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Cognitive-Affective Strategies and Cortisol Stress Reactivity in Children and Adolescents: Normative Development and Effects of Early Life Stress

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Abstract

This study examined cognitive-affective strategies as predictors of hypothalamic-pituitary-adrenal (HPA) axis responses to a social-evaluative stressor in adolescence as compared to late childhood as a function of early life experiences. Participants included 159 children (9–10 years) and adolescents (15–16 years) divided into two groups based on early care experiences: non-adopted youth raised in their birth families ($n = 81$) and post-institutionalized youth internationally adopted from orphanage care ($n = 78$). Youth completed a version of the Trier Social Stress Test modified for use with children and reported on their trait emotion regulation and coping strategies. Children reported more use of suppression and disengagement than adolescents, while adolescents reported more engagement coping strategies. Non-adopted and post-institutionalized youth did not differ in reported strategies. Cognitive reappraisal predicted higher cortisol reactivity in non-adopted children and adolescents, and was not associated with reactivity in the post-institutionalized group. This study has implications for efforts aimed at promoting self-regulation and adaptive stress responses during the transition to adolescence for both typically developing children and children who experienced adverse early care.

Keywords

stress; emotion regulation; cortisol; early experience; cognitive reappraisal

Adolescence is characterized by increased affective responses and biological stress reactivity (Dahl & Gunnar, 2009). However, many youth weather adolescent “storm and stress” without experiencing significant difficulties (Steinberg & Morris, 2001). One explanation is that many have the ability to regulate arousal during emotional and stressful experiences (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015; McRae et al., 2012; Silvers et al., 2012). However, some youth are vulnerable to dysregulated stress responding, and research is needed to understand individual differences in processes used to regulate emotion and how they are associated with stress reactivity as children approach adolescence (Denson,

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Spanovic, & Miller, 2009). The present study examines how the use of cognitive-affective strategies differs in adolescence as compared to late childhood, and is among the first to examine associations between such regulatory strategies and physiological stress reactivity. In addition to exploring the association between regulatory strategies and physiological stress reactivity, we examined how this association may differ as a function of age and early life stress. Thus, we compared children and adolescents adopted internationally from orphanage care to those reared in their birth families who were of similar education and income to the adoptive families.

Cognitive-Affective Self-Regulation

With adolescence comes changes in relationships, identity concerns, and adjustments to new social roles (Seiffge-Krenke, Aunola, & Nurmi, 2009), in addition to increased stress exposure and heightened stress reactivity (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009b; Stroud et al., 2009; Sumter, Bokhorst, Miers, Van Pelt, & Westenberg, 2010). Thus, acquiring the ability to self-regulate heightened stress and emotional reactivity is imperative.

Self-regulation is a multidimensional construct involving processes that allow for the willful control of thoughts, emotions, and behaviors (Rothbart, Sheese, Rueda, & Posner, 2011). As individuals begin the pubertal transition, changes in dopaminergic systems rapidly increase affective reactivity and appetitive motivation while prefrontal networks central to self-regulation are rewired and fine-tuned more gradually (Casey, 2015; Casey et al., 2010). These changes are coupled with heightened self-consciousness and sensitivity to social-contextual cues (Blakemore, 2008; Guyer et al., 2016; Somerville, 2013). Thus, adolescence is a period during which stress and emotional reactivity are high, and the neural mechanisms used to support the regulation of this heightened reactivity are developing at a relatively slower pace. If adolescents can learn flexible solutions to responsibly manage increased reactivity, they may be better equipped to manage stress and be less likely to develop patterns of behavior leading to maladjustment (Ahmed et al., 2015; Crone & Dahl, 2012; Silvers et al., 2012). In contrast, adolescents with poorer regulatory abilities may respond less flexibly to changing demands, be less able to manage arousal, and have difficulty across multiple developmental domains.

The specific ways in which adolescents regulate their emotions and stress, and how these strategies may change from childhood to adolescence is less clear. According to models of stress and coping, stress is a subjective experience following the cognitive appraisal that a stressor requires demands beyond resources at hand (Lazarus & Folkman, 1984). Emotions are elicited and involved in dynamic appraisal-action processes, which allow the individual to evaluate and respond to the situation at hand, and the regulation of these emotions involves transactions between cognitive and affective systems. That is, emotion provides motivational aspects of cognition, organizing one’s thinking, learning and action, while cognition guides the regulation of these emotions. Although both emotion regulation and coping are regulatory processes that shape stress responses, the terms are not synonymous. Emotion regulation encompasses processes that influence the experience and expression of both positive and negative emotions that may occur with or without the presence of a stressor, while coping refers to cognitive and behavioral processes in response to stress (Compas et al., 2014).

In early childhood, when cognitive skills are less developed, behaviorally based self-soothing strategies are more commonly employed to regulate emotion. However, as children move beyond early childhood, the maturation of neural networks supporting executive function skills allow strategies to become more cognitively based (Ahmed et al., 2015; Zelazo & Cunningham, 2007). For example, executive functions are associated with greater use of cognitive reappraisal and less use of emotion suppression in adolescence (Lantrip, Isquith, Koven, Welsh, & Roth, 2016), and suppression use tends to decrease between late childhood and mid-adolescence (Gullone, Hughes, King, & Tonge, 2010). Further, in a study of young adults, working memory ability was associated with secondary control coping, including cognitive restructuring (Andreotti et al., 2013). Throughout adolescence and emerging adulthood, maturation of the prefrontal cortex supports more effective use of cognitive strategies, such as cognitive reappraisal, as a means to regulate arousal (Guyer et al., 2016; McRae et al., 2012; Silvers et al., 2012). Development of cognitive control networks may also help support adolescents' ability to flexibly adapt to circumstances and select appropriate regulatory strategies for the current context (Casey, 2015; Crone & Dahl, 2012). Indeed, coping strategies tend to become more differentiated and flexible in mid- to late-adolescence (Kavsek & Seiffge-Krenke, 1996), and older adolescents are able to more effectively match potential sources of support with particular types of problems (Skinner & Zimmer-Gembeck, 2007).

Cognitive-Affective Regulation and Physiological Stress Reactivity in Adolescence

The inability to regulate stress and emotional reactivity may not only contribute to more impulsive behavioral responses (Sontag, Graber, Brooks-Gunn, & Warren, 2008) and a greater likelihood of behavioral maladjustment, but may have physiological consequences as well. At a physiological level, a failure to regulate emotional reactivity and repeated or prolonged activation of stress responses may lead to dysregulation within stress-response systems (e.g., McEwen, 1998). The majority of work investigating the activation and dysregulation of stress response systems has focused primarily on the hypothalamic-pituitary-adrenocortical (HPA) axis. When a threat is detected, the HPA axis activates a chain of neuroendocrine cascades, which lead to the secretion of the glucocorticoid hormone cortisol. The circulating glucocorticoids bind to glucocorticoid and mineralocorticoid receptors throughout the body and brain, through which they regulate the transcription of genes, protein synthesis, and a cascade of physiological effects, including increased cardiovascular drive, mobilization of energy, and sharpened cognition (Sapolsky, Romero, & Munck, 2000).

Given that adolescents are particularly vulnerable for repeated and prolonged physiological stress responses, research that identifies predictors of stress reactivity and regulation during adolescence is critical. Affective neuroscience points to significant overlap between neural circuitries of cognition and emotion (Ochsner & Gross, 2007), and psychoneuroendocrinology highlights these networks as primary integrators of the physiological stress response (Ulrich-Lai & Herman, 2009). The presence and prevalence of these connections suggest that cognitive-affective systems may play an essential role in physiological stress regulation. However, there is little work addressing how regulatory strategies are associated with physiological stress responses in late childhood and adolescence.

Psychosocial stress prompts the need to regulate emotions, as these stressors elicit self-conscious emotions, such as shame and embarrassment. The cortico-limbic networks central to emotion regulation interact with fear- and stress-response systems (Dedovic, Duchesne, Andrews, Engert, & Pruessner, 2009; Egloff, Schmukle, Burns, & Schwedtfeger, 2006; Root et al., 2009), and are associated with HPA axis reactivity in adults (Cunningham-Bussel et al., 2009; Putnam, Pizzagalli, Gooding, Kalin, & Davidson, 2008; Wheelock et al., 2016) and adolescents (Thomason, Hamilton, & Gotlib, 2011; Liu et al., 2012). Studies on adolescence indicate age-related improvements in the effectiveness of instructed cognitive emotion regulation strategies (McRae et al., 2012; Silvers et al., 2012). Although adolescents develop cognitive skills that support the use of cognitive strategies, it is unclear whether adolescents increase their spontaneous use of these strategies, such as cognitive reappraisal (Gullone & Taffe, 2012). While this research in adolescents has not addressed HPA reactivity specifically, studies in adults have begun to test associations between emotion regulatory strategies – reappraisal and suppression – and HPA axis responses to psychosocial stressors. Cognitive reappraisal is an antecedent-focused strategy that aims to change the cognitive perception of a situation to modify the resulting emotional reaction, while emotion suppression is a response-focused strategy that aims to inhibit emotion-expressive behavior (Gross, 1998). The majority of studies of emotion regulation and stress reactivity have examined the effect of an experimental manipulation (e.g., instructing participants to engage in reappraisal or suppression) on HPA reactivity (Gross, 2014).

Beyond instructed strategy use, measuring participants' spontaneous use of regulatory strategies can provide a better index of which strategies are actually used to manage everyday stressors. Lam and colleagues (2009) tested whether adults' trait cognitive reappraisal and emotion suppression predicted cortisol reactivity to the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). In the TSST, participants complete an impromptu speech and math task in front of a panel of judges, a task perceived to be an unpredictable, uncontrollable threat to the social self. They found that trait suppression predicted increased cortisol reactivity, and, contrary to hypotheses, trait reappraisal was also positively associated with cortisol reactivity.

There is little evidence regarding emotion regulation strategies and cortisol reactivity before the pubertal transition. In a sample of 10-year-olds, de Veld and colleagues (2012) tested associations between emotion regulation strategies and cortisol reactivity to a modified TSST. Rather than trait emotion regulation, they measured self-reported spontaneous use of reappraisal and suppression during the stressor. In girls, suppression was associated with lower cortisol reactivity, but reappraisal was not associated with cortisol responses. As the authors discussed, this reappraisal measure may have indexed response-focused rather than antecedent-focused reappraisal, because participants reported reappraisal during the stressor itself. This study was also limited by use of difference scores as the measure of cortisol reactivity rather than examining response magnitude via area under the curve or shape using growth curve modeling.

While emotion regulation refers to the general management of emotions, coping specifically refers to cognitive and behavioral responses to stress. The development of types of coping may help define adaptive responses to stress. For example, Rudolph and Troop-Gordon (2010) identified an association between earlier pubertal maturation and depression; however, this association only held among youth who engaged in effortful disengagement coping (e.g., denial, avoidance) and involuntary responses (e.g., rumination, arousal). Adolescents who utilized goal-directed coping (e.g., problem solving, effortful emotion regulation) in response to peer stressors were buffered from negative consequences of early puberty. Similarly, Sontag and colleagues (2008) found that young adolescent girls with increased vulnerability (early pubertal maturation or higher levels of peer stress) demonstrated greater internalizing problems and aggression. However, this association was fully mediated by the use of ineffective responses to stress (more disengagement, fewer primary control strategies, more involuntary engagement).

A few studies of adolescent coping have specifically examined coping strategies and cortisol responses. Sontag and colleagues’ (2008) study summarized above found that involuntary engagement coping (e.g., impulsive actions, intrusive thoughts, physiological arousal), was associated with increased cortisol reactivity to a challenge task. Also among young adolescent girls, use of voluntary engagement coping in response to interpersonal stress was associated with lower total diurnal cortisol, steeper diurnal cortisol slope, and lower cortisol awakening response, all indicative of adaptive daily cortisol patterns (Sladek, Doane, & Stroud, 2017). Regarding late adolescence, Sladek and colleagues (2016) similarly reported that high trait engagement coping was associated with lower cortisol reactivity to daily stressors in a sample of first year college students. Finally, Bendezu and Wadsworth (2017), found that, for young adolescents who experienced recent life stress exposure, cognitive avoidance was more effective than behavioral distraction for cortisol recovery following the TSST. Taken together, these studies suggest that more engaged and goal-directed coping strategies may be associated with subsequent adjustment and a greater ability to regulate stress, but that these relationships may vary by life circumstances such as previous stress exposure.

Given this prior literature, our second aim was to test whether individual differences in cognitive-affective strategies predict HPA reactivity. Furthermore, given the development of self-regulatory systems in adolescence, we examined whether cognitive-affective strategies are better predictors of HPA reactivity for adolescents compared to children. Due to development of the prefrontal cortex, improvements in executive functioning, and more opportunities to practice strategies up to their current age, we expected that adolescents might be more proficient and consistent in implementing their strategies to manage stress. In contrast, children may be less adept or inconsistent in using their self-reported strategies, and therefore, variation in the use of a particular strategy might not meaningfully predict variation in HPA reactivity at this age.

The current study addressed a critical gap regarding the way in which regulatory strategies are associated with HPA reactivity in late childhood and adolescence. There is limited developmental evidence regarding how youth regulate emotions and stress and even less evidence for the association between such regulatory strategies and stress reactivity. Because adolescence is a particularly sensitive period for vulnerability and opportunity in self-regulatory systems, individual differences in cognitive-affective processes may be particularly important for characterizing preadolescents and adolescents who thrive despite increased daily stressors and stress reactivity.

Early Life Stress

In infancy and early childhood, self-regulation develops within caregiver-child relationships as sensitive and responsive caregivers modulate and scaffold children's arousal and regulation (Cole et al., 2004; Gunnar & Donzella, 2002). Disrupted early caregiving environments provide fewer opportunities for children to practice behavioral skills and alter the development of neurobehavioral systems involved in arousal and regulation. Indeed, youth who experienced early deprivation tend to show deficits in self-regulatory behavior (e.g., Blair, 2010; Evans & Kim, 2013), changes in neural structure, connectivity, and functioning in prefrontal and limbic regions associated with self-regulation (e.g., Teicher et al., 2003; Tottenham et al., 2010), and dysregulation of stress physiology (e.g., Bosch et al., 2012; Gunnar & Quevedo, 2007). The current study includes post-institutionalized (PI) youth who were adopted internationally from orphanage care as a model of early life stress, because their chronic stress exposure is circumscribed to the time prior to adoption.

Behaviorally, PI children tend to show deficits or delays in emotion understanding (Wismer Fries & Pollak, 2004) and emotion regulation (Tottenham et al., 2010), and these effects are predicted by duration of institutional care. We know little about which emotion regulation or coping strategies PI youth commonly use or their effectiveness in managing arousal. One study found that 6–12-year-olds who experienced neglect, but not physical or sexual abuse, reported using fewer adaptive strategies for coping with emotional arousal, and displayed fewer appropriate displays of emotion, lower empathy, and lower emotional self-awareness (Shipman, Edwards, Brown, Swisher, & Jennings, 2005). Given disruptions in early caregiving environments, as well as deficits in emotion understanding and regulation, PI children might show delays in the development of skills to effectively manage their emotions and behavior, rely on more immature regulatory strategies, or find it more difficult to successfully employ more advanced cognitive-affective strategies.

When examining HPA stress responding, a large body of research demonstrates that early life stress affects the development of the HPA axis and alters stress responses, potentially leading to hypo- or hyper-reactivity to stress (Strüber, Strüber, & Roth, 2014). Findings have been somewhat mixed regarding long-term effects of early institutional care on cortisol reactivity. McLaughlin and colleagues (2015) demonstrated blunted HPA axis responses to the TSST in PI 12-year-olds who were institutionalized for more than two years before being placed in foster care, and Koss and colleagues' (2016) longitudinal study of young PI children indicated blunted cortisol responses to a laboratory visit. Gunnar et al. (2009a) found that PI 10–12-year-olds did not differ in TSST cortisol reactivity relative to non-adopted peers; however, DePasquale, Donzella & Gunnar (in press) found that pubertal status was associated with whether PI youth showed a blunted (pre/early pubertal stage) versus typical (mid/late pubertal stage) response to the TSST. Together, these studies suggest blunted HPA axis reactivity following early stress in the form of institutional care, especially for prepubertal children. However, previous research has been unable to identify the role of regulation versus reactivity in patterns of HPA hyporeactivity. The assessment of regulatory strategies in the current study and their coupling with physiological stress reactivity will clarify whether hyporesponsive PI youth are particularly adept at managing arousal, or if this pattern of reactivity exists relatively independent of regulatory behaviors. Further, regarding differences between children and adolescents, the maturation of neural circuits central to regulation during puberty might support development of more typical connections between cortico-limbic and stress response systems in PI youth.

The current study is unique in that it is the first to examine cognitive-affective and coping strategies in PI youth, and test whether the use of these strategies changes from late childhood to adolescence. Moreover, this study is also the first to investigate the association between regulatory strategies and cortisol reactivity in a PI sample.

The Current Study

In the current study, we sought to better understand the development of regulatory systems from late childhood to adolescence, a period marked by plasticity in neurobehavioral systems central to self-regulation and stress reactivity. We sampled specific age ranges to compare regulatory and reactivity patterns among preadolescents (9- and 10-year-olds) and mid-adolescents (15- and 16-year-olds). We also aimed to better understand how trait self-regulatory strategies may be associated with physiological responses to psychosocial stress. This study builds on questions regarding typical development of self-regulatory functioning from late childhood to adolescence, while also examining how early life stress may alter the development of self-regulatory systems. The specific goals of the present study are described below.

First, we examined developmental differences in children and adolescents' self-reported tendencies to use various cognitive-affective emotion regulation and coping strategies in daily life. Given links between the maturation of executive functions and use of cognitive self-regulatory strategies, we expected that adolescents would report more use of cognitive reappraisal and active engagement than children, and that children would report more emotion suppression, disengagement, and involuntary responses. We hypothesized that PI youth would report more use of suppression, disengagement, and involuntary responses than NA youth. Whether the group differences would be similar in late childhood and adolescence was largely unknown, as these questions had not been examined in adolescents.

Second, we tested the relation between these reported cognitive-affective strategies and cortisol stress reactivity in the laboratory setting. We hypothesized that reappraisal and suppression would predict decreased and increased cortisol reactivity, respectively. We also expected that engagement coping would predict decreased reactivity, while disengagement and involuntary responses would predict increased reactivity. We hypothesized that associations between self-reported strategies and cortisol reactivity would be stronger among adolescents than children. Because emotion and stress reactivity are at a developmental peak and regulatory systems undergo substantial maturation in adolescence, adaptive strategies might be particularly strong predictors of stress regulation at this age. Regarding early life stress, puberty might support the development of more typical connections between cortico-limbic and stress response systems in PI youth. Cognitive-affective strategies may be particularly important for stress regulation in this group, and PI youth who use adaptive strategies may be more likely to demonstrate typical physiological stress reactivity.

Methods

Participants

Participants included 159 9- and 10-year-old children (*M* = 9.85 years, *SD* = .55) and 15- and 16-year-old adolescents (*M* = 15.81 years, *SD* = .59) divided into two groups based on early care experiences. The NA youth (*n* = 81) were born and raised in their birth families in the United States. The PI youth (*n* = 78) had been internationally adopted at 11 months of age or more after spending the majority of their life in institutional care (*M* age at adoption = 25.82 months, *SD* = 15.44; *M* duration of institutional care = 21.03 months, *SD* = 12.79). Regions of origin for the PI group were: Eastern Europe (*n* = 39), Asia (*n* = 35), Central & South America (*n* = 3), and Africa (*n* = 1). The *N*s in each group were: 40 NA children (20 female), 41 NA adolescents (20 female), 38 PI children (20 female), and 40 PI adolescents (22 female).

Participants were recruited from registries of parents interested in research opportunities. NA youth were recruited from a registry maintained in the department of families who signed up soon after their child’s birth based on a mailing sent to all families giving birth in our region. PI youth were recruited through the Minnesota International Adoption Project registry of adopting families, maintained through mailings to lists from adoption medical clinics and adoption agencies. In both groups, over 92% had at least one parent with a four-year college degree and median family income of $75,000–125,000. PI youth (18%) were more likely than NA youth (4%) to live in a single parent home, $\chi^2(1, N = 158) = 11.20$, $p = .001$. Exclusion criteria included diagnosis of Autism, Pervasive Developmental Disorder, or Fetal Alcohol Syndrome, or use of steroid medications that confound measurement of endogenously produced cortisol levels.

Procedure

Participants and their parent arrived at the laboratory between 3:30 and 4:30 pm for a one-hour and 45-minute session (see Figure 1), during which they completed a modified version of the Trier Social Stress Test for Children (TSST-M; Yim, Quas, Cahill, & Hayakawa, 2010). Following consent, participants read leisurely for 25 minutes, then moved to a new room to hear the speech prompt delivered by the experimenter. Participants were given five minutes to prepare the speech and were randomly assigned to prepare the speech with either their parent or the experimenter. Preparation condition was not a focus of the current study and was thus entered as a covariate in all analyses. However, two published papers using these data reported the effects of parental buffering on cortisol reactivity to the TSST-M

(Hostinar, Johnson, & Gunnar, 2015a; Hostinar, Johnson, & Gunnar, 2015b). The 2015a paper reported cortisol responses in NA children and adolescents as a function of whether they prepared their speech with a parent or a stranger; significant parental stress buffering was observed for children only. The 2015b paper reported cortisol responses in PI and NA 9- and 10-year-olds; only for the NA group did parent presence buffer cortisol responses.

After five minutes of preparation, the participant moved to a new room to complete the speech (5 min.) and mental arithmetic (5 min.). For the speech, participants were to imagine that they were introducing themselves to a new classroom of students. They were instructed to talk about themselves, including why they would be liked by others in the class and at least one good and one bad trait. The mental arithmetic was a continuous subtraction task; children subtracted by 3s from 304 and adolescents subtracted by 7s from 758 as quickly and accurately as possible. After each mistake, the experimenter instructed to participant to start over from the beginning. The participant performed the task alone in a room, in front of a two-way mirror and a conspicuously placed video camera. They were told that the experimenter and two teachers were watching from the other side of the mirror. Via pre-recorded voice recordings, the teachers introduced themselves, explaining that they will grade the performance and that the video recording will be rated by a classroom of students. The experimenter delivered the instructions that are typically carried out by judges during the TSST-M. Replacing live judges with a two-way mirror successfully elevates cortisol in late childhood (Jansen et al., 2000).

After the TSST-M, participants provided a saliva sample and returned to the waiting room where they had a 10-minute break with their parent. Then, they completed questionnaires and provided a saliva sample every 20 minutes for the remaining 50 minutes. Thus, saliva was obtained 0, 20, 40, and 60 minutes after the TSST-M to assess anticipatory baseline, reactivity, initial recovery, and full recovery. Lastly, participants were debriefed and given positive feedback. The protocol was approved by the University's Institutional Review Board.

Measures

Salivary cortisol.—Participants were instructed to refrain from activities that impact the HPA axis for several hours before assessment. They expressed saliva through straws into prelabeled vials that were stored at −20°C until shipped for assay at the University of Trier, Germany using a DELFIA assay with inter- and intra-assay coefficients of variation < 10%. Raw cortisol values that exceeded three standard deviations were winsorized at 99.7% and distributions were log10 transformed.

Demographics.—Parents reported demographic information, including income, education, family structure, and for adoptive parents, child's pre-adoptive experience and age at adoption.

Daily behaviors.—Participants reported behaviors that could influence cortisol, including sleep and waking the day of the session and medications. Time since waking was included as a covariate in all cortisol analyses to control for session timing within one's diurnal rhythm. Five NA and 24 PI participants were taking a medication that could influence salivary cortisol. PI youth were more likely to use psychotropic medications (PI: 18, NA: 0). In the PI group, psychotropic medications were used to treat ADHD ($N = 16$), depression ($N = 6$; 5 comorbid with ADHD), and anxiety ($N = 3$; 2 comorbid with ADHD). All medications were coded per Granger and colleagues' (2009) guidelines and entered as a covariate.

Pubertal status.—Participants reported pubertal status using the Pubertal Development Scale (PDS; Petersen, Crockett, Richards, & Boxer, 1988). Four questions regarding physical growth, skin changes, pubic hair, and breast/voice changes were averaged, with possible scores ranging from 1 ("Has not begun") to 4 ("Is complete"). No children scored in the mid- to late puberty range (PDS score of 3 or higher), and 80% of adolescents were mid- to late puberty.

Cognitive-affective regulation.—Participants completed the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003), which assesses trait cognitive reappraisal and emotion suppression, namely, one's general tendency to use various emotion regulatory strategies in daily life, rather than responses to a particular situation such as the laboratory session. The reappraisal subscale consists of 6 questions (e.g., "When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about."), and the suppression subscale consists of four questions (e.g., "I control my emotions by not expressing them."). Participants answered each question using a 7-point scale from "Strongly Disagree" to "Strongly Agree." Higher scores reflect a greater tendency to use the strategy. Reliability was acceptable for the reappraisal (Cronbach's alpha = .71) and suppression (Cronbach's alpha = .68) subscales. Although this measure has been used in comparable age groups with similar reliability (e.g., de Veld et al., 2012; Koval, Butler, Hollenstein, Lanteigne, & Kuppens, 2015), a revised version is now available for use with children and adolescents (ERQ–CA; Gullone & Taffe, 2012). Three PI participants had incomplete ERQ data and were excluded from ERQ analyses.

Participants also completed the Responses to Stress Questionnaire (RSQ; Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000), a measure of typical coping responses to stressors. Like the ERQ, participants reported everyday coping tendencies, rather than regulatory strategies specific to the laboratory session. The peer stressors version of the RSQ was used due to the social nature of the TSST-M and participants' belief that their performance would be evaluated by peers. In this version of the RSQ, participants report frequency and severity of problems with peers (e.g., problems with a friend or feeling pressured to do something) since the start of the school year, and how often they choose various responses when faced with these problems (57 items on 4-point scale from "Never" to "Almost Always"). The RSQ contains three primary subscales: volitional engagement (e.g., "I try to think of different ways to change the problem or fix the situation."), volitional disengagement (e.g., "I try to stay away from people and things that make me feel upset or remind me of the problem."), and involuntary stress responses (e.g., "My mind goes blank when I have problems with other kids, I can't think at all."). To control for base-rate endorsement of responses, proportions were calculated as the score for each subscale divided by the total score on the RSQ (Compas, Connor-Smith, Saltzman, Thomsen, &

Wadsworth, 2001). Thus, subscale scores range from 0 to 1. Reliability was acceptable for each subscale: Engagement [Cronbach's alpha = .84], Disengagement [Cronbach's alpha = .77], and Involuntary [Cronbach's alpha = .92]. Five NA participants and five PI participants had incomplete data and were excluded from RSQ analyses.

Statistical Analysis

Preliminary analyses assessed normality of distributions and internal consistency of questionnaires. Next, two 2 (Age) by 2 (Gender) by 2 (Group) MANOVAs with Emotion Regulation and Coping subscales tested age, gender, and group effects and interactions in regulatory strategies. Gender effects were tested due to potential gender differences in emotion regulation (Gullone et al., 2010; Gross & John, 2003) and coping strategies (Calvete, Camara, Estevez, & Villardon, 2011; Sontag & Graber, 2010).

Cortisol response to the TSST-M was analyzed via hierarchical linear modeling using SAS 9.3 PROC MIXED procedure (Singer, 1998), a model ideal for examining change over time and maximizing statistical power. The Level 1 model represents individual change in cortisol as a function of linear and quadratic terms, Time and Time^2. Time represents cortisol increase in response to the stressor (positive slope) and Time^2 models cortisol decrease following the stressor (negative slope). The Level 2 model represents between-subject differences in cortisol based on Age, Gender, and Group, plus continuous measures of emotion regulation (Reappraisal, Suppression) and coping (Engagement, Disengagement, Involuntary Responses) entered as level two predictors in separate models. Gender was included in each model, because gender differences in cortisol reactivity may emerge with puberty (e.g., Gunnar et al., 2009b). Two- and three-way interactions were included in original models and non-significant interactions were removed from final models. Age, Gender, and Group were dummy coded with adolescent, female, and non-adopted as reference groups. Time since wake-up, medication, and speech preparation condition were entered as covariates in all cortisol analyses. The mixed model was fit using restricted maximum likelihood estimation (REML) and degrees of freedom were computed using the Kenward and Roger (1997) method. Type 3 *F* tests of fixed effects are reported in text, and estimated parameters are reported in tables. Figures depict observed data, not estimated values. Recall that the majority of the cortisol results were previously presented (Hostinar et al., 2015a; Hostinar et al., 2015b), but are repeated here for completeness.

Results

Cognitive-Affective Regulation

A 2 (Age) by 2 (Gender) by 2 (Group) MANOVA with Reappraisal and Suppression as dependent variables revealed a multivariate effect of age, Wilks' $\lambda = .93$, $F(2, 147) = 5.17$, $p = .007$. Univariate tests identified a main effect of age on suppression, $F(1, 148) = 10.08$, $p = .002$, in which children ($M = 3.89$, $SD = 1.11$) reported higher suppression than adolescents ($M = 3.35$, $SD = 1.14$). Reappraisal did not differ by age or gender, and there were no main effects or interactions with group for either emotion regulation strategy (see Table 1).

A 2 (Age) by 2 (Gender) by 2 (Group) MANOVA with Engagement, Disengagement, and Involuntary Responses as dependent variables identified a multivariate effect of age, Wilks' $\lambda = .88$, $F(2, 140) = 9.50$, $p < .001$. Univariate tests revealed a main effect of age on engagement, $F(1, 141) = 8.46$, $p = .004$, with higher engagement in adolescents ($M = .40$, $SD = .06$) compared to children ($M = .37$, $SD = .05$), and a main effect of age on disengagement, $F(1, 141) = 14.07$, $p < .001$, in which children ($M = .22$, $SD = .03$) reported higher disengagement than adolescents ($M = .21$, $SD = .03$). No main effects or interactions with group or gender were observed. Reports of involuntary responses did not differ by age, gender, or group (see Table 1).

Cortisol Reactivity

Descriptive statistics for cortisol samples are listed in Table 2. Across participants, the growth curve model demonstrated a significant linear [Time: $F(1, 414) = 4.67$, $p = .031$] and curvilinear [Time^2 $F(1,317) = 35.30$, $p < .001$] cortisol response, such that the TSST-M elicited expected increases in cortisol. Paired-samples t-tests revealed that cortisol levels differed at each time point: Time 1 ($M = .14$, $SD = .11$) lower than Time 2 ($M = .17$, $SD = .13$) [$t(158) = -1.99$, $p = .048$], Time 2 higher than Time 3 ($M = .13$, $SD = .11$) [$t(158) = 8.43$, $p < .001$], and Time 3 higher than Time 4 ($M = .10$, $SD = .06$) [$t(157) = 7.81$, $p < .001$].

Cortisol reactivity was modeled via HLM as a function of Time and Time^2, with Age, Gender, Group, and their interactions as between-subject factors. A significant age by gender interaction was observed on the quadratic term, Time^2 $F(1, 462) = 4.08$, $p = .044$, and a trend level effect on the linear term, Time $F(1, 462) = 3.00$, $p = .084$. Male children did not show a significant cortisol response to the TSST-M, while male adolescents displayed significant reactivity similar to female children and adolescents. Regarding early experiences, there was a trend level effect of group on the linear, Time $F(1, 462) = 3.09$, $p = .079$, and quadratic terms, Time^2 $F(1, 462) = 3.12$, $p = .078$. PI youth tended toward blunted cortisol reactivity, characterized by a less peaked response. This group trend did not interact with age or gender.

Cognitive-Affective Regulation and Cortisol Reactivity

The HLM model with Reappraisal, Age, Gender, and Group indicated that trait reappraisal predicted cortisol reactivity to the TSST-M in NA youth: there was a reappraisal by group interaction on the linear, Time $F(1, 452) = 4.93$, $p = .027$, and quadratic terms, Time^2 $F(1, 452) = 4.79$, $p = .029$ (see Table 3). In contrast to expectations, trait reappraisal predicted increased cortisol reactivity to the TSST-M in NA youth. Reappraisal was not related to cortisol in the PI group (see Figure 2). There was also a trend level reappraisal by group interaction on the intercept, $F(1, 228) = 3.78$, $p = .053$; reappraisal tended to predict higher intercept cortisol level in the NA group only. Reappraisal did not interact with age or gender on intercept, linear, or quadratic terms. Suppression did not predict cortisol reactivity as measured by linear or quadratic terms. There was a suppression by age interaction on the intercept, $F(1, 217) = 4.56$, $p = .034$. Suppression predicted higher intercept cortisol in adolescents and not children. Coping strategies (Engagement, Disengagement, Involuntary

Responses) did not predict cortisol reactivity and there were no interactions with age, gender, or group.

Discussion

Because adolescence is a period of heightened stress sensitivity, it is critical for adolescents to develop the ability to regulate arousal during stressful and unpredictable situations. We need a greater understanding of how cognitive-affective regulatory strategies may be associated with stress reactivity as children approach adolescence. Moreover, early life adversity may put children at increased risk for aberrant patterns of stress reactivity and cognitive-affective regulation. However, researchers have not yet assessed trait emotion regulation or coping strategies, or the association between emotion regulation and cortisol reactivity in PI youth. The current study aimed to address these gaps in the literature.

First, we examined developmental differences in children and adolescents' cognitive-affective trait emotion regulation and coping strategies. We hypothesized that adolescents would report more cognitive reappraisal and active engagement than children, and that children would report more emotion suppression, disengagement, and involuntary responses. We also expected that, given their developmental history and fewer opportunities to learn and practice effective regulatory strategies in early childhood, PI children would demonstrate more suppression, disengagement, and involuntary responses than NA children.

With regard to age and emotion regulation, we found that adolescents reported less use of emotion suppression than children, but contrary to expectations, cognitive reappraisal did not differ by age. A large longitudinal study of 9- to 15-year-olds measuring the use of suppression and reappraisal strategies over three years identified similar decreases in suppression with age and no clear developmental pattern for reappraisal (Gullone et al., 2010). Parents play a key role in scaffolding emotion regulation throughout childhood (Eisenberg, Cumberland, & Spinrad, 1998), and families in this sample were of moderate to high educational and socioeconomic status. Advantaged parents might scaffold the use of mature regulatory strategies like reappraisal at younger ages, even among children adopted from early life stress conditions, possibly accounting for the lack of observed differences between late childhood and mid-adolescence.

When assessing the differences in coping strategies by age, adolescents reported less use of voluntary disengagement and more use of voluntary engagement than children. These findings support previous work demonstrating that adolescents' cognitive development allows them to approach challenges in a more reflective and engaged way, such as considering multiple perspectives and formulating a plan to respond flexibly to a situation (Seiffge-Krenke et al., 2009). Adolescents and children did not differ in involuntary responses to stress, suggesting that these responses might vary on an individual level, or that the current measure was not sensitive enough to detect developmental differences in these strategies.

Interestingly, PI and NA youth did not differ in self-reported trait regulatory strategies. The fact that we found no difference in reported emotion regulation or coping strategies across PI and NA groups was surprising. Although PI youth tend to show deficits or delays in emotion understanding and behaviors (e.g., Wismer Fries & Pollak, 2004; Tottenham et al., 2010), the strategies they report using to manage their emotions and stress are not different from their NA peers. PI youth could be less successful at using these strategies, or the same strategies might not be the most effective following early stress exposure. Further, children develop regulatory strategies through socialization, and for PI youth, socialization in the adoptive home might not match emotion and behavioral systems developed in the context of institutional care. On the other hand, PI youth in this study may have demonstrated regulatory behaviors and emotion skills on par with their NA peers. Future studies should explore these associations by including behavioral assessments of emotion regulation skills along with measures of trait regulatory strategies.

The second aim of the study was to test whether individual differences in youth-reported cognitive-affective strategies were associated with cortisol reactivity during stress. We hypothesized that associations between strategies and reactivity would be stronger among adolescents than children, given greater maturity, proficiency, and flexibility of self-regulatory systems in adolescence. We also examined whether strategies might be particularly important in the PI group, such that PI youth who utilized adaptive strategies may demonstrate more typical patterns of stress reactivity.

Trait cognitive reappraisal predicted higher cortisol reactivity to the TSST-M in NA children and adolescents. This strategy was not associated with reactivity in the PI group. The association between reappraisal and cortisol in our typically developing sample supports the hypothesis that cognitive reappraisal is an important factor in understanding stress reactivity in late childhood and adolescence. Surprisingly, reappraisal was not associated with decreased reactivity, but instead, was associated with *increased* cortisol reactivity in NA youth. Although in contrast to predictions based on a top-down regulatory model, these findings support the one published study that has examined associations among trait emotion regulation strategies and cortisol reactivity to a psychosocial stressor, namely, trait reappraisal was associated with greater cortisol responses to the TSST in a sample of undergraduates (Lam et al., 2009).

According to top-down models of self-regulation, reflection and reappraisal help regulate stress responses (Jamieson, Mendes, & Nock, 2013). In adults, instructing participants to cognitively reappraise stress typically decreases physiological reactivity (Gaab et al., 2003; Giuliani, McRae, & Gross, 2008; Goldin, McRae, Ramel, & Gross, 2008; Jamieson, Nock, & Mendes, 2012). On the other hand, Denson and colleagues' (2014) experimental study with undergraduate participants found instructed reappraisal to predict increased cortisol responses to social-evaluative and physical stressors. It is possible that cognitive reappraisal increases cognitive, attentional, and emotional effort, in turn activating cortico-limbic systems and the HPA axis, particularly among children and adolescents. For example, Levesque et al. (2004) found that the preadolescent girls recruited more prefrontal networks to complete a voluntary reappraisal task relative to adult women, possibly illustrating immaturity of prefrontal-limbic connections central to conscious emotion regulation. Understanding the developing neurobiology of this regulatory network is critical to building a developmental model of stress regulation.

This study is unable to determine the directionality of the association between cognitive-affective strategies and HPA axis reactivity; the use of reappraisal could increase reactivity, or a tendency toward higher reactivity could increase trait reappraisal. This finding raises questions regarding individuals who are high in trait reappraisal. The reappraisal items on the ERQ ask how often “you change what you’re thinking about” when feeling positive or negative emotions. This tendency to rethink emotions could be related to a ruminative response style. Rumination may be particularly relevant here due to associations with internalizing behaviors that increase in adolescence (e.g., Sontag & Graber, 2010). Although rumination is typically conceptualized as an involuntary stress response, the RSQ subscale for involuntary responses is likely not sensitive enough to detect this specific effect. Lastly, reappraisal was the only strategy to predict cortisol reactivity, and associations between strategies and reactivity did not differ by age. Further research combining trait, state, and instructed measures of regulatory strategies, along with other individual characteristics, such as rumination, anxiety, and executive function, will help to clarify these developing self-regulatory systems in the context of psychosocial stressors.

Finally, it is possible that cognitive emotion regulation techniques such as reappraisal require more effortful cognitive processing, attention, and control, which could increase activation in stress-mediating systems, including the HPA axis (Parvaz, Moeller, Goldstein, & Proudfit, 2015; Sheppes, Catran, & Meiran, 2009). In this case, greater cortisol reactivity, when coupled with effective recovery, could be indicative of adaptive engagement with the stressful situation. That said, engagement coping is typically associated with decreased rather than increased HPA reactivity to stressors (Sladek et al., 2016; Sladek et al., 2017).

Regarding group differences, it is unclear why reappraisal predicted cortisol reactivity in NA youth, but was unrelated to reactivity in PI participants. One explanation could be that the PI group’s cognitive-affective strategies are not effective at modulating or engaging HPA responses; if they were, we would expect to observe an association between them. Furthermore, this null finding provides some hints that the relatively flat PI HPA axis response can be interpreted as an atypical pattern of “blunted” reactivity rather than a pattern of effective stress management following the use of successful coping strategies. If it was the case that PI participants showed a dampened response due to successful self-regulatory efforts, then presumably there should have been at least some associations between their report of self-regulatory strategies they prefer to use and their stress reactivity. Alternatively, the inference that flat reactivity reflects better stress management could have been supported by the PI group reporting superior or at least different self-regulatory strategies than the NA children, but our findings rule out both of these explanations. While other studies have reported “blunted” cortisol reactivity in PI youth (Koss et al., 2016; McLaughlin et al., 2015), this is the first study to have access to self-regulatory measures and to suggest that this pattern is unlikely to be due to the PI group being better at using self-regulatory strategies to downregulate their stress response. Finally, we must also acknowledge the possibility that this pattern of findings could be due to PI youth interpreting the self-regulation questions differently, leading their scales to map onto physiological reactivity differently. The Cronbach’s alphas for the scales were acceptable in both groups, potentially arguing against the interpretation that the PI’s scales lacked internal consistency or validity.

Nevertheless, debriefing interviews or focus groups with this population will be necessary to rule out this possibility in the future.

It is important to highlight that the HPA axis works in concert with prefrontal and limbic regions. Detrimental effects of chronic stress on cortico-limbic regions influence both higher-order cognitive functioning and connections with stress systems (Arnsten, 2009). It is therefore not surprising that the relationship between cognitive-affective strategies and cortisol reactivity would be different among PI compared to NA youth years after adoption. PI children show a range of long-term outcomes, from vulnerability to resilience. This study examined severity of early stress and regulatory strategies as individual factors that might predict stress responses; however, these factors did not predict cortisol reactivity in the PI group. Research focused on identifying other factors that could predict cortisol reactivity in PI youth is needed to better understand the observed pattern of possible hypo-reactivity of the HPA axis.

A strength of this study is the inclusion of both emotion regulation and coping as aspects of cognitive-affective regulation, as previous studies have primarily focused on one construct or the other (Compas et al., 2014). While cognitive reappraisal was significantly associated with cortisol reactivity among NA youth, we did not find evidence of a relationship between emotion suppression, engagement, disengagement, or involuntary responses and cortisol reactivity in either NA or PI youth. The non-significant associations make it difficult to draw conclusions about these particular cognitive-affective strategies as related to reactivity of the HPA axis in late childhood and mid-adolescence. A few previous studies have identified associations between coping strategies and cortisol responses in adolescence (Bendezu & Wadworth, 2017; Sladek et al., 2016; Sladek et al., 2017; Sontag et al., 2008); however, the measures of cortisol reactivity differed across each of these studies and our own. Our study assessed cortisol reactivity to a particular social-evaluative task in the lab setting, while the others assessed diurnal cortisol patterns (Sladek et al., 2017), naturalistic cortisol reactivity to self-reported daily stressors (Sladek et al., 2016), overall cortisol responses to an in-home testing session (Sontag et al., 2008), and cortisol recovery following instruction to use a particular coping strategy (Bendezu & Wadsworth, 2017). The three studies that measured self-reported coping strategies suggested that more engaged and goal-directed coping strategies were associated with greater ability to regulate stress as measured by particular cortisol outcomes (diurnal patterns, naturalistic fluctuations, overall magnitude via area under the curve). In our study, individual differences in coping strategies were not associated with patterns of cortisol reactivity in response to an acute social-evaluative stressor in the laboratory setting. It is possible that coping strategies are truly less strongly linked to physiological activity to an acute social-evaluative stressor than they are to more daily stress regulatory patterns. Alternatively, it may be that the prompt used to measure coping strategies via the peer stress version of the RSQ is less strongly related to acute laboratory stress reactivity than it is to more daily, naturalistic experiences of stress.

A similar question arises regarding the significant association between emotion regulation (i.e., cognitive reappraisal) and cortisol reactivity, but no association between coping strategies and cortisol responses in the current study. Cognitive reappraisal may truly be uniquely related to these age groups' HPA responses to social-evaluative stress, or alternatively, the types of coping strategies as measured by the peer stress version of the RSQ may be less closely associated with stress responses to the TSST than are the more general emotion regulatory prompts of the ERQ. Future investigations with larger samples and multiple measures of emotion regulation and coping may help to clarify the range of potential cognitive-affective self-regulatory processes, beyond cognitive reappraisal, that shape stress reactivity during preadolescence and adolescence.

Limitations and Conclusions

The current study is not without limitations. First, the results demonstrated an association between trait cognitive reappraisal and cortisol reactivity, but the directionality and specificity of this relationship remains unclear. Future studies should include both trait and state measures to differentiate one’s general tendency to use strategies from specific strategies used during the TSST, as both individual factors and situational demands influence strategy use (Egloff et al., 2006). Experimental manipulation of strategy use in combination with trait measures would also help elucidate the directionality of this association.

Additionally, with the exception of cognitive reappraisal, the results identify several non-significant associations between regulatory strategies and cortisol reactivity. Further research is needed to fully interpret these non-significant findings. This pattern of results may also suggest a lack of statistical power to detect these relationships. In terms of stress reactivity, the TSST-M elicited expected increases in cortisol, with the exception of male children who did not show a significant cortisol response to the stressor. Several factors might contribute to this lack of response, such as lower salience of social-evaluative cues or immaturity at the level of stress response systems, but our study is unable to directly test these possible explanations. Notably, comparable studies have demonstrated significant cortisol reactivity to a modified TSST among males of this age (e.g., Gunnar et al., 2009b; Yim et al., 2010).

This study is further limited by the cross-sectional design; however, longitudinal research on stress reactivity is difficult to carry out due to habituation effects of the stressor paradigms. Additionally, we sampled narrow age ranges in late childhood and mid-adolescence to capture developmental stages immediately before and after the pubertal transition. The findings are, therefore, limited by an inability to observe more continuous patterns across late childhood, early adolescence, and mid-adolescence. In terms of typical development, the NA families were primarily upper middle class and Caucasian to match demographics of the adoptive families. Future research should examine developmental patterns in a more diverse sample.

Lastly, the findings regarding early life stress are limited by characteristics of the PI sample. PI youth provide a model for circumscribed early life stress, but it is difficult to identify the type and severity of stress experienced in the institutional setting. Also, it is likely that PI participants experienced greater prenatal risks compared to NA participants, and we are unable to separate the impact of prenatal and postnatal factors. Finally, the findings are specific to PI youth who experience chronic, multifaceted stress as infants and young children, followed by highly resourced and supportive adoptive homes.

Despite these limitations, the present study makes several important contributions. This is the first known study to examine associations among trait cognitive-affective strategies and cortisol reactivity to a social-evaluative stressor in children or adolescents. Developmental research on self-regulatory strategies has important implications for understanding variability in responses to challenges. This study suggests that individual differences in how children and adolescents regulate their emotions predict physiological reactivity to psychosocial stress. This research also builds on previous research in PI youth that focused on either stress reactivity or emotion regulation and in one age group. The findings provide a glimpse into developmental complexities of the self-regulatory system before and after the pubertal transition. This study has implications for prevention and intervention efforts aimed at promoting self-regulation and adaptive stress responses in preadolescence and adolescence, highlighting this sensitive period as a window of opportunity for positive reorganization and growth. Changes in physiological and neurobehavioral function in adolescence may make individuals more susceptible to perturbations, but may also indicate an opportunity to intervene and promote positive adaptation. Emotion regulation and coping involve cognitive-affective neural networks that are rapidly developing during adolescence, and this developmental window offers the potential for continued neurobiological plasticity and sensitivity to intervention or training of these processes (Spear, 2000). It is important for such efforts to be developmentally appropriate; for example, the current findings suggest that cognitive reframing or reappraisal trainings developed for adults (e.g., Fresco et al., 2013; Jamieson et al., 2013) should be thoughtfully translated to younger age groups. Overall, these results highlight the importance of examining relations among cognition, emotion, and physiology, along with early life experiences, to best understand the development of reactivity and regulatory systems during the transition to adolescence.

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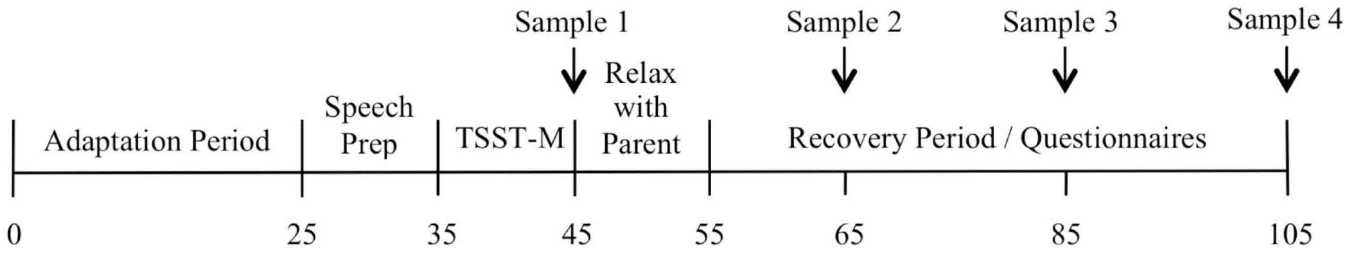

Figure 1.

Timeline of events and salivary cortisol samples. Time scale reflects minutes after arrival to the laboratory.

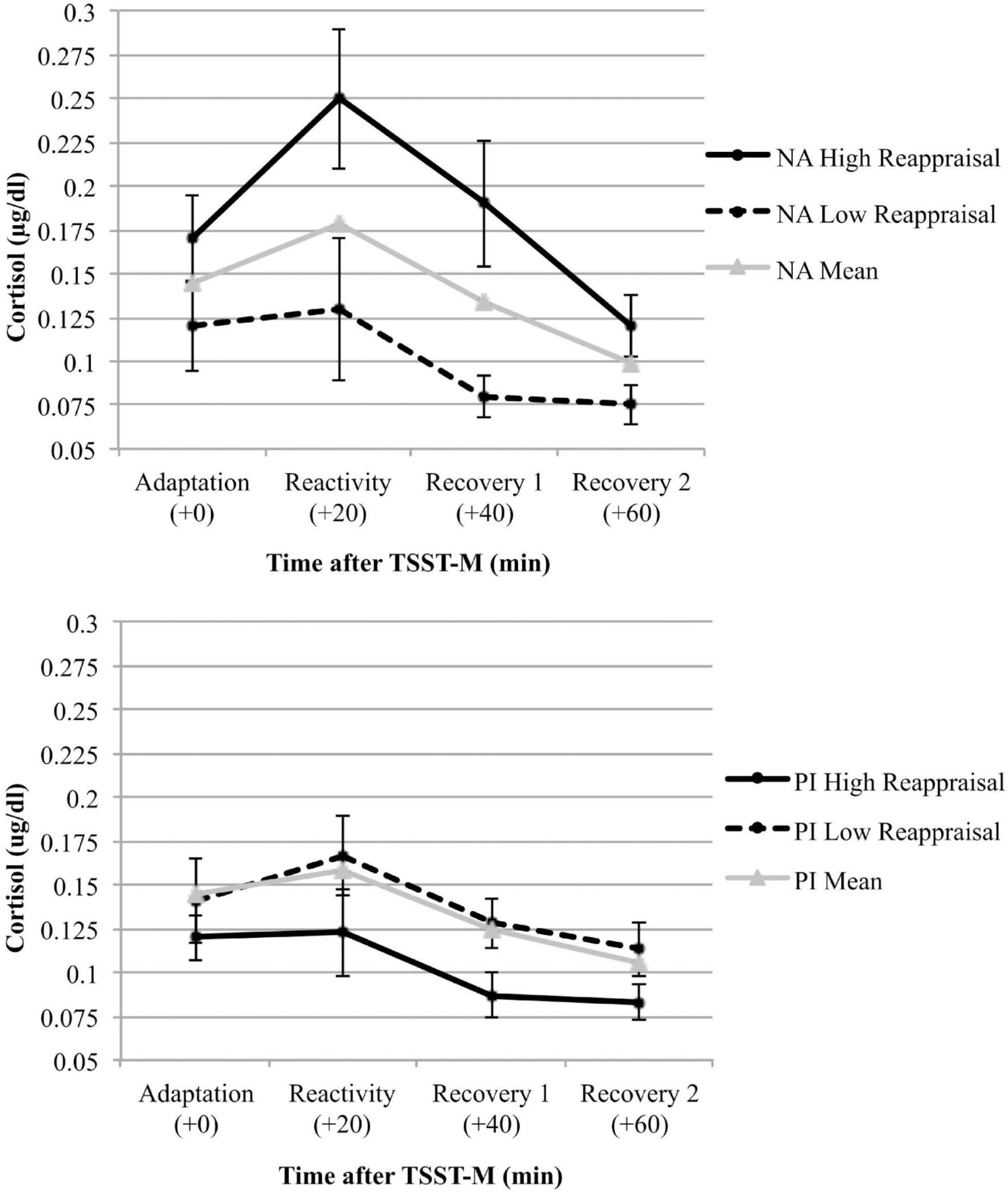

Figure 2.

Mean cortisol response to the TSST-M for A) NA and B) PI youth high in reappraisal versus low in reappraisal. High and low reappraisal are depicted here as 1 SD above and below the mean; however, reappraisal was analyzed as a continuous variable. Error bars represent ± SEM.

Table 1

Means (SD) of Cognitive-Affective Strategies for NA and PI Youth by Age and Gender

	Children		Adolescents	
	Males	**Females**	**Males**	**Females**
Non-Adopted				
Emotion Regulation				
Reappraisal	4.80 (1.01)	4.80 (1.03)	4.98 (.85)	4.89 (.91)
Suppression *	4.14 (1.37)	3.75 (.93)	3.62 (.98)	3.35 (1.01)
Coping				
Engagement *	.36 (.05)	.37 (.05)	.40 (.06)	.40 (.07)
Disengagement *	.23 (.03)	.22 (.03)	.20 (.03)	.21 (.02)
Involuntary Responses	.42 (.06)	.41 (.06)	.40 (.05)	.38 (.06)
Post-Institutionalized				
Emotion Regulation				
Reappraisal	4.85 (1.13)	5.04 (.79)	4.26 (1.17)	4.97 (.71)
Suppression *	4.32 (.87)	3.38 (1.00)	2.97 (1.31)	3.39 (1.24)
Coping				
Engagement *	.37 (.05)	.39 (.06)	.40 (.07)	.38 (.05)
Disengagement *	.22 (.03)	.23 (.03)	.20 (.03)	.21 (.03)
Involuntary Responses	.41 (.05)	.38 (.05)	.39 (.07)	.41 (.05)

[*] Across group and gender, adolescents reported lower suppression, higher engagement, and lower disengagement compared to children.

Table 2

Means (SD) of Cortisol (μg/dl) Variables for NA and PI Youth by Age and Gender

	Children		Adolescents	
	Males	**Females**	**Males**	**Females**
Non-Adopted				
Adaptation	.11 (.08)	.13 (.10)	.19 (.08)	.15 (.09)
Reactivity	.10 (.08)	.18 (.15)	.23 (.12)	.20 (.15)
Recovery 1	.09 (.05)	.14 (.13)	.16 (.07)	.14 (.13)
Recovery 2	.07 (.05)	.10 (.07)	.12 (.04)	.10 (.06)
Post-Institutionalized				
Adaptation	.10 (.04)	.15 (.15)	.20 (.12)	.13 (.12)
Reactivity	.11 (.09)	.18 (.16)	.20 (.14)	.14 (.12)
Recovery 1	.08 (.05)	.13 (.13)	.16 (.11)	.12 (.11)
Recovery 2	.08 (.07)	.10 (.07)	.13 (.06)	.11 (.08)

Note: For descriptive purposes the non-transformed values are shown.

Table 3

Parameter Estimates for Growth Curve Model of Cortisol Reactivity with Age, Gender, Group, and Reappraisal

Effect	**Estimate**	**SE**	**df**	***t* value**	***p***
Intercept	.70	.10	163	6.76	<.0001 *
Time	.07	.04	452	1.69	.09
Time^2	−.04	.01	452	−3.11	.002 *
Age	−.02	.06	228	−0.27	.79
Age x Time	.05	.05	452	1.07	.28
Age x Time^2	−.02	.02	452	−1.15	.25
Gender	.15	.06	228	2.49	.01 *
Gender x Time	−.005	.05	452	−0.10	.92
Gender x Time^2	−.004	.02	452	−0.28	.78
Age x Gender	−.25	.08	228	−2.95	.004 *
Age x Gender x Time	−.11	.07	452	−1.49	.14
Age x Gender x Time^2	.04	.02	452	1.81	.07
Group	−.001	.04	228	−0.03	.98
Group x Time	−.07	.04	452	−1.99	.05 *
Group x Time^2	.02	.01	452	2.01	.04 *
Reappraisal	.07	.03	228	2.35	.02 *
Reappraisal x Time	.06	.03	452	2.43	.02 *
Reappraisal x Time^2	−.02	.01	452	−2.74	.01 *
Reappraisal x Group	−.10	.04	228	−1.94	.05 *
Reappraisal x Group x Time	−.09	.04	452	−2.22	.03 *
Reappraisal x Group x Time^2	.03	.01	452	2.19	.03 *

* $p < 0.05$