STRESS REACTIVITY AND COGNITIVE VULNERABILITY FOR DEPRESSION IN ADOLESCENCE

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ABSTRACT
Stress Reactivity and Cognitive Vulnerability for Depression in Adolescence
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Doctor of Philosophy
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Major Depressive Disorder (MDD) is the most common mental illness, with estimated lifetime prevalence of 25% (Kessler, Avenevoli, & Merikangas, 2001). Importantly, research suggests that the one-year prevalence rates of depression are relatively low in childhood, but dramatically increase, as much as six-fold, from early to late adolescence (Hankin et al., 1998; Kessler et al., 2003). These trends have led researchers to examine the developmental antecedents of depression in hopes of identifying risk factors associated with the first onset of disorder. This study examined the relationship between two empirically supported risk factors for depression: stress reactivity and cognitive vulnerabilities (CV). To varying degrees, these factors have been examined throughout development; yet, these bodies of literature have been surprisingly separate, which may contribute to the disappointing performance of selective intervention strategies to identify and treat youth at risk (Kovacs & Lopez-Duran, 2010). The current study examined the developmental antecedents and combined effects of two risk factors for depression. A sample of 127 adolescents and their mothers from the greater Philadelphia area completed questionnaires and interviews. In addition, adolescents participated in a social stress task to elicit a stress response. Measures of biological stress reactivity were measured through the endocrine system (e.g., cortisol) and the autonomic nervous system (e.g., heart rate). Findings suggest that a number of proximal stressors predict higher levels of both CV and stress reactivity components. We did not find evidence for more distal antecedents (e.g., early life stress, maternal depression, parenting styles) in the prediction of these risk factors, however. Importantly, this study highlights the combined risk factors of CVs and biological stress

reactivity. Specifically, adolescents with higher levels of CV and a poorer ability to regulate after a stressor are at increased risk for depressive symptoms. Findings did not support the hypothesis that the mechanism through which CVs lead to depression is biological reactivity. The current study presents an important methodological and theoretical advancement in the body of literature examining risk factors for depression and stress reactivity. From the evidence obtained, it appears that in many cases these aspects of reactivity may operate synergistically in the development of depression and that the lack of physiological recovery may amplify the negative effects of different cognitive styles. The joint effects of cognitive and biological reactivity can enhance our understanding of reactions to stressful events and lead to more personalized treatment. Approaches that incorporate mindfulness and relaxation strategies may be particularly relevant to the regulation of physiological reactivity to stress that may reduce the prolonged feelings associated with stressful events. Overall, the results from the current study provide a more nuanced understanding of the relationship between stress responses and move beyond prior research on risk factors for depression.

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CHAPTER 1

INTRODUCTION

Major Depressive Disorder (MDD) is the most common mental illness, with estimated lifetime prevalence of 25% (Kessler, Avenevoli, & Merikangas, 2001). In addition, MDD is consistently a leading cause of disability and premature death worldwide (Lopez et al., 2006; Murray & Lopez, 1996). MDD has a dramatic impact on individuals and society as a whole, and leads to more medical visits than any other medical problems except hypertension (IMS Health Canada, 2001) and greater impairment in work functioning than other chronic medical conditions (Druss, Rosenheck, & Sledge, 2000). MDD is a highly recurrent disorder with roughly 80% of individuals with a first episode experiencing at least one recurrence (Judd, 1997). Importantly, research suggests that the one-year prevalence rates of depression are relatively low in childhood, but dramatically increase, as much as six-fold, from early to late adolescence (Hankin et al., 1998; Kessler et al., 2003). Adolescence is also a time period in which the gender gap in depression begins to emerge (Hankin & Abramson, 2001; Nolen-Hoeksema, 2001), whereby in adulthood, women are twice as likely to become depressed as men (Angst et al., 2002; Kuehner, 2003). Furthermore, early onset of depression during adolescence has been associated with a number of psychosocial problems in adulthood, including poor academic outcomes and increased risk for substance abuse and suicide (Birmaher et al., 1996). These trends have led researchers to examine the developmental antecedents of depression in hopes of identifying risk factors associated with the first onset of disorder. A multitude of risk factors have been examined with implications for prevention strategies, early identification and intervention, and empirically informed treatment development.

Depression is a multidimensional disorder with numerous factors that are hypothesized and supported to predict the onset of MDD. This study examined the relationship between two empirically supported risk factors for depression: stress reactivity and recovery (referred to as reactivity hereafter) and cognitive vulnerabilities (CV). To date, each of these factors has garnered considerable support as a risk factor for the onset and maintenance of depression, yet little is known about the development and relationship between these two vulnerabilities. Importantly, an integrative approach is necessary to capture the complex association between individual risk, environmental influences, and their subsequent prediction of depressive outcomes. This study provided a first step in understanding the relationship between CV and stress reactivity during the salient developmental time period of adolescence.

Theoretical Approach to Risk Factors

The relationship between stress and depression has been well established (Hammen, 2005). Much research has examined this relationship by focusing on diathesis-stress models in which some individuals are at risk for depression after exposure to negative events among youth (Grant & McMahon, 2005) and adults (Monroe, 2008). Beyond diathesis-stress models of depression, a number of theories have been suggested and supported to help understanding of the dynamic relationship between stress and depression further. One such theory has attempted to explain the high frequency of depression and its changing relationship with stress. Post's (1992) kindling hypothesis describes a process whereby major stressors play a greater role in triggering an initial episode of depression compared to subsequent episodes. Thus, an episode of depression sensitizes an individual's reaction to stressful events and the threshold of stress needed to trigger a recurrence is reduced (Lewinsohn, Allen, Seeley, & Gotlib, 1999; Monroe & Harkness, 2005; Stroud, Davila, & Boyer, 2008). Other risk factors, such as exposure to severe early life stress

also may sensitize an individual to stress (Harkness, Bruce, & Lumley, 2006), thus placing them at further increased risk for depressive recurrences. Taken together, the relationship between stress and vulnerability factors must be viewed as intrinsically dynamic and changing. More recently, both lines of research (stress and vulnerability factors) have been integrated (Hankin & Abramson, 2001; Hyde, Mezulis & Abramson, 2008); yet research to date is limited. For example, no study has examined the relationship between CV and stress reactivity, two important risk factors for MDD, on subsequent depressive symptoms.

Cognitive Vulnerabilities and MDD

Prominent cognitive models of depression propose that individuals with certain dysfunctional cognitive styles are more vulnerable to developing depression when faced with stressful life events (i.e., cognitive vulnerability-stress models of depression). The most influential cognitive models are Beck's cognitive theory (Beck, 1967), the Hopelessness theory (Abramson, Metalsky, & Alloy, 1989), and response styles theory (Nolen-Hoeksema, 1991). Beck's model (1967) suggests that some individuals are vulnerable to depression because they have maladaptive self-schemata in the form of dysfunctional attitudes, which are rigid and extreme beliefs about the self and the world. The Hopelessness theory (Abramson, Metalsky, & Alloy, 1989) proposes that individuals who make stable and global attributions about the causes of negative events and infer negative consequences and self-characteristics are more vulnerable to depression when confronted with negative life events. Response styles theory (Nolen-Hoeksema, 1991) suggests rumination, a process of repeatedly focusing on depressive symptoms and their causes and consequences, provides vulnerability to depression. In support of these theories, studies have demonstrated that individuals with negative cognitive styles are more likely to prospectively experience both a first onset and recurrences of MDD (Alloy et al., 2006).

Using a longitudinal design, Black and colleagues (under review) found that cognitive vulnerability moderated the relationship between negative events and depressive symptoms at two-week intervals, such that, individuals at high cognitive risk experienced significantly greater increases in depressive symptoms when confronted with negative life events. In addition, Abela and Skitch (2007) found that children with high levels of dysfunctional attitudes and lower levels of self-esteem reported more elevated depressive symptoms after increases in lower severity stressors. Finally, research has found that higher levels of rumination predict increases in depressive symptoms and the onset of major depressive episodes in adolescence (Abela & Hankin, 2011). Consistent with a vulnerability-stress perspective, rumination moderated the association between negative life events and the development of depressive symptoms and episodes (Abela & Hankin, 2011). These studies highlight the process of stressful events activating a negative cognitive style to increase depressive symptoms over time.

Development of Cognitive Vulnerabilities

Numerous studies have examined the developmental origins of cognitive vulnerabilities (Hankin et al., 2009). Some studies have examined genetic factors associated with CV and found potential heritability (Lau, Rijsdijk, & Eley, 2006) and genes (Hilt, Sander, Nolen-Hoeksema, & Simen, 2007) associated with cognitive styles. In addition, interpersonal factors have been shown to play a role in the development of CV. Parental modeling and feedback (Mezulis, Hyde, & Abramson, 2006) of negative cognitive styles and general maladaptive parenting styles (Alloy et al., 2006) are associated with CV in offspring. Moreover, peer influences such as rejection (Crick & Ladd, 1993), victimization (Gibb, Abramson, & Alloy, 2004), and contagion (Stevens & Prinstein, 2005) have been associated with CV. Finally, childhood maltreatment may contribute to the development of CV (Rose & Abramson, 1992; Gibb et al., 2006).

Stress Reactivity and MDD

Two biological systems play a role in an individual's stress response: the hypothalamic-pituitary-adrenal (HPA) axis and the autonomic nervous system (ANS). The majority of research on the relationship between stress reactivity and MDD has focused on neuroendocrine regulation using cortisol assays, the final product of the HPA axis response to stress (Gunnar, Talge, & Herrera, 2009). In adults, numerous studies show differences in regulation of the HPA axis between MDD and control individuals during stressful tasks, in that depressed individuals take longer to return to baseline following a stressor (Plotsky, Owens, & Nemeroff, 1998; Bagley, Weaver, Buchanan, 2011; Rooij, Schene, Phillips, & Roseboom, 2010). This research has been translated to younger samples with similar dysregulation found in young children (Luby et al., 2003; Hankin, Badanes, Abela, & Watamura, 2010) and adolescents (Hankin, Badenes, Abela, & Watamura, 2010; Rao, Hammen, Ortiz, Chen, & Poland, 2008). However, the direction of the association between depression and stress reactivity is not well established, with few studies examining stress reactivity and regulation differences in adolescents at risk as predictors of depressive outcomes (Adam et al., 2010; Goodyer, Herbger, Tamplin, & Altham, 2000). Methodological considerations also have been highlighted as a limitation, as there are associations with differences in basal levels of cortisol production and responsivity to stressors (Gunnar, Frenn, Wewerka, & Ryzin, 2009; Kudielka & Wust, 2010). To date, the majority of studies examine stress response and regulation using cortisol, but the relationship between the HPA axis and ANS is also an important (Spear, 2009) area of inquiry. The ANS and HPA axis produce similar net effects, but accomplish these effects differently and some studies support asymmetries between ANS and HPA in response to stress among youth (Spear, 2009). The ANS, through the sympathetic nervous system, is a fast acting response (Gunnar & Quevedo,

2007) that activates the 'fight-or-flight' response by increasing biological systems such as respiration and heart rate (Bernston, Cacioppo, & Quigley, 1991). The HPA axis communicates through the use of hormones that are released into the bloodstream. The HPA axis is a more slow-acting stress response compared to the ANS due to a cascade of responses needed to activate the HPA system (Rudolph, Troop-Gordon, & Granger, 2011). When stress occurs, the hypothalamus increases the amount of corticotropin releasing hormone (CRH) which stimulates the pituitary gland to release adrenocorticotropic hormone (ACTH), which then stimulates the adrenal glands' production of cortisol (for review see, Sapolsky, Romero, & Munck, 2000). Importantly, one of the major functions of the HPA axis is to return the body to homeostasis after a stress response (Straub, 2014). Few studies use both measures to study risk for depression (Balodis, Wynne-Edwards, & Omstead, 2010; Rooij, Schene, Phillips, & Roseboom, 2010), but including both measures can inform a more complete understanding of the dynamic interplay between developmental patterns of stress-induced activation and regulation.

Development of Stress Reactivity

There are normative developmental changes in stress and emotional functioning in adolescence (Dahl & Gunnar, 2009), in the HPA axis (Gunnar, Frenn, Wewerka, & Ryzin, 2009; Kudielka & Wust, 2010), and ANS (Strahler, Mueller, Rosenloecher, Kirschbaum, & Rohleder, 2010). For example, Sumter and colleagues (2010) evaluated the stress response in a sample of individuals ranging from 9 to 17 years of age. Consistent with the idea of biological stress sensitivity during adolescence, results suggest an increasing response to stress in both the HPA axis and ANS system, which increased both as a function of age and pubertal status (Sumter et al., 2010). Several factors have been shown to lead to dysregulation and changes in normal trajectories in adolescence. Parenting and family functioning including maternal quality of care

(Bernard & Dozier, 2010), parenting styles (Roisman et al., 2009), poor parental relationship (Pendry & Adams, 2007), and parental divorce (Bloch, Peleg, Koren, Aner, & Klein, 2007) predict differences in dysregulation of stress responsivity. In addition, early environmental influences such as poverty (Evans & English, 2002), low SES (Lupien, King, Meaney, & McEwen, 2001; West, Sweeting, Young, & Kelly, 2010), homelessness (Cutuli, Wiik, Herbers, Gunnar, & Masten, 2010), and early stressful and traumatic events (Bergh, Calster, Smits, Huffel, & Lagae, 2008; Gunnar, Morison, Chisholm, & Schuder, 2001) including maltreatment (Harkness, Steward, & Wynne-Edwards, 2011; Heim et al., 2002; Tarullo & Gunnar, 2006) contribute to HPA dysregulation.

Gender and Racial Differences during the important Developmental Period of Adolescence

Adolescence is a developmental period with a number of important transitions including puberty, changes in parental and peer support, dating, self-identity, and cognitive maturation (Steinberg & Morris, 2001). Experience of stressful life events also increases from childhood to adolescence (Ge, Lorenz, Conger, Elder, & Simons, 1994). Some suggest a saturation effect occurs in adolescence, whereby some adolescents experience an increase in stressors without sufficient resources to cope (Simmons, Burgeson, Carlton-Ford, & Blyth, 1987).

The examination of risk factors for depression must include sensitivity regarding sample characteristics that include gender and racial differences. Adolescence marks the beginning of the gender gap in prevalence of MDD (Hankin et al., 1998). In addition, adolescent girls report more stressors, especially interpersonal negative events, than boys (Rudolph, 2002; Rudolph & Hammen, 1999). Research examining stress reactivity has found sex differences in adults (Bagley, Weaver, & Buchanan, 2001; Kudielka & Kirschbaum, 2005; Schmaus, Laubmeier, Boquiren, Herzer, & Zakowski, 2008), yet few studies have examined differences in adolescence

(Charbonneau, Mezulis, & Hyde, 2009), with some studies finding no differences (Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004). Furthermore, little research examines racial differences in the relationships between CV (Alloy et al., 2012) or stress reactivity (Rausch, Auerbach, & Gramling, 2008) with depression, making it difficult to generalize findings that primarily examine Caucasian participants. Importantly, it is unclear whether non-Caucasians experience a similar rise in depression and the gender divide evident in Caucasian samples during adolescence (Kessler et al., 2003; Siegel, Yancey, Aneschensel, & Schuler, 1999). Thus, consideration of gender and racial differences in CV and stress reactivity during adolescence will lead to a more ecologically valid assessment of risk for depression during this important developmental period.

Integrative Approach

In their review of the state of research on juvenile MDD, Kovacs and Lopez-Duran (2010) commented on the importance of understanding the multifaceted equifinality of early life experiences in the etiology and course of depression, to inform prevention programs. The current study examined the relationship between the development and effects of two empirically supported risk factors for depression, namely CV and stress reactivity. To varying degrees, these factors have been examined throughout development; yet, these bodies of literature have been surprisingly separate, which may contribute to the disappointing performance of selective intervention strategies to identify and treat youth at risk. These two factors, which support the framework for cognitive behavioral therapy, are important aspects of a programmatic examination necessary to improve prevention programs, early intervention strategies, and treatment outcomes among youth.

The Current Study

The goal of the current study was to examine the developmental antecedents of CV and stress reactivity and understand their relationship so as to better understand potential causes of the rise in depression during adolescence. This study investigated the development and relationship between CV and stress reactivity, and their potential roles in depressive outcomes. Participants (N=127) consisted of a racially diverse community sample of adolescents and their mothers. Participants were followed for a minimum of two assessments and data were gathered on symptoms, diagnostic episodes, life events, cognitive styles and physiological stress reactivity including cortisol and autonomic nervous system response and recovery.

Hypotheses

Primary Aims

1) To examine the developmental antecedents of CV and stress reactivity in adolescence. Given research suggesting that early life experience including familial psychopathology, early stressful life events, chaotic family environments, and negative parenting styles, as well as proximal life stressors, may contribute to the development of risk for depression, we predicted that these early experiences would contribute to the development of CV and stress reactivity.

*2) To evaluate the combined role of these two risk factors for depression in adolescence***.** We predicted that adolescents with higher levels of both of these risk factors would evince heightened responses to proximal stressful life events, such that the interaction of greater CV and biological stress reactivity would predict more depressive outcomes.

*3) To examine whether CV predicts stress reactivity***.** We examined the relationship between CV and biological stress reactivity. CV has been shown to lead to more negative interpretations of life events and, in turn, depression. Given that cognitively vulnerable

individuals interpret events more negatively, they also were predicted to have a more maladaptive biological stress response to these events.

Exploratory Aims

*1) To examine the mediating role of stress reactivity***.** Given that CV has been found to influence psychological responsiveness to stressful events and predict depression, we examined whether the relationship between CV and depression was mediated by biological stress reactivity. This exploratory aim built on the primary aim that hypothesized that higher levels of CV would predict increased cortisol and ANS stress reactivity. As such, the direct relationship between each of the individual constructs of cognitive vulnerabilities and stress reactivity with depression is well established. Research has begun to support the relationship between CV and stress reactivity, yet the integration of these factors is understudied. Similar theoretical models support the mediational relationship. An individual's interpretation or appraisal of events may modulate the biological reaction to these events (Obradovic, 2012; Denson, Spanovic, & Miller, 2009). When an individual with a cognitive vulnerability is confronted with a stressful life event, they automatically appraise the event. If this event triggers a negative self-schema, is interpreted as a threat, or is thought about repetitively, it may amplify the physiological responses to the event. If this event is not interpreted negatively, then this physiological response may not be activated. Therefore, the relationship between cognitive vulnerabilities and depression may be mediated by the physiological response to stressful life events. According to vulnerability-stress models, stressful life events are the activators of the underlying vulnerability, but it is this vulnerability that elicits the biological response to stress, which then may be the mediating mechanism that leads to depressive symptoms or the onset of a depressive episode.

2) Examine gender and racial differences in the effects of these risk factors. Beginning in adolescence, risk for depression is greater in girls than boys. In addition, racial differences are under-studied in the examination of risk factors and etiology of depressive disorders. Thus, we predicted greater CV and stress reactivity in girls than boys and we explored racial differences in these risk factors.

CHAPTER 2

METHODS

Participants

Initial Participant Recruitment

Participants were initially recruited through Philadelphia area middle schools when they were 12-13 year old. Importantly, the participants for the current study were selected from the ongoing NIMH R01 grants (MH079369, MH101168) being conducted by Dr. Alloy at Temple University (ages 14-16 for the current study). Participants were initially recruited in two main ways. First, with the Philadelphia School District's permission and provision of demographic and contact information, we mailed a letter of introduction and description of the project to parents of Caucasian and African-American students aged 12-13 years old (approximate N = 8,662) attending some schools in the Philadelphia School District. Although mothers could call or return a prepaid postcard indicating their interest in the project, most families were recruited by this method through follow-up phone calls from project staff inviting mothers and their adolescent children to participate. Second, advertisements describing Project ACE (Adolescent Cognition and Emotion) were placed in Philadelphia area newspapers (e.g., Metro Kids, community newspapers) and mothers (approximate N = 134) called in to indicate their interest. Youth who were Caucasian, African American, or biracial and were English speaking (and their mothers were English speaking), were invited into the final sample. Study exclusion criteria were: 1) there was no female caregiver available to participate; 2) either the adolescent or mother did not read or speak English well enough to be able to complete the study assessments; and 3) either the adolescent or mother was mentally retarded, had a severe learning disability or other cognitive impairment, had a severe developmental disorder (e.g., autism), had psychotic symptoms, or

exhibited any other medical or psychiatric problem that would prevent either of them from being able to complete the study assessments. Following screening, eligible participants were called to further describe the study. Mothers and youths who gave verbal consent were scheduled for Time 1. At Time 1, mothers signed written consent forms and their adolescent child provided written assent. The current study capitalized on this ongoing study and recruited from participants who had completed at least both sessions of Time 1 (N=506). In the overall sample, participants included 53% females, 47% Caucasian participants who were on average 12.9 years old (SD = .64 years). Income was roughly evenly distributed and 48% of the participants qualified for free or reduced lunch, a measure of financial need that accounts for the number of dependents being supported on the family's income.

Current Study Participants

Of the 506 participants who completed both sessions at Time 1, 25% participated in the current study (N = 127). Participants in the current study sample consisted of adolescents who were 49% female, 47% Caucasian, and were on average 15.28 years old (SD = 1 year). Table 1 includes demographic characteristics of the initial study sample and the current study sample. A series of independent samples *t* tests and a chi-square test were conducted to assess potential differences between the overall sample and the current study sample on demographic variables. Specifically, the two groups were compared in terms of gender, race, income, and those who qualified for free or reduced lunch. Participants in the current study did not differ based on gender ($t = 1.072$, $p > .05$), race ($t = 0.016$, $p > .05$), income ($\chi^2 = 10.39$, $p > .05$) or qualification for free/reduced lunch ($t = 0.126$, $p > .05$). In addition, 16 individuals who were approached for this study chose not to participate in the additional component. The majority of these 16 did not elect to participate in the current study because they did not have enough time to stay for the

extra component (N = 12) and many had asked to be approached at a future session. Comparison of demographic characteristics between those who participated and those who declined participation indicated no gender ($t = 0.52$, $p > .05$), racial ($t = 0.66$, $p > .05$), income ($\chi^2 = 8.11$, $p > .05$) or qualification for free/reduced lunch ($t = 1.48$, $p > .05$) differences.

Table 1. Demographic charachteristics of the sample

	Initial Sample (N = 506)	Current Sample (N = 127)
Female	53%	49%
Caucasion	47%	47%
Age, years (SD)	12.90 (.64)	15.28 (1.00)
Income		
0-14,999	14%	11%
15-29,999	17%	14%
30-44,999	18%	17%
45-59,999	13%	14%
60-74,999	11%	9%
75-89,999	8%	10%
90,000 + up	18%	25%
Free/Reduced Lunch	48%	45%

Note: SD = Standard Deviation

Procedure

Screening

The Philadelphia School District provided permission and contact information to send a letter home to the parents of students enrolled in the district in the desired age range with information about the study. Youth who were eligible based on race and exclusion criteria stated above were invited into the final sample. Following the mailer, potential participants were called to further describe the study and eligible mothers and youths who gave verbal consent were scheduled for Time 1.

Time 1

At the initial assessment, mothers signed written consent forms and their child provided written assent. The Time 1 assessment consisted of two sessions scheduled roughly a month apart. During Time 1, adolescents completed self-report measures of cognitive vulnerability, and depressive and anxiety symptoms, among other assessments. Participants' mothers completed measures of parenting, family functioning, and early childhood stress experienced by the adolescents. Both mothers and adolescents completed a diagnostic interview of current and lifetime DSM-IV Axis I disorders. All participants were paid roughly $10 per hour for their participation.

Regular Prospective Assessments (RPAs):

Every 6 months, adolescents and their mothers are asked to come back into the lab for an RPA. RPA sessions are split between two visits that are scheduled roughly 2-4 weeks apart. During these sessions, adolescents were asked to complete questionnaires about current symptoms and cognitive styles and interviews about life event experiences that have occurred since the last interview. In addition, each year, diagnostic interviews are conducted to evaluate the prior year's psychopathology onset or continuance. The current study included an additional cortisol measure (described below) in the next RPA that the family attended. Participants were approached about the inclusion of this new task. Those who chose to participate were asked to provide an additional written consent (and assent) to participate and were paid an added $20 for their inclusion. Research suggests that the time of day affects cortisol levels (Ryzin, Chatham, Kryzer, Kertes, & Gunnar, 2009; Gunnar & Vazquez, 2001). The circadian rhythm of cortisol indicates that levels are generally low at night and dramatically increase after awakening. After this rise, the levels of cortisol reduce linearly throughout the day; therefore, only families who

came to interviews after 3:00 PM (Mean = 5:07 PM) were asked to participate in an attempt to assess adolescents at a more standard time of day.

Social Stressor Task

Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST is a widely used method to elicit a stress response (Gunnar, Talge, & Herrera, 2009). This test originally consisted of a public speaking task (mock job interview) in front of a 2-3 person audience (Kirschbaum, Pirke, & Hellhammer, 1993). Gunnar, Talge, and Herrera (2009) reported that public speaking stressors that have an evaluative component have been shown to effectively activate a stress response in children and adolescents. This task was modified for adolescents with instructions that they would be applying for a summer job and to speak about why they should be accepted. Instead of a 2-3 person audience, a video camera was placed in front of the participant, and they were told that their performance would be rated by an expert panel of judges on how well they did and that those who performed the best would get a prize. In addition, the interviewer sat in the room with a clipboard and was instructed to maintain a neutral expression. This stress paradigm was chosen because it has been shown to be particularly effective in eliciting a stress response in adolescents and is less invasive (e.g., physical examination, inoculation, venipuncture) and more feasible (e.g, peer rejection paradigm, parent-child conflict discussion) than other paradigms. In addition, social stress paradigms have been used with participants of all ages including infants, toddlers, young children, adolescents and adults (Gunnar et al., 2009; Chida & Hamer, 2008). After a 30 min baseline period, in which participants completed the consent forms and other measures in this study, participants were given instructions for the task. They received 5 min to prepare their speech while alone in the room. Following the 5 min preparation time, the interviewer came back into the room and read a

condensed portion of the instructions for the job interview. Participants were asked to stand, face the camera, and were prompted to speak for 2 minutes. Standardized prompts were given to the participants if there were long pauses (e.g., 20 seconds), such as "You still have time remaining, please continue." After the two min speech, the participants were prompted to stop but remain standing. An unexpected additional task was then introduced as participants were asked to solve a calculation task aloud. They were asked to count backwards from 2,083 to zero in 13-step sequences. They were instructed to calculate as quickly and correctly as possible and if they made a mistake the interviewer would say "error, 2,083" and were asked to start over. They were not instructed on the duration of this task but after they began, participants completed this task for 1 min. All portions of the TSST were videotaped. Following this task, participants were told that the new task was completed and continued to complete other study measures in the remaining time of the RPA. At the end of the day's session, participants and their mothers were debriefed on the study protocol.

Measures

Early Life Stress

Children's Life Events Scale (CLES; Crossfield, Alloy, Gibb, & Abramson, 2002; Chandler, 1981). To examine early childhood stress, prior to Time 1 of the main study, mothers completed the CLES. The CLES is a checklist of 50 moderate to major stressful events that children may experience in their lifetime. The CLES is an expanded version of the previously established Source of Stress Inventory (Chandler, 1981). Mothers identified whether each of the events occurred in the child's life between birth and Time 1 and if it did occur, the child's age at the time. The CLES includes achievement events (e.g., academic failure), peer difficulties (e.g., break-up with best friend), family difficulties (e.g., divorce of parents, family death, serious

financial difficulties), and assorted other categories (e.g., death of pet). Total scores can range from zero to fifty with higher scores indicated more negative events. In the previous Cognitive Vulnerability to Depression (CVD) Project, mothers' and fathers' reports on the CLES were correlated, r = .61 (Crossfield et al., 2002) and high levels of CLES events in combination with negative maternal inferential feedback was associated with the child's cognitive vulnerability to depression (Crossfield et al., 2002). Several studies (e.g., Crossfield et al., 2002; Grandin et al., 2007) have demonstrated the predictive validity of the CLES. This measure was given at Time 1. Internal consistency in this sample was α = .80.

Parenting and Maternal Characteristics

Children's Report of Parental Behavior Inventory – Parent Report version (CRPBI; Schaefer, 1965). The CRPBI-PR was modeled after the original CRPBI, which was a 180-item self-report questionnaire (90 items each about mother and father) given to children to report about their parents' parenting styles. This measure was adapted to a shorter 90-item version (Raskin et al., 1971) with good psychometric properties. Following a factor analysis, this measure yields three scales: Positive Involvement (Acceptance vs. Rejection); Negative Control (Psychological Autonomy vs. Psychological Control); and Lax Discipline (Firm Control vs. Lax Control). This measure was adapted for the current project and given to mothers to rate their own parenting (Safford, Alloy, & Pieracci, 2007). Each item describes a discrete parental behavior (e.g., "often praises child") that is rated in terms of whether the statement is ''like,'' ''somewhat like,'' or ''not like'' how they acted toward their child between birth and age 12. Of the 90 items, 48 items were found to comprise the three primary scales. Positive Involvement (22 items) reflects an active interest and engagement in a child's experiences and activities (e.g., "Believed in showing my love for my child"). Negative Control (16 items) reflects a parent's attempts to

control a child's behavior in psychologically harmful ways (e.g., "Thought my child was not grateful when he/she didn't obey"). Lax Discipline (10 items) reflects a parent's emphasis on autonomy, but in a way that suggests lack of engagement (e.g., "Gave my child as much freedom as he/she wanted"). Prior studies demonstrate excellent internal consistencies of these scales (Raskin et al., 1971; Safford et al., 2007). In addition, the scales have demonstrated concurrent validity with other measures of parenting behaviors (Safford et al., 2007). This measure was completed by mothers at Time 1. Internal consistency in the current sample was α = .78 for Negative Control, α = .92 for Lax Discipline, and α = .77 for Positive Involvement.

Maternal Depression: Schedule for Affective Disorders and Schizophrenia-Lifetime (SADS-L; Endicott & Spitzer, 1978). The SADS-L is a semi-structured clinical interview used to diagnose adult psychopathology. An expanded version of the SADS-L was employed to accurately determine whether mothers met *DSM-IV-TR* criteria for Axis I disorders in their lifetime prior to study enrollment. Although the SADS-L assesses many different diagnoses (e.g., anxiety, substance abuse, etc), the current study only used the depression section. The SADS-L has demonstrated strong inter-rater reliability (Alloy, Reilly-Harrington, Fresco, Whitehouse, & Zechmeister, 1999) and test-retest reliability (Alloy & Abramson, 1999) in prior studies. Diagnosticians for the current study included postdoctoral fellows, clinical psychology doctoral students, and post-baccalaureate research assistants, all of whom had approximately 200 hours of training on the expanded SADS-L interview. Training included didactic sessions, role-playing, supervised administration, practice with case vignettes, feedback from highly experienced trainers, and assessing symptomatology of Axis I disorders as per the *DSM-IV-TR*. Inter-rater reliability, when compared with an expert psychiatric diagnostic consultant, yielded κ = .86 (based on 100 expanded SADS-L interviews). The mothers in the project were assessed with the

expanded SADS-L at Time 1. Those who met diagnostic criteria for Major Depressive Disorder (MDD) at some point in their lives were categorized as having the presence of MDD, whereas those without such history were categorized as not having the presence of this disorder.

Self-Report Cognitive Vulnerability Questionnaires

Adolescent Cognitive Style Questionnaire (ACSQ; Hankin & Abramson, 2002). The ACSQ measures the cognitive vulnerability to depression featured in the hopelessness theory. The ACSQ presents the adolescent with 12 negative hypothetical events in achievement, interpersonal, and appearance domains, and asks the youth to make inferences about the causes (internal-external, stable-unstable, and global-specific), consequences, and self-worth implications of the hypothetical event. For each item, adolescents are asked to write a sentence about what they believe to be the major cause of each event. Then using 7-point Likert scales, they rate the internality (e.g., "Do you think this event was caused by something about you or caused by something else?"), stability (e.g., "Do you think this will happen again or not?"), and globality (e.g., "Do you think this event will affect other areas of your life?") of the cause of the event, the consequences of each event (e.g., "Do you think other bad things will happen to you because someone said something bad about your looks?"), as well as possible negative self-implications of the event (e.g., "Do you think there is something wrong with you because someone said something bad about your looks?"). Following the usual scoring method, a composite score was calculated by taking the average score across the stability, globality, consequences, and self-implications items to create a negative composite score, with higher scores indicating a more negative cognitive style. The ACSQ has demonstrated excellent internal consistency, good test-retest reliability and stability, a factor structure consistent with the hopelessness theory (Hankin & Abramson, 2002), and good validity (Alloy et al., in 2012;

Calvete, Villardon, & Estevez, 2009; Hankin, 2008). Internal consistency in this sample for the overall negative composite score was α = .96. This measure was given at Time 1 and once a year thereafter. For the present study, the ACSQ was used from the same RPA that the TSST was given.

Children's Response Styles Questionnaire (CRSQ; Abela, Brozina, & Haigh, 2002). The CRSQ is a 25-item self-report questionnaire that assesses a youth's style to respond to sad/depressive moods and contains 3 subscales (Rumination, Distraction, Problem-Solving). Adolescents are asked to rate what they usually do, not what they think they should do, when they feel sad. They respond on a scale from "Almost Never", "Sometimes," "Often" and "Almost Always" to items such as "When I am sad, I think about how alone I feel." Each subscale has shown moderate internal consistency in 3rd and 7th graders (Abela, Brozina, & Haigh, 2002; Abela & Hankin, 2011) and good construct validity (Alloy et al., 2012; Abela, Vanderbilt, & Rochon, 2004). The current study only used the rumination subscale (13 items) with scores ranging from 13 to 52, with higher scores indicating more of a tendency to ruminate. This measure demonstrated good internal consistency (α = .93). This measure was given at the Time 1 and once a year. The CRSQ from the same RPA as the TSST was given was used in this study.

Hopelessness Scale for Children (HSC; Kazdin, French, Unis, Esveldt-Dawson, & Sherick, 1983). The HSC is a 17-item self-report questionnaire that assesses hopelessness in youth in the previous 2 weeks. Adolescents respond by answering true or false to the items with higher total scores indicating more hopelessness. Items include "I might as well give up, because I can't make things better for myself" and "I don't think I will have any real fun when I grow up." The HSC exhibits good psychometric properties and construct validity (Alloy et al., 2012;

Abela, Brozina, & Haigh, 2002; Kazdin, Rogers, & Colbus, 1986; Spirito, Williams, Stark, & Hark, 1988). Internal reliability in this sample was α = .80. This measure was given at Time 1 and every RPA; the HSC from the same RPA as the TSST was given was used in this study.

Proximal Stressful Life Events and Family Context

Adolescent Life Events Questionnaire (ALEQ ; Hankin & Abramson, 2002). The ALEQ assesses a broad range of negative life events that typically occur among adolescents, including school/achievement problems, friendship and romantic difficulties, and family problems. Youth were asked to indicate how often (Likert scale ranging from never (0) to always (4)) these negative events had occurred to them over the past 6 months. The 63 different negative life events included in the ALEQ can be categorized into events occurring in different categories such as interpersonal (e.g., peers, romantic partners, family) and achievement (e.g. academics, work) domains (Hankin, Badanes, Abela, & Watamura, 2010; Hankin & Abramson, 2002) as well as independent versus dependent types of events. Independent, or fateful, events are those that may not be due to an individual's characteristics (e.g., death of a relative, house flooding, car breaks down), whereas dependent events are those that may be the result of individuals' characteristics (e.g., fight with a friend, fail a test, break-up with boy/girlfriend). Events were a priori coded into event categorizations by a team of four doctoral students in clinical psychology (κ = .76). The current study separately examined total, interpersonal, and dependent events as they are each particularly relevant to depression (Hammen, 2005; Liu & Alloy, 2010). The life event variables used reflect sums of the number of each type of events. The ALEQ demonstrated good predictive validity in past research with U.S. (Hankin, Badanes, Abela, & Watamura, 2010; Hankin, 2008; Stange, Hamilton, Abramson, & Alloy, 2014), European (Calvete, Villardon, &

Estevez, 2009), and Chinese (Abela et al., 2011) samples. This measure is given at each RPA and the ALEQ from the same RPA that the TSST was given was used in this study.

Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003). The CTQ assesses emotional abuse and emotional neglect by a parental figure. This is a self-report measure given to adolescents to report on the occurrence of familial emotional abuse or neglect that occurred since the last assessment. Each subscale consists of five items and each item is rated on a 5-point Likert scale ranging from 1 (*"Never true"*) to 5 (*"Very often true"*). The total score of each subscale is obtained by summing all five items after reverse-scoring some of the items, with higher scores indicating more emotional abuse or neglect. Both subscales have demonstrated excellent reliability (Bernstein et al., 2003). Internal consistency in this sample was α = .75 for emotional abuse and α = .88 for emotional neglect. This measure was given at each RPA and the CTQ from the same RPA as the TSST was given was used in the present study.

Family Assessment Measure (FAM-III-G: Skinner, Steinhauser, & Santa-Barbara, 1995). The FAM-III-G provides a measure of strengths and weaknesses in the family system. The FAM-III is based on a Process Model of Family Functioning (see Steinhauer, Santa-Barbara, & Skinner, 1984). The Process Model focuses on major domains of family functioning and the interaction between these domains. Mothers were asked to respond to the 50 items by indicating on a 4-point scale how much they agreed or disagreed with the statements that applied to their family since the last interview from "Strongly Agree" to "Strongly Disagree." The original measure included items from various categories such as task completion (e.g., "family duties are fairly shared"), role performance (e.g., "We agree about who should do what in our family"), communication, and affective expression (e.g., "We sometimes hurt each other's feelings"). A general score was calculated from the average raw score of each subscale with higher scores

indicating higher levels of disturbance or problems in the family system. This measure was normed on a large population by the developers and has demonstrated good reliability and validity (Skinner at al., 1995). Internal consistency in this sample was α = .93. This measure was given at each RPA and the FAM-III from the same RPA as the TSST was given was used for this study.

Self-Report Symptom Questionnaires

Children's Depression Inventory (*CDI; Kovacs, 1981; 1985*). The CDI is the most widely used self-rating scale of depressive symptoms in youth. The CDI is designed for use with 7 - 17 yr. olds and consists of 27 items reflecting affective, behavioral, and cognitive symptoms of depression. Adolescents read a series of three statements (e.g., "I am sad once in a while," "I am sad many times," "I am sad all of the time') and choose which statement best describes them in the past two weeks. In this sample, scores ranged from zero to 40, with higher scores indicating more depressive symptoms. Internal consistency, retest reliability, and convergent and discriminant validity are well established (Klein, Dougherty, & Olino, 2005). Internal consistency was α = .87 at Time 1 and test-retest reliability was r = .70. The CDI was given at Time 1 and every RPA; for the current study, the CDI from the RPA at which participants completed the TSST was used.

Biological Stress Response

Timing. Biological response to the social stressor (TSST) was assessed at four time points. Salivary cortisol and heart rate/blood pressure were measured at the end of the baseline which began after the participant signed consent forms and then began completing study measures in the room (T1: M = 23.82 minutes after the participant was in the room, SD = 4.41 minutes), immediately after the speech (T2: M = 16.43, SD = 3.22 minutes after the initial saliva

collection and the instructions were given), and 30 (T3: M = 30.59 minutes, SD = 1.28 minutes) and 60 minutes (T4: M = 30.74 minutes, SD = 2.89 minutes after the prior assessment) after the speech. These collection times were based on meta-analytic findings indicating that peak cortisol response occurs 21-40 min following the onset of a stressor and that complete recovery occurs within 41-60 min after stressor offset (Dickerson & Kemeny, 2004). Therefore, T3 was aimed at assessing the peak stress and T4 was aimed at assessing the recovery period. T2 was included as a time point to measure an individual's autonomic response to stressors, which is a much quicker process than the production of cortisol. Because the autonomic stress reactivity is faster, an assessment immediately post stressor was a more valid time for this type of assessment. In addition, a measurement of cortisol at that time point could also assess increase of cortisol production after the instructions were given to examine whether there was a moderate increase due to preparation and introduction of the task in comparison to giving the actual speech.

Biological Measurement. Saliva samples were collected with salivettes (cotton swab) from Sarstedt AG & Co., Germany. Participants were instructed to put the salivette into their mouths for two minutes. They were asked to make their mouths moist before putting the swab into their mouths and attempt to not swallow frequently or chew on the swab. While the salivette was collecting saliva, the participant's autonomic nervous system was assessed in order to obtain a multi-modal measurement of reactivity to stress. The participant's heart rate and blood pressure was assessed using an Omron BP785 cuff. In addition, as a check on the subjective stressfulness at each time point, participants were asked to indicate how distressed they felt at that time on a distress thermometer with a concurrent 10 point likert scale from 0 (not at all distressed) to 9 (extremely distressed). Individuals' salivary cortisol, heart rate/blood pressure, and subjective distress were measured at each of the four aforementioned time points.

All saliva samples were labeled and immediately placed in a freezer for short-term storage overnight and then taken to a sub-zero freezer for long-term storage before they were assayed. Samples were assayed for cortisol using a corticosterone enzyme immunoassay kit (Arbor Assays, Ann Arbor, MI) with intra- and inter-assay coefficients of variation ranging from 6.0%-14.7% and 7.2%-10.9%, respectively. To minimize variability, all samples from each participant were assayed within the same assay batch and all samples were tested in duplicate. Duplicate test values were averaged to create the cortisol score for that time period with values in picagrams per milliliter (pg/mL). Cortisol values that were returned below the minimum or above the maximum standard curve of comparison were re-run. If these cortisol samples did not have a readable value after they were re-analyzed, they subsequently were not used in analyses. If a participant had more than one value that was above/below a readable score (N = 5) or if the participant did not have a readable baseline (N = 1), they were excluded from all analyses.

Cortisol Questionnaire. A number of individual variables influence basal cortisol levels and cortisol reactivity separately. After signing consent forms, participants were interviewed about several factors that may affect cortisol secretion. These included the use of caffeine, nicotine and alcohol. Adolescents reported on the consumption and timing of food intake during the day of assessment, the presence of asthma or allergies and the associated medication used, and any other medications taken. Adolescents also responded about the presence of any health conditions, their regular physical exercise, and the presence of any gum disease, canker sores, or other types of mouth infections. Interviewers also obtained information on the typical sleep and wake time of the participants as well as their general restfulness, and the number of hours slept the night before the assessment. In addition, the participants' height and weight were measured in the lab and their BMI was calculated. Finally, for female participants, they were assessed on

whether they had begun having their menstrual period, when their last menstrual period began, and whether they used any type of birth control method. These measures were used to examine influences on overall cortisol production and reactivity of cortisol response and later controlled in analyses if found to be a significant contributor to differences.

CHAPTER 3

RESULTS

Preliminary Analyses and Data Management

Sample Description

As described earlier, the current sample did not differ based on demographic variables (age, gender, race, income or qualification for free/reduced lunch) from the broader study sample from which it was drawn. An examination of main study measures given at Time 1 was conducted to determine differences between the current sample and the overall sample. Independent sample *t* tests suggest that the current sample did not significantly differ from the overall sample on Time 1 measures of depressive symptoms ($t = .84$, p = ns), anxiety symptoms ($t = .64$, p = ns), maternal parenting characteristics (Negative Control [$t = .15$, p = ns], Lax Discipline [$t = .94$, p = ns], and Positive Involvement [$t = .61$, p = ns]), or negative cognitive style ($t = 1.39$, p = ns). Relative to those in the overall study, participants in the current sample had higher rumination scores ($t = 2.10$, $p < .05$, $d = .31$) and lower hopelessness scores ($t = 2.34$, $p < .05$, $d = .29$). Table 2 provides descriptive statistics of the main study variables for the current sample.

Table 2. Descriptive statistics of main study variables

	Range			
	Minimum	Maximum	Mean	SD
Early Life Stress				
Negative Life Events	0.00	45.00	19.47	10.33
Parenting/Maternal Charachteristics				
Negative Control	0.00	38.00	25.32	6.24
Lax Discipline	0.00	30.00	26.53	4.95
Positive Involvement	0.00	66.00	55.68	10.21
Maternal MDD, percent			29%	
Cognitive Vulnerabilities				
Negative Cognitive Style	49.00	251.00	120.95	43.39
Rumination	13.00	52.00	25.40	9.27
Hopelessness	0.00	14.00	3.05	3.01
Proximal Stress and Family Context				
Total Stressors	0.00	41.00	12.53	8.40
Interpersonal Stressors	0.00	31.00	8.11	6.52
Dependent Stressors	0.00	28.00	9.60	6.36
Familial Emotional Abuse	5.00	17.00	7.83	2.97
Familial Emotional Neglect	5.00	24.00	9.29	3.90
Family Problems	1.43	11.43	5.86	2.12
Symptoms				
Depressive Symptoms	0.00	40.00	6.79	6.76

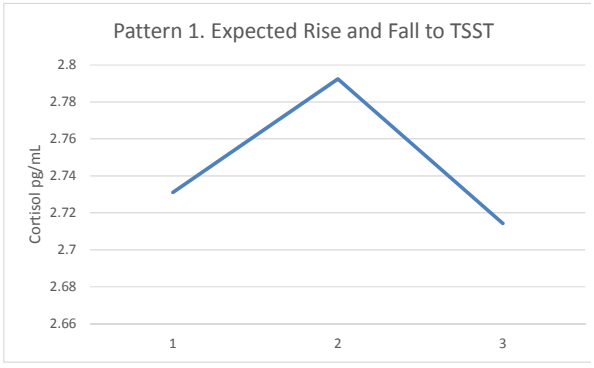
Note: The measures of Early Life Stress and Parenting/Maternal Charachteristics were given at Time 1. The measures of cognitive vulnerabilities, proximal stress, and symptoms were given at the RPA that the TSST was given.

Stress Response Variables

An examination of the data for assumptions of statistical tests was conducted. Heart rate values were normally distributed and thus, no transformations were needed. Consistent with prior studies, an examination of the raw cortisol data revealed that the distribution of concentrations at each time point were leptokurtic and positively skewed. Therefore, $\log_{10}$ transformations were used to establish a more normal distribution prior to analyses (Blair et al., 2008; Gunnar et al., 2009; Klimes-Dougan et al., 2001). All analyses of cortisol data utilized the log-transformed values; however, the non-transformed data are reported in Table 3 (along with the other

measures of response to the TSST) in order to facilitate interpretation. Cortisol mean and range were consistent with prior studies (e.g., Harkness et al., 2011; Gunnar et al., 2009). Examination of the cortisol values revealed that no values were outside the range of physiological possibility, and there were few outliers (less than 5%) above 2 standard deviations, with no values above 3 standard deviations. Thus, no data were excluded. Importantly, visual examination of the cortisol values revealed differing patterns between participants. Whereas many participants evinced the expected rise and fall following the TSST, some participants did not show cortisol reactivity to the stressor (see Figure 1). The difference in slope between participants who reacted (positive slope) and those who had lowering reactivity (negative slope) has implications for the statistical tests in later analyses. Importantly, prior research also has demonstrated similar patterns of cortisol data (Harkness et al., 2011; Waugh, Muhtadie, Thompson, Joorman, & Gotlib, 2012) based on differing predictors. Similar patterning was seen in the heart rate reactivity data. These patterns were explored in analysis.

a)



b)

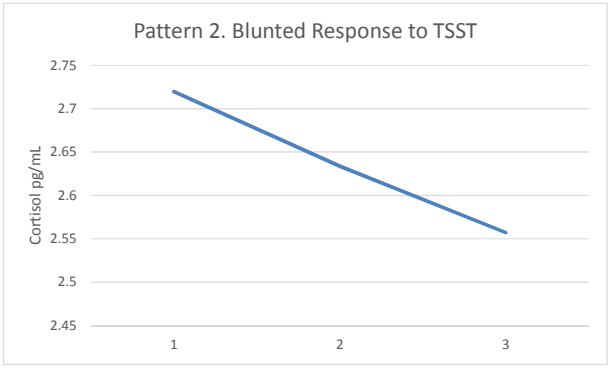


Figure 1. Two prominent patterns of Stress Reactivity

Consistent with the hypotheses, and prior studies (e.g., Harkness et al., 2011), a number of cortisol stress response variables were created from the raw data. We included the (a) log baseline as a measure of 'resting phase,' (b) 'cortisol reactivity,' defined as the peak concentration minus the baseline, and (c) 'cortisol regulation," defined as the difference between the last time period concentration and the peak concentration. In addition, these same calculations were made for heart rate using data from T1, T2, and T3. As such, (a) a resting phase was the T1 heart rate value, (b) the 'heart rate reactivity' was a calculation of the T2 heart rate minus the T1 heart rate, and (c) the heart rate regulation was calculated by taking the difference between T2 and T3 heart rate.

As seen in Table 3, participants' distress ratings increased from pre to post stressor on the 10 point likert scale. Examination of demographic differences between subjects reporting distress revealed that Caucasian participants reported significantly higher levels of distress (increase from pre to post-stress) compared to African American participants ($t = 3.565$, $p < .01$, $d = .65$). In addition, a one-way ANOVA revealed income differences ($F = 3.075$, $p < .01$) in distress reactivity. Follow-up analysis suggested that those who qualified for free/reduced lunch reported less distress ($t = 2.29$, $p < .05$, $d = .40$) than participants who did not qualify for free/reduced lunch. There were no gender or age differences in reported distress reactivity in the sample.

Table 3. Biological Stress Response Measures

		Range			
		Minimum	Maximum	Mean	SD
Time 1					
	Distress	0.00	8.00	1.42	1.92
	Heart Rate	51.00	101.00	74.70	11.43
	Cortisol (pg	202.00	6170.80	1016.46	1070.06
Time 2					
	Distress	0.00	9.00	3.12	2.40
	Heart Rate	52.00	100.00	74.31	11.20
	Cortisol (pg	214.44	5414.00	1011.19	939.05
Time 3					
	Distress	0.00	8.50	1.18	1.54
	Heart Rate	52.00	114.00	73.55	11.23
	Cortisol (pg	200.92	6352.80	944.47	1060.58
Time 4					
	Distress	0.00	8.50	0.94	1.55
	Heart Rate	49.00	103.00	72.02	11.11
	Cortisol (pg	150.00	4336.40	648.53	674.51

Note: Cortisol values are presented as the raw data. Consistent with prior studies, cortisol values were positively skewed which effects measures of central tendency as presented above. Data for analysis used log transformed cortisol values.

Associations among Study Variables

Covariate analyses were conducted first to examine demographic and individual characteristics that may influence the measures of stress response (See Table 4). Consistent with normative changes in daily cortisol levels, correlation analysis revealed that the time of the start of the TSST (Pearson's r = -.29, p < .01) was related to cortisol values such that earlier start times were related to higher average cortisol. In addition, gender was correlated (Pearson's r = -.21, p < .05) with average cortisol, such that girls had higher cortisol values than boys. Thus, time of day and gender were used as covariates in analysis.

Table 4. Covariation of variables affecting average cortisol and cortisol reactivity

			Pearson Correlation	
	Percent	Mean (SD)	Average Cortisol	Cortisol Reactivity
Time of Day (when arrived)		4:42 PM (1:11 M)	-.29**	-0.05
Demographic Variables				
Age		15.28 (1.00)	0.09	-0.03
African American	53%		0.04	-0.01
Body Mass Index		23.53 (5.81)	-0.11	-0.04
Height (inches)		66.24 (4.15)	0.17	-0.14
Weight (lbs)		146.41 (35.75)	-0.05	-0.10
Female	48%		-.21*	-0.01
Cycle Y/N	44%		-.20*	-0.04
Days Since Last Period		19.04 (17.35)	0.14	-0.09
Cycle Regular	86%		0.06	0.09
Take Birth Control	5%		0.02	-0.01
Intake Information				
Regularly Intake Caffeine	60%		0.08	-0.07
Caffeine Today	40%		-0.03	-0.12
Ever Used Nicotine	4%		0.09	0.04
Nicotine Today	2%		0.07	0.20
Minutes Since Last Ate		148.36 (126.15)	0.12	0.01
Ate within Past 30 minutes	17%		-0.01	0.05
Ate within past 60 minutes	34%		0.00	0.01
Ate within Past 120 minutes	48%		-0.10	0.01
Health Information				
Take Any Medication	13%		-0.11	-0.06
Presence of Mouth Infection	1.60%		0.07	0.07
Dx with Asthma or Allergies	44%		-0.08	-0.06
Take Asthma Medication	23%		-0.05	-0.05
Take Allergy Medication	20%		-0.08	0.03
Specifically Albuterol Inhaler	14%		-0.13	-0.01
Daily Activities				
Activity Level (Ave Days)		2.20 (2.10)	0.08	-.21*
Average Hours of Sleep		7.67 (1.52)	0.00	0.02
Days Feeling Rested		3.83 (2.45)	0.00	0.06
Hours of Sleep Last Night		7.80 (1.77)	-0.01	-0.03

Note: * $p < .05$, ** $p < .01$, *** $p < .001$

An examination of demographic differences (age, gender, income, and race) using independent samples *t* tests, analysis of variance, or chi-square in the case of income, was conducted on other main study variables of interest (cognitive vulnerabilities, early and proximal stress, parental and family factors, and symptomatology). Gender was significantly related to anxiety symptoms ($t = 4.15$, $p < .001$, $d = .75$) and rumination ($t = 2.98$, $p < .01$ $d = .54$), such that girls had higher levels of anxiety and rumination. In addition, race was significantly related to negative cognitive style ($t = 2.32$, $p < .05$, $d = .41$), such that Caucasian participants had more negative cognitive styles. Age was significantly related to baseline heart rate ($F = 2.23$, $p < .05$), with older participants exhibiting higher baseline heart rates than younger participants. Finally, income was not related to any main study variables. Consequently, gender and race were used as covariates in main study analyses when relevant.

Table 5 presents the bivariate correlations among all study variables included in analyses. As indicated, all heart rate and cortisol variables at the various time points were correlated with their respective constructs, but were not correlated between each system. Similarly, early life stressors and parenting/maternal characteristics and proximal life stressors were associated with their respective constructs. Of these, only early life stress was associated with proximal stressors. Rumination was associated with negative cognitive style, but not hopelessness. In addition, rumination was associated with a number of proximal stress variables. Finally, anxiety and depression were associated with risk factors including proximal stressors, cognitive vulnerabilities, and heart rate.

Table 5. Correlation of main study variables

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Early Life Stress	-	.27**	.19*	.31**	.08	.11	.05	.08	.24**	.07	.18*	.10	.07	.14
2	Negative Control		-	.55***	.53***	.18	-.13	-.05	-.02	.11	.12	.00	.10	.02	.04
3	Lax Discipline			-	.74***	-.10	-.14	.00	-.10	.09	-.01	-.09	-.15	-.09	-.06
4	Positive Involvement				-	.02	-.03	.04	.03	.07	.04	-.03	-.14	-.12	.05
5	Maternal Depression					-	.04	-.09	.02	.05	.16	-.08	-.14	-.08	.11
6	Negative Cognitive Style						-	.35***	-.06	.12	.02	.13	-.03	.23*	.38***
7	Rumination							-	.09	.25**	.08	.29**	.12	.29**	.45***
8	Hopelessness								-	.07	.01	.08	.05	.02	.29***
9	Total Stressors									-	.40***	.49***	.15	.39***	.33***
10	Peer Victimization Events										-	.23*	-.05	.01	.12
11	Familial Emotional Abuse											-	.47***	.50***	.39***
12	Familial Emotional Neglect												-	.45***	.18*
13	Family Problems													-	.33***
14	Depressive Symptoms														-
16	Distress_Average														
17	Systolic Average														
18	Diastolilc Average														
19	Heart Rate Average														
20	Log Cortisol Average														
21	Distress Reactivity														
22	Systolic Reactivity														
23	Diastolilc Reactivity														
24	Heart Rate Reactivity														
25	Log Cortisol Reactivity														

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

Table 5. Correlation of main study variables, continued

		15	16	17	18	19	20	21	22	23	24
1	Early Life Stress	.12	.05	.19*	.16	-.01	-.02	.10	.00	-.11	.02
2	Negative Control	.08	.06	.16	.05	-.26**	.05	-.03	-.17	-.09	-.07
3	Lax Discipline	.00	-.06	.06	-.09	-.14	-.03	-.01	-.03	-.15	.02
4	Positive Involvement	.01	-.01	.04	-.01	-.07	-.04	.13	-.03	-.15	.01
5	Maternal Depression	.08	.12	-.04	.04	-.06	.17	-.04	.13	.15	-.08
6	Negative Cognitive Style	.25**	-.09	-.13	-.01	.02	.02	.02	-.06	.01	.01
7	Rumination	.29**	-.16	.01	.17	.02	-.01	-.01	.09	.05	.01
8	Hopelessness	-.08	-.05	-.03	.10	-.05	.03	.13	.05	-.07	.08
9	Total Stressors	.14	-.09	.02	.15	-.02	-.09	-.12	-.13	-.09	-.06
10	Peer Victimization Events	-.07	-.06	-.07	.10	.05	-.04	.08	-.05	-.06	-.05
11	Familial Emotional Abuse	.20*	-.03	.10	.21*	.07	.02	.00	.09	-.02	-.07
12	Familial Emotional Neglect	.06	.02	.14	.22*	.03	-.12	-.04	.01	.06	-.15
13	Family Problems	.26**	-.12	-.01	.23*	.21*	.00	-.10	-.14	-.03	.06
14	Depressive Symptoms	.36***	-.03	.13	0.17T	.04	.01	.05	.03	-.08	.06
15	Distress_Average	-	-.01	.11	.05	-.03	.17*	-.10	-.12	-.06	.01
16	Systolic Average		-	.63***	-.14	.10	-.14	.02	-.04	.02	-.09
17	Diastolilc Average			-	.23*	-.08	-.07	-.09	.08	-.04	.07
18	Heart Rate Average				-	.06	.15	-.08	.14	-.03	-.01
19	Log Cortisol Average					-	.03	-.02	-.11	.11	.05
20	Distress Reactivity						-	-.02	-.04	-.08	.00
21	Systolic Reactivity							-	.17	-.03	.04
22	Diastolilc Reactivity								-	.31***	.05
23	Heart Rate Reactivity									-	-.12
24	Log Cortisol Reactivity										-

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

Distribution of Variables and Regression Diagnostics

Examination of the distribution of study variables revealed generally normally distributed variables with little skew and few outliers. Depressive symptoms were the exception to the normality assumptions, with preliminary analyses revealing a positive skew. This was submitted to a square root transformation to satisfy assumptions of normality. There were relatively few outliers (less than 5%) on the main study variables, which is what would be expected given random sampling. In addition, relatively few variables were missing (less than 5%) due to incomplete completion of a questionnaire. When examining the data for missingness, it was determined that it was missing at random, as *t*-tests between missing and non-missing on each variable, performed on all other variables, were found to be non-significant. An examination of the Q-Q plots of study variables suggested that all study variables met the linearity assumption between the expected and observed values. The relative variance of negative cognitive style was reduced by dividing all values by a constant to meet the assumption of equality of variance between study variables. In addition, collinearity diagnostics (i.e., Variance Inflation Factor; VIF) were conducted in all analyses that included multiple domains of vulnerability as predictor variables. In all cases, there were no indications of multicollinearity using a standard VIF critical value of 3.

Aims and Hypotheses

Primary Aims. (1) We predicted that individuals with higher levels of early life stress, more chaotic environments, and familial psychopathology would exhibit heightened levels of CV and stress reactivity. In addition, (2) we predicted that adolescents with higher levels of both CV and physiological stress reactivity would evince greater negative reactivity to proximal stressful

life events in the form of depression, such that the interaction of greater CV and stress reactivity would predict more depressive outcomes. Finally, (3) we predicted that greater CV would be associated with greater physiological stress reactivity.

Exploratory Aims. Given that CV predicts psychological responsiveness to stressful life events and, in turn, depression, (1) we examined whether the association between CV and depression is mediated by biological stress reactivity. In addition, (2) we expected that CV and stress reactivity would be greater in girls than boys. Finally, we explored racial differences in these risk factors.

Test of Study Hypotheses

Primary Aim 1: Predictors of CV and stress reactivity

To examine whether early life stress, parenting/maternal characteristics, or proximal/family stressors predicted CV or stress reactivity, three sets of regression analyses were conducted. In the first set, the three CV variables were regressed on each predictor variable of interest separately. In the second and third set of analyses, cortisol and heart rate variables were regressed on each predictor variable of interest separately. Covariates were entered for each regression as described in the preliminary analysis section.

Table 6 shows the regression analyses examining predictors of CV. Only proximal stressors were predictive of a more negative cognitive style and higher levels of rumination. More specifically, higher levels of dependent stressors and higher levels of family stress predicted a more negative cognitive style. In addition, higher levels of total stress, interpersonal stress, dependent stress, familial emotional abuse, and overall family stress predicted a more ruminative style. Of note, no early life stress, parenting/maternal characteristics, or proximal/family stress predicted hopelessness. In addition, no early life stressors predicted differences in CV.

Table 7 shows the regression analyses examining predictors of heart rate stress reactivity. Analysis revealed that higher levels of family emotional maltreatment and family stress predicted higher baseline heart rate. No predictors in the model predicted increases in heart rate reactivity to the TSST. Only higher levels of interpersonal stress predicted a poorer recovery from the TSST. As described in the preliminary analyses, specific patterns of heart rate were demonstrated in the current sample of adolescents. We compared participants who exhibited a

heightened heart rate reactivity to the TSST versus those who did not on the predictor variables. Independent samples *t*-tests revealed that adolescents with higher levels of familial emotional abuse ($t = 2.41$, $p < .05$, $d = .59$) and lower levels of relaxed maternal discipline ($t = 2.33$, $p < .05$, $d = .63$) were more likely to be in the heart rate reactive group versus the non-reactive group.

Table 8 displays the regression analyses examining predictors of cortisol stress reactivity. Analysis revealed that higher levels of maternal negative control predicted lower baseline cortisol levels, whereas higher levels of proximal family stress predicted higher baseline cortisol levels. No predictor variables predicted cortisol reactivity to the TSST similar to the heart rate models. Higher levels of maternal negative control, a history of maternal depression, proximal total, interpersonal and dependent stressors all predicted poorer cortisol recovery. Again, as described in the preliminary analyses, specific patterns of cortisol were demonstrated in the current sample. We examined participants who showed a heightened cortisol reactivity to the TSST versus those who did not on the predictor variables. Based on a prior study (Harkness et al., 2011), we included an additional subscale of the early life stress questionnaire to examine differences based on specific maltreatment history. Harkness and colleagues (2011) found that individuals with maltreatment histories evinced a blunted cortisol response compared to those without such history. Independent samples *t*-tests revealed that adolescents with higher levels of dependent proximal stressors ($t = 2.07$, $p < .05$, $d = .51$) and a history of childhood maltreatment ($t = 2.06$, $p < .05$, $d = .52$) were more likely to be in the cortisol non-reactive (blunted) group compared to the reactive group.

Table 6. Predictors of Cognitive Vulnerability

	Negative Cognitive Style					Rumination					Hopelessness			
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*
Early Life Stress														
Negative Life Events	0.45	0.37	0.11	1.19	.011	0.04	0.08	0.05	0.56	.074	0.02	0.03	0.08	0.88
Parenting/Maternal Charachteristics														
Negative Control	-0.92	0.65	-0.13	1.42	.017	-0.07	0.14	-0.04	0.47	.081	-0.01	0.05	-0.02	0.23
Lax Discipline	-1.24	0.82	-0.14	1.51	.019	0.03	0.17	0.02	0.16	.080	-0.07	0.07	-0.10	1.06
Positive Involvement	-0.14	0.39	-0.03	0.36	.001	0.05	0.08	0.06	0.63	.083	0.01	0.03	0.03	0.32
Maternal MDD	3.84	10.11	0.04	0.38	.002	-0.32	2.14	-0.01	0.15	.116	0.10	0.65	0.02	0.15
Proximal Stress and Family Context														
Total Stressors	0.89	0.46	0.17	1.92	.030	0.37	0.09	0.34	3.97***	.186	0.03	0.03	0.07	0.74
Interpersonal Stressors	0.93	0.58	0.14	1.59	.020	0.40	0.12	0.29	3.35**	.165	0.04	0.04	0.08	0.83
Dependent Stressors	1.54	0.59	0.23	2.62*	.053	0.52	0.12	0.36	4.25***	.207	0.04	0.04	0.09	0.94
Familial Emotional Abuse	1.79	1.29	0.13	1.39	.016	0.80	0.27	0.26	2.99**	.150	0.08	0.09	0.08	0.87
Familial Emotional Neglect	-0.36	0.99	-0.03	0.36	.001	0.31	0.22	0.13	1.54	.100	0.04	0.07	0.05	0.59
Family Problems	4.75	1.89	0.23	2.52*	.053	1.34	0.40	0.29	3.33**	.160	0.03	0.14	0.02	0.03

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. Regression analysis for rumination controlled for sex as described in preliminary analysis section. Each row represents a separate analysis.

Table 7. Predictors of Heart Rate Stress Reactivity

	Heart Rate Baseline					Heart Rate Reactivity					Heart Rate Recovery			
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*
Early Life Stress														
Negative Life Events	0.21	0.10	0.19	2.10*	.053	-0.08	0.07	-0.11	1.23	.013	-0.09	0.07	-0.12	1.34
Parenting/Maternal Charachteristics														
Negative Control	0.18	0.17	0.10	1.05	.023	-0.12	0.12	-0.09	0.97	.010	-0.04	0.12	-0.03	0.35
Lax Discipline	-0.01	0.22	-0.01	0.07	.013	-0.25	0.15	-0.17	1.73	.028	-0.17	0.14	-0.11	1.18
Positive Involvement	0.10	0.10	0.09	0.95	.021	-0.12	0.07	-0.16	1.71	.028	-0.12	0.07	-0.16	1.71
Maternal MDD	0.99	2.72	0.04	0.37	.019	2.02	1.67	0.13	1.21	.024	0.01	1.62	0.00	0.01
Proximal Stress and Family Context														
Total Stressors	0.18	0.12	0.13	1.40	.021	-0.09	0.08	-0.10	1.07	.010	-0.17	0.09	-0.14	1.49
Interpersonal Stressors	0.28	0.16	0.16	1.75	.040	-0.19	0.11	-0.09	0.96	.009	-0.22	0.11	-0.18	1.98*
Dependent Stressors	0.25	0.16	0.14	1.51	.034	-0.20	0.11	-0.06	0.68	.005	-0.15	0.11	-.12	1.32
Familial Emotional Abuse	0.77	0.35	0.20	2.22*	.055	-0.21	0.23	-0.02	0.19	.001	-0.32	0.23	-0.13	1.39
Familial Emotional Neglect	0.57	0.27	0.19	2.10*	.051	-0.22	0.18	0.06	0.64	.005	-0.04	0.18	-0.02	0.20
Family Problems	1.22	0.49	0.23	2.46*	.071	-0.23	0.34	-0.03	0.34	.002	-0.37	0.34	-0.10	1.09

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. Regression analysis controlled for age as described in preliminary analysis section. Each row is a separate analysis.

Table 8. Predictors of Cortisol Stress Reactivity

	Cortisol Baseline					Cortisol Reactivity					Cortisol Recovery			
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*
Early Life Stress														
Negative Life Events	0.00	0.00	0.03	0.77	.101	0.00	0.00	0.01	0.10	.011	0.00	0.00	-0.09	1.07
Parenting/Maternal Charachteristics														
Negative Control	-0.01	0.01	-0.21	2.33*	.140	0.00	0.00	-0.06	0.64	.022	-0.01	0.00	-0.25	2.73*
Lax Discipline	-0.01	0.01	-0.14	1.53	.116	0.00	0.01	0.04	0.41	.020	-0.01	0.00	-0.16	1.71
Positive Involvement	0.00	0.00	-0.07	0.75	.101	0.00	0.00	0.01	0.09	.019	0.00	0.00	-0.14	1.50
Maternal MDD	-0.08	0.08	-0.10	0.99	.125	-0.02	0.07	-0.04	0.36	.025	-0.10	0.04	-0.24	2.25*
Proximal Stress and Family Context														
Total Stressors	0.00	0.00	0.02	0.21	.121	-0.00	0.00	-.14	1.50	.031	-0.00	0.00	-0.19	2.01*
Interpersonal Stressors	0.00	0.01	0.02	0.20	.113	-0.01	0.00	-0.13	1.39	.032	-0.01	0.00	-0.20	2.23*
Dependent Stressors	0.00	0.01	0.05	0.57	.115	-0.01	0.00	-0.16	1.75	.041	-0.01	0.00	-0.21	2.24*
Familial Emotional Abuse	0.01	0.01	0.08	0.93	.119	0.00	0.01	-0.04	0.45	.017	-0.01	0.01	-0.11	1.16
Familial Emotional Neglect	0.01	0.01	0.14	1.57	.131	-0.01	0.01	-0.17	0.01	.045	0.00	0.01	0.04	0.37
Family Problems	0.03	0.02	0.19	2.12*	.155	0.00	0.01	-0.03	0.33	.007	0.01	0.01	0.06	0.63

Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for rumination controlled for sex and time of day as described in preliminary analysis section. Each Re represents a separate analysis.

Primary Aim 2: CV and stress reactivity as predictors of depressive symptoms

To examine whether the combined risk of cognitive vulnerability and stress reactivity predicted depressive symptoms, a series of hierarchical regressions were conducted. First, each risk factor was entered individually, with their appropriate covariates, to examine whether each predicted higher levels of depressive symptoms. The main effect analyses revealed that no cortisol variables predicted higher levels of depressive symptoms. An individual's baseline heart rate was significantly predictive of depressive symptoms (Beta = .21, $t = 2.07$, $p < .05$, $R^2 = .04$), such that higher baseline heart rate predicted higher depressive symptoms. In addition, poorer heart rate recovery (Beta = -.18, $t = 1.97$, $p < .05$, $R^2 = .03$) predicted higher levels of depressive symptoms. Finally, a more negative cognitive style (Beta = .38, $t = 4.51$, $p < .001$, $R^2 = .15$), higher levels of rumination (Beta = .45, $t = 5.27$, $p < .001$, $R^2 = .20$), and higher levels of hopelessness (Beta = .29, $t = 3.32$, $p < .01$, $R^2 = .09$) predicted higher levels of depressive symptoms.

The main predictor variables of CV and stress reactivity were mean centered (Aiken & West, 1991) and then, their interaction was entered in an additional step to examine the moderating effect of stress reactivity on the relationship between CV and depressive symptoms after controlling for the relevant covariates. To examine this, we employed an SPSS macro (MODPROBE) to test whether there was a significant interaction (Hayes & Matthes, 2009). As seen in Table 9, a number of regression analyses supported the hypotheses that higher levels of CV, when combined with stress reactivity and recovery, would lead to higher levels of depressive symptoms. More specifically, as seen in Figures 2a and 2b, a less effective cortisol recovery moderated the relationship between more negative cognitive style (Beta = -.17, $t = 2.08$, $p < .05$, $\Delta R^2 = .03$) and high levels of hopelessness (Beta = -3.34, $t = 2.48$, $p < .05$, $\Delta R^2 = .05$)

and higher depressive symptoms. To examine the form of the interaction, follow-up analyses examined the simple slopes of the interaction at one standard deviation above and below the centered mean (Aiken & West, 1991). Analysis revealed that the slope was significant only for poor cortisol recovery ($t = 4.42$, $p < .001$; $t = 3.67$, $p < .001$), for both interactions respectively, and not for better cortisol recovery. In addition, as seen in Figures 2c and 2d, a less effective heart rate recovery moderated the relationship between more negative cognitive style (Beta = -.005, $t = 2.29$, $p < .05$, $\Delta R^2 = .04$) and high levels of rumination (Beta = -.022, $t = 2.75$, $p < .01$, $\Delta R^2 = .05$) and higher depressive symptoms. Similarly, follow up analysis of the simple slopes revealed only a significant slope for poor heart rate recovery ($t = 5.04$, $p < .001$; $t = 5.97$, $p < .001$), for negative cognitive style and rumination respectively, such that high recovery was not significantly different from zero. Finally, as seen in Figure 2e, higher baseline heart rate moderated the association of more negative cognitive style (Beta = .003, $t = 1.98$, $p < .05$, $\Delta R^2 = .03$) with depressive symptoms. The simple slope analysis revealed the slopes were significant for both low and high baseline heart rate ($t = 2.03$, $p < .05$; $t = 5.38$, $p < .001$). Taken together, the findings suggested that individuals with higher levels of a negative cognitive style, rumination, and hopelessness and a poorer ability to recover post stressor had higher levels of depressive symptoms.

Table 9. Interaction of negative cognitive style and stress reactivity predicting depressive symptoms

	Depressive Symptoms			
	β	S.E.	*t*	Δ R^2
Regression 1				0.23***
Negative Cognitive Style	0.06	0.01	4.95***	
Heart Rate Baseline	0.13	0.05	2.55**	
Interaction	.003	.001	1.98*	.030*
Regression 2				0.18***
Negative Cognitive Style	0.06	0.01	4.81***	
Heart Rate Reactivity	-0.11	0.08	-1.38	
Interaction	-.003	.002	-1.37	.010
Regression 3				.21***
Negative Cognitive Style	0.05	0.01	4.05***	
Heart Rate Recovery	-0.20	0.08	-2.52*	
Interaction	-.005	.002	2.29*	.040*
Regression 4				.19***
Negative Cognitive Style	0.06	0.01	4.69***	
Cortisol Baseline	0.72	1.78	0.41	
Interaction	-.052	.037	1.42	.010
Regression 5				.18***
Negative Cognitive Style	0.06	0.01	4.63***	
Cortisol Reactivity	1.45	2.26	0.64	
Interaction	.023	.062	0.33	.001
Regression 6				.21***
Negative Cognitive Style	0.06	0.01	4.47***	
Cortisol Recovery	-1.75	3.07	-.57	
Interaction	-.171	.082	2.08*	030*

Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for Heart Rate included age as a covariate and Cortisol included sex and baseline time. For ease of presentation covariates were excluded from the table. In addition, R2 of the baseline model and interaction model were included. Δ indicates a change in R2 due to the inclusion of the interaction term

Table 10. Interaction of rumination and stress reactivity predicting depressive symptoms

	Depressive Symptoms			
	β	S.E.	*t*	Δ R^2
Regression 1				.24***
Rumination	0.31	0.06	4.88***	
Heart Rate Baseline	0.09	0.05	1.82	
Interaction	.007	.006	1.29	.012
Regression 2				.23***
Rumination	0.32	0.06	5.22***	
Heart Rate Reactivity	-0.09	0.08	-1.09	
Interaction	-.017	.009	1.94	.026
Regression 3				.28***
Rumination	0.32	0.06	5.37***	
Heart Rate Recovery	-0.20	0.08	2.61*	
Interaction	-.022	.008	2.75**	.050**
Regression 4				.23***
Rumination	0.35	0.07	5.23***	
Cortisol Baseline	-0.16	1.77	0.09	
Interaction	-.130	.180	0.74	.003
Regression 5				.23***
Rumination	0.36	0.07	5.37***	
Cortisol Reactivity	2.20	2.29	0.96	
Interaction	.110	.290	0.38	.001
Regression 6				.23***
Rumination	0.35	0.07	5.14***	
Cortisol Recovery	1.60	3.11	0.52	
Interaction	-.130	.390	0.34	.001

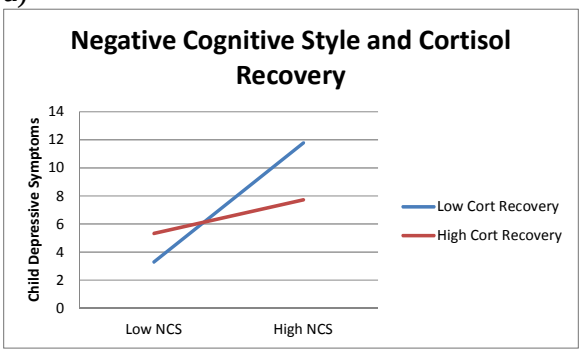
Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for Heart Rate included age as a covariate and Cortisol included sex and baseline time. For ease of presentation covariates were excluded from the table. In addition, R2 of the baseline model and interaction model were included. Δ indicates a change in R2 due to the inclusion of the interaction term

Table 11. Interaction of hopelessness and stress reactivity predicting depressive symptoms

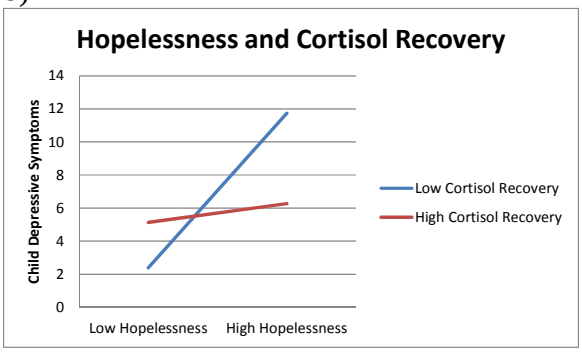
	Depressive Symptoms			
	β	S.E.	*t*	Δ R^2
Regression 1				.12**
Hopelessness	0.58	0.20	2.91**	
Heart Rate Baseline	0.11	0.05	2.05*	
Interaction	-.001	.020	0.03	.000
Regression 2				
Hopelessness	0.75	0.21	3.59***	.12**
Heart Rate Reactivity	-0.08	0.09	0.95	
Interaction	.020	.040	0.54	Δ .002
Regression 3				.12**
Hopelessness	0.64	0.20	3.18**	
Heart Rate Recovery	-0.18	0.08	2.31*	
Interaction	-.020	.030	0.61	.003
Regression 4				.14**
Hopelessness	0.67	0.20	3.41***	
Cortisol Baseline	2.89	1.82	1.59	
Interaction	.920	.670	1.37	.015
Regression 5				.12*
Hopelessness	0.70	0.21	3.39**	
Cortisol Reactivity	-1.66	2.36	0.70	
Interaction	-1.18	.880	1.34	.015
Regression 6				.16**
Hopelessness	0.83	0.22	3.86***	
Cortisol Recovery	-3.36	3.22	1.04	
Interaction	-3.34	1.350	2.48*	.050*

Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for Heart Rate included age as a covariate and Cortisol included sex and baseline time. For ease of presentation covariates were excluded from the table. In addition, R2 of the baseline model and interaction model were included. Δ indicates a change in R2 due to the inclusion of the interaction term

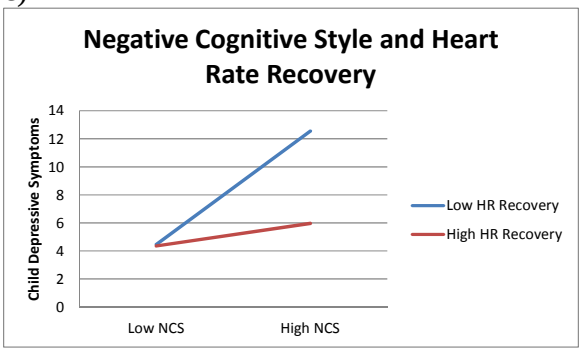
a)



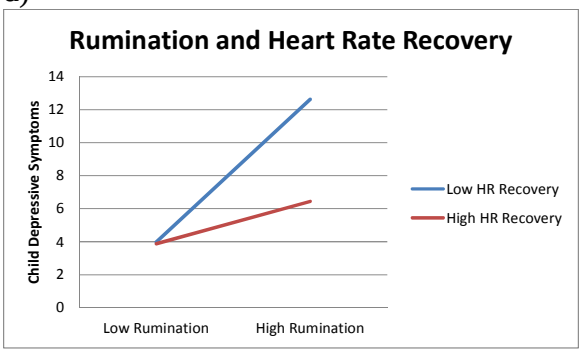
b)



c)



d)



e)

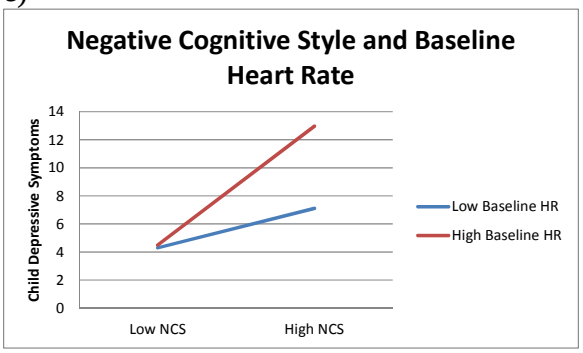


Figure 2. Interactions of CV and Stress Reactivity

Primary Aim 3: CV as predictors of stress reactivity

To examine whether CV predicted physiological stress reactivity, two sets of regression analyses were conducted for heart rate and cortisol reactivity separately. In the first set, heart rate baseline, heart rate reactivity, and heart rate recovery were each regressed on the three CV variables. In the second set of analyses, cortisol baseline, cortisol reactivity, and cortisol recovery were each regressed on the three CV variables. Covariates were entered for each regression as described in the preliminary analyses section.

Table 10 shows the regression analyses examining CVs as predictors of stress reactivity. As shown in the table, only rumination predicted higher levels of baseline heart rate. CVs did not predict either heart rate or cortisol reactivity or recovery after controlling for covariates. To examine whether CVs predicted differences between groups of reactors versus non-reactors to the stressor based on heart rate or cortisol, a series of independent samples t-tests were conducted. Measures of negative cognitive style, rumination, and hopelessness did not distinguish between individuals who reacted to the social stressor based on heart rate or cortisol or not. The absence of associations between CVs and physiological stress reactivity precluded many of the proposed additional analyses examining the mediating effects of stress reactivity in the relationship between CV and depressive symptoms.

Table 12. Cognitive vulnerability predicting stress reactivity

	Heart Rate Baseline					Heart Rate Reactivity					Heart Rate Recover			
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*
Cognitive Vulnerabilities					.115					.018				
Negative Cognitive Style	-0.03	0.03	-0.11	1.13		-0.01	0.02	-.04	0.33		0.00	0.02	0.01	0.05
Rumination	0.25	0.12	0.20	2.09*		0.05	0.09	0.06	0.53		-0.15	0.09	-0.20	1.81
Hopelessness	0.44	0.36	0.11	1.22		-.22	0.26	-0.08	0.83		0.36	0.25	0.14	1.43
	Cortisol Baseline					Cortisol Reactivity					Cortisol Recovery			
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*
Cognitive Vulnerabilities					.159					.053				
Negative Cognitive Style	0.00	0.00	0.11	1.10		0.00	0.00	-0.05	0.53		0.00	0.00	0.14	1.36
Rumination	0.01	0.00	0.13	1.27		-0.01	0.00	-0.18	1.64		0.00	0.00	-0.20	1.93
Hopelessness	-0.01	0.01	-0.06	0.65		0.01	0.01	0.09	0.92		0.00	0.01	0.03	0.28

Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for HR included age as a covariate. Regression analysis for Cortisol included sex and baseli
a covariate as described in preliminary analysis section.

Exploratory Aim 1: Examination of stress reactivity as a mediator between the relationship of CV and depressive symptoms.

In Primary Aim 3, regression analyses examined cognitive vulnerabilities as predictors of stress reactivity and recovery. Findings suggested that a negative cognitive style, rumination, and hopelessness generally did not predict differences in heart rate and cortisol baseline, reactivity, and recovery. Only rumination predicted higher baseline heart rate levels. To examine whether higher baseline heart rate mediated the association of rumination with adolescents' depressive symptoms, we employed an SPSS macro (INDIRECT) to test the significance of the indirect effect with a bootstrapping approach to obtain confidence intervals (Hayes, 2012). Using the macro, we estimated the effect of rumination on adolescent depressive symptoms directly as well as indirectly, through baseline heart rate. Bootstrapping is superior to other common methods for determining the significance of indirect effects, as the assumption of normality for the sampling distribution is not required and power is improved (Preacher & Hayes, 2004). The macro generated bias-corrected 95% bootstrap confidence intervals using 5,000 bootstrap samples for the conditional direct and indirect effects of rumination at the mean and ± one standard deviation from the mean.

Consistent with the regression analysis, in this model, rumination predicted higher levels of depressive symptoms directly (Beta = .31, $t = 4.98$, $p < .001$). Importantly, within the model, rumination did not predict higher levels of baseline heart rate (Beta = .19, $t = 1.71$, $p > .05$) and higher baseline heart rate did not predict higher depressive symptoms (Beta = .09, $t = 1.82$, $p > .05$). Finally, as expected based on these main effects results, the indirect effect of rumination through baseline heart rate was not significant (Estimate .018, SE = .015, CI -.001 - .059). Taken together, no stress reactivity variable mediated the relationship between CV and depressive

symptoms in this sample.

Exploratory Aim 2: Examine gender and racial differences.

To examine gender and racial differences in the relationship between vulnerability factors and depressive symptoms, a series of regression analyses were conducted. First, gender and race were entered individually, with their appropriate covariates, to examine whether each predicted higher levels of any risk factor. As seen in Table 11, the main effect analyses revealed females had higher levels of rumination (Beta = .25, $t = 2.87$, $p < .01$), lower levels of baseline cortisol (Beta = -.23, $t = 2.64$, $p < .01$), and higher cortisol recovery (Beta = -.23, $t = 2.55$, $p < .05$) than males. In addition, Caucasian participants had higher negative cognitive styles (Beta = .21, $t = 2.34$, $p < .05$) than African-American participants.

Table 13. Gender and Racial Main Effect Differences

	Heart Rate Baseline					Heart Rate Reactivity					Heart Rate Recovery				
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2
Predictor															
Female	3.49	1.99	0.15	1.75	.080	-0.04	1.36	-0.00	0.03	.016	-0.13	1.35	-0.01	0.09	.00
White	-0.97	2.13	-0.04	0.45	.063	1.82	1.43	0.12	1.27	.029	1.39	1.53	0.09	0.98	.01
	Cortisol Baseline					Cortisol Reactivity					Cortisol Recovery				
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2
Predictor															
Female	-0.16	0.06	-0.23	2.64**	.101	0.02	0.05	0.04	0.44	.011	-0.09	0.04	-0.23	2.55*	.05
White	-0.03	0.06	-0.04	0.48	.049	0.00	0.05	0.00	0.01	.009	0.01	0.04	0.04	0.38	.00
	Negative Cognitive Style					Rumination					Hopelessness				
	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2	β	S.E.	Beta	*t*	R^2
Predictor															
Female	-5.22	7.72	-0.06	0.67	.004	4.68	1.63	0.25	2.87**	.060	0.20	0.54	0.03	0.37	.00
White	17.79	7.58	0.21	2.34*	.042	0.46	1.69	0.03	0.27	.001	0.62	0.54	0.10	1.14	.01

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. Regression analysis for HR included age as a covariate. Regression analysis for Cortisol included baseline time as a covariate as described in preliminary analysis section.

To examine whether gender or race moderated the relationship between either CVs or stress reactivity variables and depressive symptoms, we employed an SPSS macro (MODPROBE) to test whether there were significant interactions involving either gender or race and the regions of significance (Hayes & Matthes, 2009) in the same way as for Primary Aim 2. As seen in Tables 12a and b, two regression analyses supported our hypotheses of gender differences, such that higher levels of rumination and less effective cortisol stress recovery interacted with gender to predict higher levels of depressive symptoms. More specifically, as seen in Figure 3a, girls with higher levels of rumination had higher depressive symptoms compared to boys (Beta = .31, $t = 2.44$, $p < .05$, $\Delta R^2 = .04$). Follow-up analyses revealed that the simple slope was significant only for girls (GIRLS: $t = 5.52$, $p < .001$; BOYS $t = 1.73$, $p > .05$), suggesting that rumination was not a significant predictor of depressive symptoms in boys. In addition, as seen in Figure 3b, girls with a less effective cortisol recovery had higher levels of depressive symptoms compared to boys (Beta = -13.22, $t = 1.97$, $p < .05$, $\Delta R^2 = .03$). Follow-up analyses, however, revealed that although the slope for boys and girls differed, neither slope was statistically different from zero (GIRLS: $t = 1.46$, $p > .05$; BOYS $t = 1.33$, $p > .05$).

Table 14. Interaction of Gender and Race on vulnerability factors predicting depressive symptoms

	Female				White			
	β	S.E.	*t*	Δ R^2	β	S.E.	*t*	Δ
Regression 1				.052				.0
Demographic	1.13	1.25	0.91		-.01	1.31	0.01	
Heart Rate Baseline	0.12	0.06	2.15*		0.13	0.06	2.27*	
Interaction	.020	.112	0.20	.000	-.006	.110	0.05	.0
Regression 2				.024				.0
Demographic	1.69	1.26	1.34		-.03	1.34	0.02	
Heart Rate Reactivity	-.07	0.09	0.86		-.05	0.09	0.53	
Interaction	.026	.181	0.14	.000	.107	.203	0.52	.0
Regression 3				.043				.0
Demographic	1.33	1.24	1.08		-.15	1.32	0.11	
Heart Rate Recovery	-.17	0.08	1.96*		-.16	0.08	1.92	
Interaction	-.031	.171	0.18	.000	-.009	.170	0.06	.0
Regression 4				.038				.0
Demographic	1.83	1.29	1.41		-.01	1.28	0.01	
Cortisol Baseline	1.95	1.98	0.99		0.72	1.88	0.39	
Interaction	4.720	3.920	1.20	.013	-.606	3.730	0.16	.0
Regression 5				.039				.0
Demographic	1.43	1.26	1.13		0.03	1.28	0.03	
Cortisol Reactivity	-.04	2.41	0.02		0.43	2.43	0.18	
Interaction	7.28	4.830	1.51	.020	6.880	4.860	1.42	.0
Regression 6				.058				.0
Demographic	1.58	1.30	1.21		0.02	1.30	0.02	
Cortisol Recovery	0.39	3.35	0.12		-1.77	3.31	0.53	
Interaction	-13.22	6.69	1.97*	.034	-2.69	6.66	0.41	.0

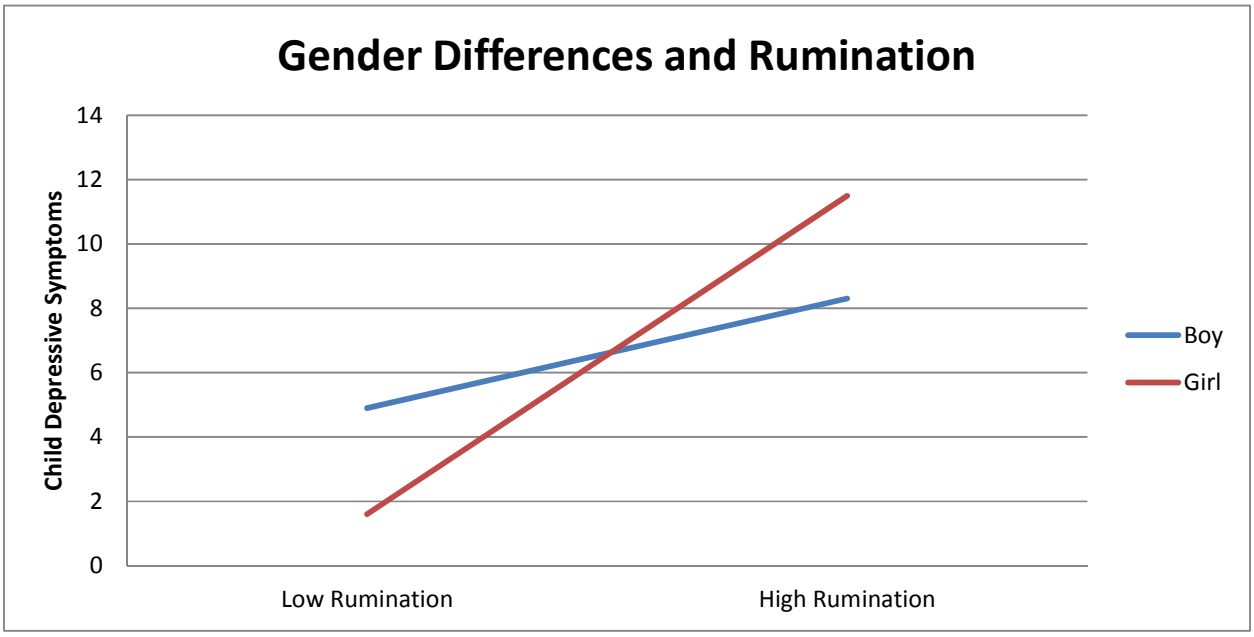
Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for Heart Rate included age as a covariate and Co included sex and baseline time. For ease of presentation covariates were excluded from the table. In addition, R the baseline model and interaction model were included. Δ indicates a change in R^2 due to the inclusion of the interaction term

Table 14. Interaction of Gender and Race on vulnerability factors predicting depressive symptoms

	Female				White			
	β	S.E.	*t*	Δ R^2	β	S.E.	*t*	Δ
Regression 7				.181				.16
Demographic	1.68	1.12	1.49		-.97	1.15	0.84	
Negative Cognitive Style	0.06	0.01	4.69***		0.07	0.01	4.85***	
Interaction	.046	.026	1.76	.021	-.05	.027	1.65	.01
Regression 8				.242				.20
Demographic	-.13	1.14	0.11		0.21	1.14	0.18	
Rumination	0.30	0.06	4.79***		0.33	0.06	5.33***	
Interaction	.306	.125	2.44*	.039	-.04	.130	0.29	.00
Regression 9				.102				.08
Demographic	1.23	1.16	1.06		-.59	1.18	0.50	
Hopelessness	0.63	0.19	3.31**		0.66	0.19	3.31**	
Interaction	.360	.380	0.93	.007	-.13	.390	0.34	.00

Note: * p < .05, ** p < .01, *** p < .001. Regression analysis for Heart Rate included age as a covariate and Co included sex and baseline time. For ease of presentation covariates were excluded from the table. In addition, R the baseline model and interaction model were included. Δ indicates a change in R^2 due to the inclusion of the interaction term

a)



b)

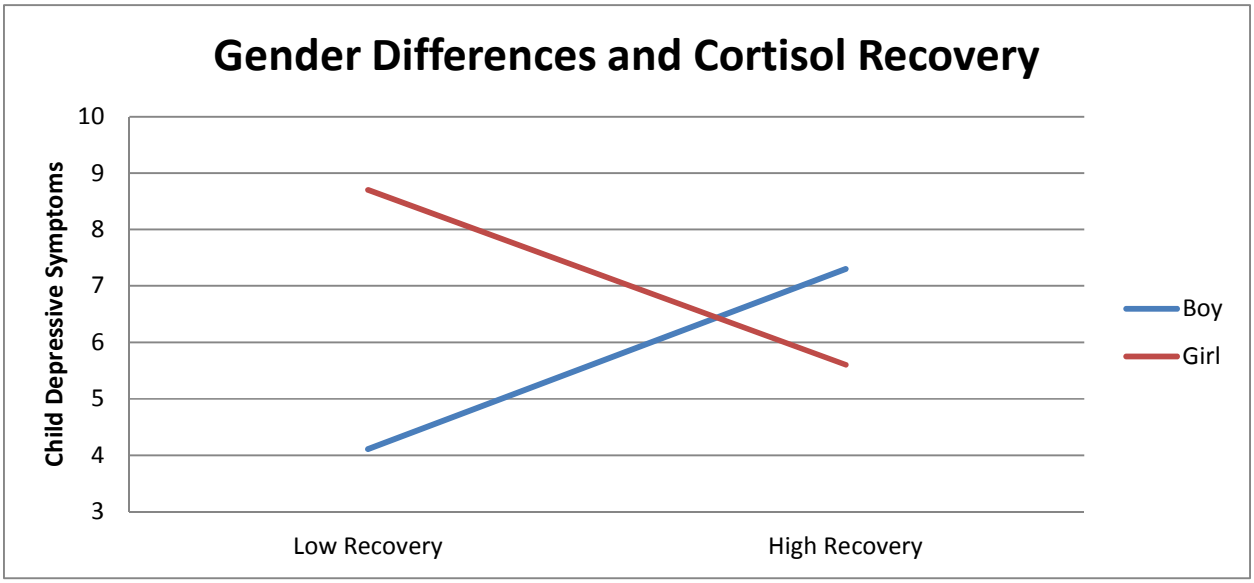


Figure 3. Gender moderates risk factors in predicting depression.

CHAPTER 4

DISCUSSION

The primary aims of the current study were to examine the developmental antecedents of and relationship between two known risk factors for depression. Linking cognitive and biological aspects of reactivity to stress is integral in more fully understanding mechanisms that may place individuals at a higher risk for the development of depression and a worse course once developed. Importantly, this study examined these risk factors in the pivotal developmental period of adolescence. Adolescence is a period rife with changes in life circumstances and increases in both stressful life events (Ge et al., 1994) and the onset of depression (Hankin et al., 1998). Additionally, depression that occurs during adolescence is likely to continue or recur in adulthood, making this period an important time to examine further.

The first primary aim was to examine the developmental antecedents of both cognitive and biological aspects of stress reactivity. Prior research highlights that these two risk factors share a number of precursors including early negative life experiences (Shapero & Alloy, under review). We examined a number of early life stressors including measures of cumulative stressful life events, maternal depression history, and maternal parenting styles. In addition, we examined several more proximal predictors including recent stressful life events (total, interpersonal, and dependent), familial emotional abuse and neglect, and family problems. Cognitive vulnerabilities largely were predicted only by more proximal stressors and not by early life events. Specifically, higher levels of rumination and more negative cognitive styles were predicted by higher levels of dependent stressors and family problems. In addition, higher rumination was predicted by greater interpersonal stressors and familial emotional abuse. Research has shown that family context is predictive of a ruminative style in adolescence (Hilt,

Armstrong, & Essex, 2012). Hilt and colleagues (2012) found that the effects of early family context were moderated by temperament in predicting higher levels of rumination in adolescence. Importantly however, we did not find that early life experiences predicted the development of these cognitive risk factors. In addition, contrary to hypotheses, hopelessness was not predicted by any early life or proximal predictors.

These findings generally are consistent with prior studies examining developmental antecedents of cognitive styles (Hankin et al., 2009). Importantly, few studies have examined the origins of cognitive vulnerabilities in an adolescent sample. Whereas studies of adults have shown that early life stress (Gibb, Abramson & Alloy, 2004) and maternal/parenting characteristics (Alloy et al., 2001) are predictors of cognitive vulnerabilities, relatively few studies have found similar results in an adolescent sample (e.g., Mezulis, Hyde, & Abramson, 2006). The lack of studies focused on predicting cognitive styles in the adolescent years may be due, in part, to the lack of stability of these constructs at this time (Cole et al., 2008; Hankin, 2008). A recent review suggests that adolescence is a time of possible stabilization of these cognitive vulnerabilities, but notes that there is still significant fluctuation that occurs (Hankin et al., 2009). For example, Mezulis, Hyde, and Abramson (2006) found that temperament and parenting styles predicted increases in a more negative cognitive style in early adolescents only when they were moderated by the experience of negative life events. In addition, Garber and Flynn (2001) found that stressful life events predicted negative cognitions beyond maternal depression. Consistent with these findings, the current study found that more proximal stressors elicited higher levels of rumination and a negative cognitive style. This suggests, that during adolescence, recent stressful life events may be more predictive, or even needed in order to prime a more negative cognitive reaction to events.

In addition, we examined predictors of both autonomic and endocrine reactivity to a laboratory social stress task. Adolescents' resting heart rate was higher for individuals with higher levels of early life stress. In addition, adolescents who more recently experienced higher levels of stressors, familial maltreatment, and family problems also evinced higher resting heart rates. Only interpersonal stressors predicted poorer heart rate recovery, suggesting that social stressors may impede the effective regulation of the stress system as will be discussed below. Adolescents' resting levels of cortisol were predicted by higher levels of family problems and lower levels of maternal negative control-type parenting. Additionally, poorer cortisol recovery was predicted by higher levels of maternal negative control and maternal depression, which supports prior research (Roismen et al., 2009). Similar to the autonomic recovery, endocrine recovery also was impeded by higher levels of proximal interpersonal and dependent stressors. Relatively few research groups have examined the coherence between the fast acting autonomic system and the slower endocrine response. For example, in one study of at risk girls, researchers found similar differences between autonomic and cortisol responses to stress based on maternal depression history, but did not test these at the same time (Waugh et al., 2012). The current study only found significant predictors of the recovery period in both response systems, but not in the reactivity component of these stress systems. And indeed, the expected proximal risk factors predicted similarly poorer regulation of these systems based on recent stressors, thus adding to the literature that both systems may be affected by similar individual differences. Additionally, proximal stressors predicted higher levels of resting heart rate and cortisol, which is most comparable to prior research examining cortisol awakening response curves (Chida & Steptoe, 2009). Higher levels of these systems may be suggestive of a priming of these stress responses or perhaps a heightened level of general arousal. Interestingly, by and large, proximal stressors

predicted more differences in cognitive and biological stress responses compared to earlier life history factors, suggesting a salience for recent events.

An examination of the autonomic and endocrine reactivity and regulation to the TSST revealed two prominent patterns of response. Many adolescents displayed the expected rise and fall in response to the social stressor, whereas other adolescents had a more blunted, non-response to the social stressor. These findings are similar to prior studies that have found a non-response pattern to social stressors based on various risk factors (Harkness et al., 2011; Waugh et al., 2012). Consistent with prior studies (Harkness et al., 2011), the current study found that higher levels of early life maltreatment predicted a more blunted response to the social stressor, suggesting a dampened cortisol response. Conversely, individuals with higher levels of proximal familial emotional abuse were more likely to have a reactive autonomic system. Importantly, there were no differences in reported distress based on those who biologically responded versus non-responded to the task. Interestingly, these two stressors are similar in nature but different in timing. To postulate, early life stress (i.e., maltreatment) is a distal predictor that may lead to overall dysregulation of the stress system and a different trajectory of reactivity to stressors. These findings are similar in nature to prior studies showing a blunting response based on severe forms of early stress (e.g., Harkness et al., 2011). In contrast, proximal stressors may prime an individual to react to stressful events more strongly. Overall, this may suggest that the effect of familial maltreatment may depend on the timing of its occurrence.

The findings of different patterns of response are consistent with biological mechanisms related to stress reactivity. The adaptive goal of the stress system is to effectively react to a stressor (i.e., allocate appropriate biological resources to combat the stressor) and then effectively return to homeostasis (i.e., quickly re-regulate after the stressor is gone). The net

effect of cortisol that is excreted into the blood stream acts as a signal to return to homeostasis. Dysregulation in the stress system can occur both at the reactivity phase, as well as the regulation phase, of the stress response. Both heightened reactivity (e.g., Guerry & Hastings, 2011; Hankin et al., 2010) and poor regulation (e.g., Barden et al., 1995; Ising et al., 2005) are related to MDD. For individuals with a maltreatment history, a blunted cortisol response suggests that lower levels of cortisol are being excreted into the blood stream upon initial response to the stress and may thus be less effective in shutting off the HPA response system (i.e., a more prolonged exposure to cortisol), while the fight or flight response, which is indicative of increases in heart rate, remains unaffected.

Although, to date, the majority of studies examining the stress response and regulation focus on the HPA system, the relationship between the HPA axis and autonomic nervous system (ANS) remains an important area of inquiry. The ANS and HPA axis produce similar effects, but accomplish these effects differently. The ANS is a fast acting response to a stressor that diverts biological resources (ie., heart rate, energry resources, respiration) to combat the stressor, whereas the HPA is slower acting and acts to re-regulate after a stressor. Even though these systems are activated by the same event, some studies support asymmetries between the ANS and HPA in response to stress among youth (Spear, 2009). Importantly, few studies use measures of both systems to study risk for depression, which may be informative to more completely understand the dynamic interplay between patterns of stress-induced physiological activation and regulation. Further research is needed to understand the similarities and differences in responses to stressors. Risk factors, such as maltreatment, may affect different levels of arousal (e.g., initial response, regulation of the system). The current study found some similarities and differences in these systems, yet more research is needed. Importantly, the differential patterns of response to

the stressor in the current study, with some individuals evincing a blunted response and others showing the expected reactivity may affect overall statements predicting to the reactivity of these systems. Because some individuals have a rise in ANS and HPA response to the stressor and some have a decline, the net effect may average to a less pronounced slope and thus limit prediction.

The second primary aim, and most important contribution to the literature, examined the combined effects of cognitive and biological risk factors for depression. This study provided a novel test of the relationship between CV and stress reactivity that has not been examined previously in the literature and hypothesized that maladaptive cognitive styles and a more maladaptive biological stress response would be associated with greater depressive symptoms. Both cognitive vulnerabilities and stress reactivity have been established as risk factors for the onset of depression, yet the integration of these two vulnerabilities remains underdeveloped. As expected, we found that adolescents with higher levels of CV and more maladaptive stress response evinced higher depressive symptoms.

Moreover, each of the cognitive vulnerabilities interacted with either autonomic or endocrine system recovery to predict depressive symptoms, such that adolescents with both maladaptive cognitive styles and poorer stress recovery exhibited higher depressive symptoms. Importantly, our findings suggest that only a poorer recovery of the stress system, but not the reactivity component, amplifies the effects of cognitive styles on depressive symptoms. Consistent with recent reviews evaluating the importance of understanding physiological reactivity to stress, this study highlights the impact of an individual's interpretation or appraisal of events, which may modulate the biological reaction to stress (Obradovic, 2012; Denson, Spanovic, & Miller, 2009). In line with this appraisal theory, the perseverative cognition

hypothesis (Brosschot, Gerin, & Thayer, 2006) suggests that repetitive, intrusive thoughts may amplify, maintain, or reactivate physiological responses to stress. Recent research examining this relationship has focused on rumination and stress reactivity (Zoccola & Dickerson, 2012). Studies that have examined the relationship between rumination and cortisol levels found that higher levels of rumination predicted greater increases in the cortisol awakening response (Zoccola, Dickerson, & Yim, 2011) and greater cortisol reactivity to a psychosocial laboratory stressor (Zoccola, Quaz, & Yim, 2010; Denson Fabiansson, Creswell & Pedersen, 2009). Findings from the current study extend this research and show that a more negative cognitive style and hopelessness in addition to rumination, when combined with poorer biological recovery, leads to higher levels of depressive symptoms, thus suggesting that not only the reactivity component but also a lack of recovery may maintain or exacerbate the negative effects of stress. These findings were robust to the specific type of biological recovery mechanism and suggest a coherence between the effects of a maladaptive autonomic and endocrine recovery to stressful events. Both poor heart rate recovery and poor cortisol recovery amplified the negative effects of a maladaptive cognitive style. The integration of cognitive and biological aspects of stress response demonstrates synergistic risk for depression and may be an important target for future research and intervention.

These findings are also consistent with biological models of depression (e.g., Holsboer, 2000). As discussed, research has found a consistent association between HPA dysregulation and MDD. The dexamethasone test is an established measure to detect functional alterations in the HPA system and has been used to determine how the HPA system is related to depression (Ising et al., 2005). Dexamethasone is a synthetic drug that mimics the reactivity of cortisol. After administration, individuals with a normal functioning HPA axis will suppress the excretion

of cortisol (reduced levels) because this drug binds to the receptor sites that inhibit its production. Researchers have given this drug to those with and without depression, and have found that those with MDD do not effectively suppress cortisol after administration (e.g., Hoslboer, 1983). Importantly, this research highlights that the HPA dysregulation occurs at the glucocorticoid receptors (GR), which inhibit the further secretion of cortisol. That is, MDD is associated with reduction in the efficiency of GR and the negative feedback and recovery of the stress system (Ising et al., 2005). Indeed, researchers have suggested that treatment for depression, using antidepressants, primarily stabilizes mood through acting on the HPA system directly (Barden, Reul, & Hoslboer, 1995) and may be a good indicator for treatment response (Ising et al., 2005). The current findings show that a poorer recovery of the stress system increases the association between cognitive vulnerabilities and depressive symptoms. This is consistent with the effects of a more negative cognitive style. In that, if an individual continually re-experiences a negative event (rumination), perceives an event as negatively affecting their sense of self (i.e., negative cognitive style), or finds it to lead to hopeless thoughts, and are not able to physically regulate their response to the event, then they are at a heightened risk for maladaptive outcomes. The current findings suggest that there is a relationship between cognitive and biological risk factors for depression and their interplay may be particularly pernicious.

We further examined the relationship between cognitive vulnerabilities and stress reactivity by investigating whether one's cognitive styles predict a more maladaptive stress response. In line with the appraisal hypothesis (Lazarus & Folkman, 1984), the perception of an event as stressful may lead to a biological response to stress and be the mechanism through which negative cognitions lead to depressive symptoms. Indeed, Schlotz and colleagues (2011)

found that individuals who perceive themselves as reactive to stress also exhibited a heightened cortisol response in a sample of young men. Additionally, a recent study has found that rumination, the tendency to repetitively brood about depressive feelings and events, led to an impaired cortisol recovery in a sample of adolescents (Stewart et al., 2013). The current study failed to show that higher levels of a negative cognitive style, rumination, or hopelessness led to biological stress reactivity or recovery, which precluded an examination of the mediating effects of biological response to stress in the relationship between cognitive styles and depression. Other prominent theories suggest that stressors trigger a simultaneous response both biologically and emotionally (Cannon, 1927), which may suggest that these systems are not temporally related. Additionally, the James-Lange theory (1984) proposes the opposite effect than the one hypothesized here, in that an event triggers a biological reactivity to stress, which is then interpreted by the individual. Taken together, findings suggest that the biological system may amplify the effects of negative cognitions and be a combined risk, as opposed to the mechanism through which cognitions lead to depression.

Finally, we explored whether there were gender differences in the risk factors and whether these gender differences predicted increases in depressive symptoms. Adolescence marks the beginning of the gender gap in prevalence of MDD (Hankin et al., 1998) and theoretical models suggest that a central component to the development of these differences is the gender variability in vulnerability-stress models (Hankin & Abramson, 2001; Hyde, Mezulis, & Abramson, 2008). Many studies report that girls are generally more reactive to stress than boys during adolescence psychologically (Hankin et al., 2007; Rudolph & Hammen, 1999; Shih et al., 2006) and findings have demonstrated sex differences in adults suggesting that women are more vulnerable to HPA-dysregulation than men in response to stressors (Bagley, Weaver, &

Buchanan, 2011; Kudielka & Kirshbaum, 2005). The present study's findings showed some differences based on gender. Consistent with prior research (Johnson & Whisman, 2013), girls had signifcantly higher levels of rumination compared to boys. Additionally, girls with higher levels of rumination had higher levels of depressive symptoms, whereas boys with higher levels of rumination did not have higher depressive symptoms compared to boys with low rumination. This gender interaction suggests that rumination may be a specific risk factor for girls during adolescence. Findings also suggested that boys have higher resting cortisol levels, consistent with literature suggesting that sex hormones may alter the HPA-axis response (Oldenhinkel & Bouma, 2011). Although a heightened basal cortisol level in boys may be counter-intuitive given the gender differences seen in psychological response to stressors and depressive symptoms during adolescence, it has been suggested that girls' overall HPA-axis may be dysregulated (Oldenhinkel & Bouma, 2011) and may be dependent on the nature of the stressors that occur. Consistent with this intepretation, gender differences interacted with a poor cortisol recovery to predict depressive symptoms. Girls with poor recovery of their HPA-axis had significantly higher levels of depressive symptoms compared to boys with poor recovery. No differences were found between boys and girls for those adolescents with better biological recovery.

The current study also examined whether there were racial differences in risk factors during adolescence. Few studies have examined racial differences in cognitive and stress reactivity (e.g., Rausch, Aurbach, & Gramling, 2008). Findings suggest that Caucasian adolescents had significantly more negative cognitive styles compared to African American teens. However, this racial difference did not predict differences in depressive symptoms in the current study. There were no racial differences in biological reactivity to stressors which, when combined with earlier reported findings, suggest that proximal and distal stressors are more

important predictors of differences in response to stress than race.

Several points may be noted regarding the current findings. First, relatively few early life factors predicted higher levels of cognitive vulnerability and biological stress reactivity. The measure of early life stress employed in the current study is limited in the examination of severe forms of childhood stressful events and a more complete interview of childhood adversity (e.g., Harkness et al., 2011) may be beneficial to capture shared developmental antecedents of one's development of a maladaptive response to stress. Also worth noting is that, although past research and theory suggests that cognitive processes may lead to biological responses to stress (Dickerson & Kemeny, 2004), the current findings do not support the notion that cognitive vulnerabilities predict increased physiological reactivity to stress. Importantly, the constructs of CV tested were not domain specific to the type of social stressor employed to elicit biological reactivity and a more nuanced approach may be necessary to understand the mechanisms through which this relationship occurs. For example, Schlotz and colleagues (2011) employed questionnaires that examined domain specific perceptions of stress, and found that the way in which individuals perceive their reactivity to specific stressors may lead to a more maladaptive biological response. Finally, the individual differences in the patterns of the cortisol and heart rate responses may have contributed to the failure to find early life predictors of stress reactivity and the prediction of biological reactivity by cognitive style. Research suggests that chronic levels of stress may dampen or blunt one's reactivity to proximal stressors. Overall, reactivity and effective regulation in response to stressors is expected, but general non-reactivity to stress may pose a particular risk for poor outcomes. The current study did not assess forms of chronic stress that may help elucidate factors that led to the differing patterns of biological stress reactivity observed.

Findings from the current study should be interpreted through the lens of several strengths and limitations. The current study was comprised of participants from a community sample of diverse backgrounds both racially and economically. This builds upon prior research that has generally examined cognitive and biological stress reactivity in primarily Caucasian samples. Additionally, a community sample enhances the generalizability of our findings and extends prior studies that have focused on comparisons of selected individuals based on psychopathology or specific maladaptive risk factors. Additionally, this study employed the gold standard of social stress tasks in a sample of adolescents to elicit a stress response in the social domain. Importantly, the majority of prior studies have examined stress response using only measures of cortisol; thus, the current study provides an important advance by allowing for the comparison of responses in the autonomic and endocrine systems. Finally, the current study examined a number of distal and proximal risk factors for the development of cognitive and biological stress reactivity.

The present findings, however, also must be interpreted within the context of its limitations. First, a power analysis based on a power of .80 and an $\alpha = .05$ (one-tailed) was conducted using G-Power. As Gunnar, Talge, and Herrera (2009) noted in their review of the effect sizes of stress paradigms in developmental studies, it is nearly impossible to quantify effect sizes as most data appear in graphs, and at times, only the significance and direction of the effects are noted. Although no studies to date have examined the relationship between CVs and stress reactivity, the best estimates from the existing literature suggest a small to moderate effect size (Chida & Hamer, 2008). Therefore, a relatively conservative estimate that the effect size is somewhat less than moderate, with $\alpha = .05$, suggests a sample size of 110 is needed. Importantly, because of the differing patterns of stress response (reactive vs. blunting) observed in

participants, a suppressor effect may have impeded finding predictors of differences in stress reactivity. Nevertheless, the results showed differences in the predictive power of the recovery of the biological systems. This study also included a large number of analyses, particularly in the prediction of CV and stress reactivity that would often require an adjustment to address issues of multiplicity (e.g., a Bonferroni correction). However, a Bonferroni correction was considered overly conservative, given concerns about power to detect effects. Thus, it is critical to emphasize that results warrant replication before serving as the basis for firm theoretical or clinical conclusions. Although this study included a rigorous diagnostic interview of maternal depression, this study largely relied upon self-report questionnaires, which are subject to reporter bias, similar to other studies in examining differences in cognitive style. Nevertheless, response to the social stressor was measured with biological indicators, which are not subject to reporter bias. The use of stress interviews and interviews of early childhood stress will be helpful for future studies to disentangle subjective reporter bias (Hammen et al., 1986; Monroe & Reid, 2008). Finally, the current study focused on prediction of symptoms of depression; however, it would be beneficial to examine diagnostis of depressive episodes in future studies.

Conclusions and Clinical Implications

Despite some limitations, the current study provided an important methodological and theoretical advancement in the body of literature examining risk factors for depression and stress reactivity. Whereas cognitive vulnerabilities and physiological stress reactivity have been examined individually and shown to be risk factors for depression, the relationship between these risk factors was unclear. From the evidence presented, it appears that in many cases these aspects of reactivity may operate synergistically in the development of depression and that the lack of physiological recovery may amplify the negative effects of different cognitive styles.

General theories of the relationship between these systems have begun to integrate these factors. Denson, Spanovic, and Miller (2009) proposed an integrated model based on their review of social stress research. They suggested a coherence between appraisal and physiological responses to stressors. Importantly, the relationship between maladaptive responses to stress is complex and research and theoretical models are still needed to help elucidate the process that may lead to the development of depression.

Research examining these processes has implications for clinical treatment and early intervention. The joint effects of cognitive and biological reactivity can enhance our understanding of these aspects of reaction to stressful events and lead to more personalized treatment. Personalized treatment is underway to compare the effects of medicine and psychotherapy (Cuijpers et al., 2012), yet this same model also can compare the effects of treating the different aspects of stress reactivity. Evidence from this study suggests that one's lack of physiological recovery may lead to a more negative effect of cognitive vulnerabilities, which suggests that clinicians may need to target both cognitive styles as well as methods to re-regulate physiologically. Specifically, clinicians may bolster a youth's coping strategies for responding to stress, such as utilization of social support and positive cognitive appraisals as well as mindfulness techniques to control physiological responses (Compas, 1987; Compas et al., 2001; Biegel et al., 2009). Research highlights the importance of cognitive reappraisal as an important skill to cognitively regulate one's emotions as opposed to expressive suppression that may prolong one's negative state (Lam et al., 2009). In fact, research has found that internal abilities of coping and cognitive hardiness buffer against the effects of life stress (Beasley, Thompson, & Davidson, 2003). Approaches that incorporate mindfulness and relaxation strategies may be particularly relevant to the regulation of physiological reactivity to stress that

may reduce the prolonged feelings associated with stressful events. Additionally, recent research highlights the importance of implementing interventions that consider the unique and potentially beneficial role of exposure to stress, such as Stress Inoculation Training (SIT), which may help individuals cope with stressful events as well as "inoculate" individuals to future stressors (Meichenbaum, 1996).

Overall, the results from the current study provide a more nuanced understanding of the relationship between different stress responses and moves beyond past research efforts. Importantly, in past decades, research has found support for the interrelationship between these reactions to stress (Campbell & Ehlert, 2012; Denson et al., 2009), yet a more complete understanding of these stress response systems will help to understand the onset and maintenance of depression. Further work examining the intricacies and mechanisms that underlie the diathesis-stress models for depression can help researchers and clinicians understand the risk associated with one's reaction to stress. Additionally, it will be important for future work to examine the developmental trajectories of these reactivity components over time to predict episodes of depression during this developmentally salient period.

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