HPA axis is contingent on either exposure to stress or the mere threat of stress (Stroud et al., 2009). Examining cortisol secretions in *anticipation* of a stressor may provide a more accurate measure of the body's stress response, and provides a unique perspective of contexts in which the threat of stress is frequently present, and the potential for continuous over-activation of the HPA. Recent research measuring cortisol in anticipation of a stressful event has shown significant associations with later substance use (Evans et al., 2012, 2013; Moss et al., 1999).

The primary purpose of the present study was to test a model linking negative family emotional climate, emotional dysregulation, blunted anticipatory cortisol, and substance use in adolescents. A second exploratory purpose of the study was to determine if the model differed by sex. Based on prior literature we proposed that a negative family emotional climate would contribute to emotional dysregulation in youth. Emotional dysregulation, in turn, would be associated with blunted anticipatory cortisol, which would be associated with elevated substance use.

2. Method

2.1. Participants

Participants included 229 urban adolescents ($M = 11.95$ years, $SD = 1.55$; 42% male; 92% African American) and their maternal caregivers participating in a 4-wave longitudinal study of stressors, physiological stress responses, and substance use. Just over half of the sample (54%) had household incomes below the poverty line based on Federal guidelines, and median caregiver education was completion of high school. A range of family structures was represented in the sample, although many (41%) of the caregivers had never married.

2.2. Procedure

The Institutional Review Board at Virginia Commonwealth University approved the project. Participants were recruited from neighborhoods in and around Richmond, VA, with high levels of violence and/or poverty based on police statistics and census data. Participants were recruited through community agencies and events, and by canvassing qualifying neighborhoods via flyers posted door-to-door. To be eligible, participants had to have a fifth or eighth grader living in the home, and a female caregiver needed to participate in the interview. Only English-speaking participants were recruited into the study. Participants were not screened for substance use as a criterion for participation. Eligible respondents were scheduled for interviews, which were conducted in participants' homes unless a family requested to be interviewed elsewhere. Sixty-three percent of eligible participants agreed to be in the study, which is consistent with studies using similar designs and populations.

Interviewers thoroughly reviewed the parental consent and adolescent assent forms with the family. Assent was provided by the adolescent before initiating the adolescent interview. Participants agreed to participate in a series of four annual interviews. A Certificate of Confidentiality was obtained from the National Institutes of Health (NIH) to protect families' responses since adolescents were reporting on illegal behavior (i.e., substance use) as part of the study. Face-to-face interviews using visual aids were used to collect the data, and all questions were read aloud, with the exception of a small portion of the adolescent interview. Adolescents who had passed a reading-screening test answered several (primarily sensitive) questions in a booklet without interviewer assistance. Tests for interviewer race and sex effects revealed no systematic biases, $p > 0.10$. Interviews with the caregiver and adolescent lasted approximately 2.5 h and participants received \$50 in gift cards per family at each wave.

2.3. Measures

2.3.1. Family emotional climate—The 10-item negative dominant subscale of the *Family Expressiveness Questionnaire* (FEQ; Halberstadt, 1986), reported by parents at Wave 1, was used to assess family emotional climate. Items represent a range of negative emotions typical of many families and are rated on a 9-point scale ranging from (1) *not at all frequently in my family* to (9) *very frequently in my family*. Participants were instructed to complete the measure with respect to the family with whom they currently lived, including themselves, their spouses/partners (if applicable), children, and other individuals living in the household. Halberstadt (1986) reports excellent reliability and validity for the measure. This subscale was concurrently correlated with family stressors and maternal adjustment problems ($r_s = 0.32$ – 0.39), also evidencing its validity. In the current study, Cronbach alpha was 0.80. Higher scores reflect a more negative emotional climate.

2.3.2. Emotion dysregulation—Parent-reported emotional lability and frustration tolerance, assessed at Waves 2 and 3, were used to index a latent construct of emotion dysregulation. Lability was assessed with the 16-item lability subscale from the Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997). Each item on the ERC is rated on a four-point Likert scale from (1) *never* to (4) *always*. The lability subscale consists of items tapping lack of flexibility, mood lability, and anger dysregulation, such as “Exhibits wide mood swings.” The ERC has excellent reliability and validity. Cronbach alphas in the present study were 0.86 for Wave 2 and 0.84 for Wave 3. The 5-item frustration tolerance subscale of the Teacher-Child Rating Scale – Parent Version (TCRS-P; Wyman et al., 1999) was used to measure frustration. Each item on the TCRS subscale is rated on a 5-point scale ranging from (1) *not at all well* to (4) *very well*. The frustration tolerance subscale includes items such as “accepts things not going his/her way.” The TCRS has excellent validity and reliability. Scale scores were recoded that higher scores reflected worse frustration tolerance. Cronbach alpha in the present study was 0.83 at both Waves 2 and 3.

2.3.3. Substance use—Three measures of adolescent substance use at Wave 4 were used as manifest indicators of a latent construct of substance use. These included: (1) the 6-item drug use subscale of the Problem Behavior Frequency Scales (PBFS; Farrell, Kung, White, & Valois, 2000), which assessed past month substance use. Adolescents indicated how

frequently they engaged in the behavior over the past 30 days using a six-point scale: never, 1–2 times, 3–5 times, 6–9 times, 10–19 times, and 20 times or more. Items included: drunk beer (more than a sip or taste); drunk wine or wine coolers (more than a sip or taste); drunk liquor; been drunk; smoked cigarettes; and used marijuana. Mean item scores were calculated; higher scores represented more use. The measure has good reliability and validity based on work with urban samples of youth (Sullivan, Farrell, & Kliewer, 2006). Cronbach's alpha in the present study was 0.88; (2) the 18-item drug use severity subscale from the Personal Experiences Inventory (PEI; Winters & Henly, 1989), which assessed the degree of adolescent chemical involvement. Adolescents rated items on a scale from (0) *never* to (3) *often*. A sample item is “How often have you made excuses to your parents about your alcohol or drug use?” The measure has good reliability and validity. Cronbach's alpha in the present study was 0.90; and (3) a single-item indicator of past 30 day cigarette use, modelled after the Monitoring the Future study (www.monitoringthefuture.org). Adolescents indicated how frequently they smoked over the past 30 days using a seven-point scale: not at all, less than one cigarette per day, 1–5 cigarettes per day, about half a pack per day, about a pack per day, about 1 ½ packs per day, and two packs or more per day. Due to skewness, the two scales and measure of cigarette use were log transformed for the analyses.

2.3.4. Controls—Controls included time of day, because cortisol varies by time of day, past month substance use at Wave 1 (alpha = 0.86), drug use severity at Wave 1 (alpha = 0.91), adolescent age at Wave 1, and sex.

2.3.5. Physiological responses—Physiological data from Wave 4 was used in the present study. Adolescents completed the Social Competence Interview (SCI; Ewart, Jorgensen, Suchday, Chen, & Matthews, 2002), a 15–20 minute audiotaped interview in which adolescents were asked to reexperience their most stressful event of the past couple months. The SCI is designed to promote physiological arousal and is correlated with changes in blood pressure and heart rate (Ewart & Kolodner, 1991). Participants first were provided with instructions for completing the SCI in order to elicit arousal in anticipation of re-experiencing a stressful event. Saliva samples then were collected from the adolescents before, during, and following the SCI. Participants were instructed not to exercise, to eat, or to drink caffeinated beverages 2 h prior to the SCI. The sample collected after instructions yet prior to the start of the SCI was used to capture anticipatory responses. The physiological data was collected using salivettes. Adolescents were asked by the interviewer to place a cotton swab in their mouth and chew for about 1 min. The adolescent spit the swab into the salivette tube and the samples were frozen at –70 °C or below until the samples were taken to the laboratory for analysis. The saliva samples were assayed at the General Clinical Research Center at Virginia Commonwealth University for the stress hormone, cortisol, an enzyme immunoassay specifically designed for saliva analysis. Saliva samples were spun and frozen prior to testing. On the day of the assay, samples were thawed and assayed directly with no further centrifugation. All samples were assayed for salivary cortisol using a highly sensitive enzyme immunoassay US FDA (510k) cleared for use as an in vitro diagnostic measure of adrenal function (Salimetrics, State College, PA). The test used 25 ml of saliva and had a lower limit of sensitivity of 0.007 mg/dl, with a range of

sensitivity from 0.007 to 3.0 mg/dl. Samples were assayed in duplicate; average intra- and inter-assay coefficients of variation were <5% and 10%.

2.4. Analyses

A longitudinal path model using Mplus 7.31 (Muthén & Muthén, 2012) was used to test the key hypothesis. Model fit was assessed using the χ^2 value, the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA), with maximum likelihood (ML) estimates. Values of 0.90 or above for the CFI (Bentler, 1992) and 0.08 or below for the RMSEA (Browne & Cudeck, 1993) indicated that the model adequately fit the data. Multiple group analyses were used to evaluate the model for sex differences. We compared an unconstrained model where the path coefficients were allowed to vary by sex to a constrained model where path coefficients were set to be equal across sex. The fit for the unconstrained and constrained models was evaluated by examining the χ^2 difference test and differences in the models based on the CFI, RMSEA, and the Bayesian Information Criterion (BIC) (Raftery, 1993).

3. Results

3.1. Attrition analyses

Sixty-nine percent of the sample was retained across the four waves of the study, but not all participants at Wave 4 had useable cortisol data. Youth who participated in all four waves of the study and on whom cortisol data and control variables was available at Wave 4 ($N = 229$) were compared with youth who were missing cortisol data or control variables at Wave 4 ($N = 129$) on demographics, family emotional climate assessed at Wave 1 and emotion dysregulation measures assessed at Waves 2 and 3. Youth who attrited were more likely to be male ($p < 0.01$), older ($p < 0.05$), and less able to regulate their emotions at Wave 2 ($p < 0.05$). There were no differences on emotion regulation at Wave 3 or on family emotional climate at baseline.

3.1.1. Descriptive information and bivariate analyses—Descriptive information on and correlations among the key study variables are presented in Table 1. Negative emotional climate in the home was positively associated with emotion dysregulation at subsequent waves. Emotion dysregulation was negatively associated with anticipatory cortisol, and was positively associated with substance use at Wave 4. There were no zero-order associations between anticipatory cortisol and Wave 4 substance use.

3.2. Model testing of the key hypotheses

The model was an adequate fit to the data ($N = 229$; $\chi^2 (69) = 128.98$, $p < 0.001$; RMSEA = 0.062 [90% CI = 0.045, 0.078]; CFI = 0.943; SRMR = 0.076). Negative emotional climate was associated with dysregulated emotion ($b = 0.32$, $p < 0.001$); dysregulated emotion was associated with lower anticipatory cortisol ($b = -0.14$, $p = 0.011$), controlling for time of day of assessment ($b = -0.55$, $p < 0.001$); and anticipatory cortisol was marginally associated with substance use ($b = -0.13$, $p = 0.059$) after accounting for baseline use ($b = 0.42$, $p < 0.001$), age ($b = 0.18$, $p = 0.013$), and sex ($b = 0.14$, $p = 0.044$). Results of the multiple group analysis favored the unconstrained model, suggesting moderation by sex [fit for

unconstrained model ($N = 229$, $BIC = 4785.008$; $\chi^2 = (138) = 260.44$, $p < 0.001$; $RMSEA = 0.088$ CI [0.072, 0.104]; $CFI = 0.891$); Fit for constrained model ($N = 229$, $BIC = 4788.136$; $\chi^2 = (133) = 252.24$, $p < 0.001$; $RMSEA = 0.088$ CI [0.072, 0.105]; $CFI = 0.893$).

Fig. 1 presents the unconstrained model results. As seen in the figure, a negative emotional climate in the family was associated with dysregulated emotion for both males and females. However, the path linking emotional dysregulation to suppressed anticipatory cortisol and the path linking anticipatory cortisol to substance use only were significant for females.

4. Discussion

To our knowledge, this study is the first to document prospective paths linking family emotional climate, emotion dysregulation, physiological responses to stress, and substance use within a sample of primarily low-income, urban, African-American youth. Higher levels of negative emotion in the family context were associated with higher levels of dysregulated emotion for all youth. However, dysregulated emotion was associated with blunted anticipatory cortisol, and blunted anticipatory cortisol was associated with substance use only among females.

Results from this study confirm and extend those of the extant literature in several ways. First, these results expand upon Evans' et al. (2012) finding that hypo-arousal of the autonomic nervous system is associated with alcohol and tobacco use among a sample of Dutch adolescents. In our sample of urban, low-income, African-American youth, we found that blunted anticipatory cortisol was related to substance use in females, implicating additional biological systems in alcohol and drug use. Next, these results contribute to the literature by demonstrating pathways from higher levels of emotional dysregulation to blunted levels of cortisol in anticipation of threat, albeit only for females. Prior research similarly has linked emotion dysregulation with inhibited cortisol response in preadolescents (Ayer et al., 2013) and adults (Kudielka, Hellhammer, & Wüst, 2009) suggesting a continuous mechanism may operate across development. Finally, this study adds to research documenting the negative influence of family emotional climate on emotion regulation.

Our data lend some support to the developmental perspective of HPA hypo-arousal theory, which conceptualizes atypical physiological stress responses as due to cumulative risk from exposure to stress and adversity at an early age (Essex et al., 2011; Evans & Kim, 2007; Lovallo, 2013). Recent research has established links between early childhood trauma and dysfunction in the HPA axis among adolescents (e.g., Kuhlman, Geiss, Vargas, & Lopez-Duran, 2015). The current study extends this literature by documenting links from somewhat milder, more common experiences – a negative family emotional climate – to dysfunction in the HPA axis – in females. Further, a negative family emotional climate is linked to dysfunction in the HPA axis through emotion dysregulation; frequent and chronic expressions of dysregulated emotion may then further add to one's cumulative stress load. Together, these cumulative stressors may cause wear and tear to the HPA axis, leading to impaired axis activation and lower levels of cortisol. These suppressed levels of cortisol may lead youth to try to regulate their own physiology through sensation seeking and engaging in risky behaviors, such as substance use.

Understanding these pathways is important in developing effective prevention programs, in order to define valuable targets for maximal change. For example, recent research among very young children (Ellis, Alisic, Reiss, Dishion, & Fisher, 2014) suggests that intervening early and teaching parents to practice emotion coaching with their children – to identify and validate their child's emotions as a teaching tool – may buffer the negative effects of family stress on emotion regulation. Given that our study's results suggest that dysregulated emotion due to stress leads to impaired biological systems and later risky sensation seeking behavior to potentially externally regulate those impaired systems, efforts aimed at helping children to develop strong emotion regulation skills may provide an effective and efficient deterrent to substance use. Future research could examine emotion coaching interventions with parents of older children and adolescents as a potential adolescent substance use prevention strategy. Future research should also untangle why paths from emotion dysregulation to blunted anticipatory cortisol and substance use were observed for females and not males.

A few limitations to this study should be noted. First, our measures of cortisol and substance use were collected at the same time, limiting our ability to determine the direction of the relation between these variables. In addition, there were some significant differences on demographics and emotion dysregulation measures between those youth participants for whom cortisol data was available at Wave 4, and youth who had dropped out of the study. Those who dropped out were more likely to be male, older, and less able to regulate emotion at Wave 2.

Our study also had several notable strengths. We used a prospective design spanning three years. We had multiple sources (caregiver, youth) and types of data (self-report, biological measures). We assessed anticipatory cortisol levels, which have been studied less frequently in the literature, and included appropriate controls in our model. Finally, our sample primarily was urban, African American families. Researchers have documented the elevated rates of adverse experiences and exposure to violence often suffered among this group (Foster & Brooks-Gunn, 2009). The chronic stress associated with adverse childhood experiences and exposure to violence has been linked with poor family functioning and poor youth emotional health (Sheidow, Jenry, Tolan, & Strachan, 2014), and with impairments in physical and mental well-being as well as cortisol functioning (Aiyer et al., 2014; Shonkoff et al., 2012). Thus, our sample may not be representative of associations between poor family functioning, emotion dysregulation, anticipatory cortisol, and substance use that might be observed in the general population.

Thus, future research examining these concepts in other populations would add additional support to these findings. Overall, however, we believe the present study contributes to the understanding of associations between family emotional climate, individual differences, HPA axis activation, and risk behavior in adolescents.

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Fig. 1.

Structural equation model of the relations between family emotion climate at Wave 1, emotion dysregulation at Waves 2 and 3, anticipatory cortisol at Wave 4, and drug use at Wave 4, controlling for baseline drug use, youth age, and time of data collection.

Standardized beta weights are presented. Values before the / are for females; values after the / are for males. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

Table 1

Descriptive information on and correlations among key study variables.

	1	2	3	4	5	6	7	8	9	10	11
1-Neg Fam Emo Clim (W1)	–	0.24 ^{***}	0.21 ^{***}	0.28 ^{***}	0.19 ^{***}	–0.04	0.14	0.02	0.12 ⁺	0.03	–0.03
2-Emotional Lability (W2)		–	0.67 ^{***}	0.80 ^{***}	0.61 ^{***}	–0.13 [*]	0.19 ^{**}	0.16 [*]	0.23 ^{***}	0.06	0.14 ^{**}
3-Frustration Tol (W2)			–	0.61 ^{***}	0.69 ^{***}	–0.14 [*]	0.13 [*]	0.19 ^{**}	0.09	0	0.12 [*]
4-Emotional Lability (W3)				–	0.66 ^{***}	–0.19 ^{**}	0.22 ^{***}	0.22 ^{***}	0.25 ^{***}	0.09	0.14 [*]
5-Frustration Tol (W3)					–	–0.15 [*]	0.21 ^{**}	0.25 ^{***}	0.17 ^{**}	0.06	0.15 [*]
6-Anticipatory cort (W4) ^a						–	–0.08	–0.03	–0.03	0.03	0.08
7-Drug use (W4) ^b							–	0.61 ^{***}	0.56 ^{***}	0.30 ^{***}	0.22 ^{***}
8-Drug use severity (W4) ^b								–	0.41 ^{**}	0.25 ^{***}	0.33 ^{***}
9-Past 30 day cig use (W4) ^b									–	0.20 ^{**}	0.18 ^{**}
10-Drug use (W1) ^b										–	0.53 ^{***}
11-Drug use severity (W1) ^b											–
Mean	45.50	29.55	–13.57	28.87	–14.32	0.35	0.17	0.22	0.05	0.10	0.15
SD	14.02	7.22	4.64	6.72	4.44	0.13	0.33	0.38	0.13	0.24	0.35

Note. Ns range from 223 to 347 due to missing data.

^aSquare root transformed.^bLog transformed.⁺ $p < 0.10$.^{*} $p < 0.05$.^{**} $p < 0.01$.^{***} $p < 0.001$.