BEHAVIORAL DISINHIBITION AND CORTISOL REACTIVITY AS A FUNCTION OF PSYCHOSOCIAL STRESS AND PERSONALITY IN ADOLESCENTS

BY

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THESIS

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ABSTRACT

Although the developmental period of adolescence is characterized by impulsive and risk-taking behaviors, explanations for the range of behavioral disinhibition across adolescents that include biological, personality, and environmental factors have not been fully elucidated. Additionally, these factors may affect changes in stress responses that occur during this period. To inform this area of research, we examined the interaction between psychosocial stress exposure and the personality traits of Negative Emotionality (NEM) and Constraint (CON) on behavioral disinhibition (as indexed by impulsivity and riskiness tasks) and salivary cortisol reactivity in a sample of 88 adolescents. Results demonstrated that NEM and CON were protective of impulsivity and riskiness, respectively, for adolescents in the no-stress condition. Importantly, low CON adolescents in the no-stress condition were more risky than low CON adolescents in the stress condition, while there was no effect of Stress Group for high CON adolescents. Further, low CON adolescents exposed to psychosocial stress exhibited greater cortisol reactivity compared to high CON adolescents, suggesting that individuals low in CON may mobilize greater resources (e.g., cortisol reactivity, cognitive control) in stressful relative to non-stressful situations. Results suggest that distinct facets of behavioral disinhibition are differentially affected by stress and personality traits in adolescents.

To My Family

ACKNOWLEDGMENTS

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CHAPTER 1: INTRODUCTION

Behavioral disinhibition, defined as the inability to resist expressing behavior (Young, Stallings, Corley, Krauter, & Hewitt, 2000), is manifested through impulsive, sensation-seeking, and risk-taking actions (Anderson, Smith, & Fischer, 2003; Dindo, McDade-Montez, Sharma, Watson, & Clark, 2009; Leeman, Grant, & Potenza, 2009). Behavioral disinhibition has been characterized as a generalized vulnerability for psychopathology throughout the lifespan (for a review, see Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001) and is a particularly strong risk factor for many problematic behaviors in children and adolescents, such as conduct problems (Caspi, Moffitt, Newman, & Silva, 1996; Vitacco & Rogers, 2001) and substance use disorders (Iacono, Carlson, Taylor, Elkins, & McGue, 1999; Tarter et al., 2003; von Diemen, Bassani, Fuchs, Szobot, & Pechansky, 2008). Because the developmental period of adolescence is characterized by impulsive and risk-taking behaviors, it is important to determine the role that multiple factors (e.g., situational variables, individual differences, changes in stress hormones) play in determining when behavioral disinhibition is manifested among youth. In addition, these factors may affect changes in biological systems [e.g., hypothalamic-pituitary-adrenal (HPA) axis activity] that occur during this period (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009). Therefore, the current study investigated the interaction between psychosocial stress exposure and the personality traits of Negative Emotionality (NEM) and Constraint (CON) on behavioral disinhibition (as indexed by impulsivity and riskiness tasks) and salivary cortisol reactivity in adolescents.

CHAPTER 2: LITERATURE REVIEW

Stress Effects on Behavioral Disinhibition

The acute physiological responses to stressors are relatively well understood. In the typical individual, the stress response is regulated by glucocorticoids (like the stress hormone cortisol) feeding back on the hypothalamus, pituitary gland, and adrenal glands to inhibit further HPA activation. Stress enacts defensive mobilization, which can be manifested in three emergency responses: fight, flight, and freeze (Gray & McNaughton, 2000; Jarvik & Russell, 1979). Fight and flight responses represent action tendencies that increase the likelihood of behavioral responses characterized by minimal planning via rapid response deployment (i.e., behavioral disinhibition). In some situations, these responses may be adaptive in promoting survival; however, these responses may be disadvantageous in other situations. For example, stress exposure and associated negative affect have been associated with disinhibited behaviors such as gambling (Lightsey & Hulsey, 2002), eating high calorie foods (Tice, Bratslavsky, & Baumeister, 2001), excessive drinking (Richman & Flaherty, 1990), choosing smaller, more immediate rewards rather than preferred, long-term gains (Gray, 1999), and aggressive behaviors (Verona & Kilmer, 2007). In addition, hyperactivity of the HPA axis has been directly linked to disinhibited behaviors (e.g., impulsive suicide; for a review, see Brunner & Bronisch, 1999).

Conversely, freezing is a state in which active behaviors are inhibited (Carder & Cheng, 1976). Freezing responses have been extensively documented in animals (Gallup & Maser, 1977) and self-reported by humans (Schmidt, Richey, Zvolensky, & Maner, 2008) during exposure to acute stress. Though researchers typically conceptualize the freezing response as brief in duration, freezing behavior can last from a few seconds to many hours, depending on the circumstances (Gallup, 1977). In addition, freezing can have residual effects on psychological

factors such as vigilance. For instance, freezing has been associated with increased responsivity to stimuli and self-regulation against competing behavioral impulses (Marks, 1987).

The stress response (i.e., HPA reactivity) has also been associated with increased freezing behavior during stressful situations (Nunez, Ferre, Escorihuela, Tobena, & Fernandez-Teruel, 1996). Further, cortisol reactivity in response to a stressor has been shown to be related to an attentional bias towards threatening stimuli (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007). Therefore, because acute stress increases caution and vigilant watchfulness, it could also decrease behavioral disinhibition in certain situations, particularly those involving threat.

Although it is clear that stress can affect behavioral patterns in different ways, most research has focused on how behavioral disinhibition is increased under stress (e.g., Galván & McGlennen, 2012; Porcelli & Delgado, 2009; Preston, Buchanan, Stansfield, & Bechara, 2007). Indeed, there is a dearth of research on the ways in which behavioral disinhibition can be both increased and/or decreased under stress. Further, different facets of behavioral disinhibition may be differentially affected by stress. For example, impulsivity, which is characterized by responding on the spur of the moment in an unplanned manner (Kreek, Nielson, Butelman, & LaForge, 2005), could be increased under stress, as stress could decrease an individual's capacity to inhibit behavior by depleting self-control resources (e.g., effective function; Barkley, 1997; Muraven & Baumeister, 2000). Alternatively, riskiness is characterized by behaviors performed under uncertainty in which the threat of potential risks/costs outweigh the potential rewards (Kreek et al., 2005). Therefore, because stress can lead to increased vigilance and attentional focus to threat which, in turn, enhance the chances of survival in threatening situations (Lang, 2000), stress could decrease behavioral disinhibition, such as with risk-taking. Moreover, it is

likely that the effects stress has on behavioral disinhibition are affected by multiple factors (e.g., individual differences, context).

Personality-Environment Interactions on Behavioral Disinhibition

Personality traits represent one important factor that can interact with stress exposure to predict behavior. Within one framework (which we refer to as Stress as Moderator; SM), stress can be conceptualized as moderating the relationship between personality and behavior. In other words, the relationship between a personality trait (e.g., NEM, also referred to as neuroticism), and an outcome (e.g., behavioral disinhibition) could be stronger or weaker under stressful compared to neutral conditions. For instance, compared to individuals low in NEM, individuals high in NEM are more likely to engage in impulsive behaviors (Cyders & Smith, 2008), such as impulsive spending. Consequently, during times of stress, the relationship between personality (e.g., NEM) and outcome (e.g., impulsive spending) could be strengthened. However, because "powerful" situations may cause behavior regardless of personality traits (Block, 1968; Haney, Banks, & Zimbardo, 1973; Milgram, 1963), the relationship between personality and behavioral disinhibition may be lessened during more stressful contexts. In other words, personality effects on behavior may be heightened or diminished, depending on how "powerful" the stressful context is. Therefore, it is necessary to obtain contextual information (i.e., presence or absence of a stressor) to know how an individual will respond/behave.

Support for the SM model has been demonstrated by research confirming the interplay between stress and NEM, which seems to function as a general vulnerability factor towards both internalizing and externalizing psychopathology, including behavioral disinhibition (Krueger & Markon, 2006). Relevant to the current study, several studies have shown that NEM is positively associated with antisocial behavior (Hicks, Markon, Patrick, Krueger, & Newman, 2004;

Krueger, Hicks, & McGue, 2001; Verona, Patrick, & Joiner, 2001) and substance use disorders (Elkins, King, McGue, & Iacono, 2006; McGue, Slutske, & Iacono, 1999; McGue, Slutske, Taylor, & Iacono, 1997; Taylor, Reeves, James, & Bobadilla, 2006), suggesting that high NEM is a risk factor for disinhibitory psychopathology. Indeed, after exposure to a stressor or provocation, individuals with high trait NEM have been shown to be more aggressive than are individuals with low trait NEM (Caprara et al., 1987; Caprara, Renzi, Alcini, D'Imperio, & Travaglia, 1983; Netter, Hennig, Rohrmann, Wyhlidal, & Hain-Hermann, 1998; Verona, Patrick, & Lang, 2002). These results indicate that the SM model can be applied to laboratory-based measures of behavioral disinhibition, in that the interaction between preexisting dispositions (e.g., high NEM, poor coping with distress) and stress may play a role in determining when behavioral disinhibition is manifested.

The personality trait of constraint (CON; also referred to as conscientiousness) consistently demonstrates negative associations with behavioral disinhibition and externalizing disorders (Ge & Conger, 1999; Krueger, Caspi, Moffitt, Silva, & McGee, 1996; Krueger et al., 2002; Krueger, McGue, & Iacono, 2001; Taylor et al., 2006), such as substance use disorders (Cloninger, Sigvardsson, & Bohman, 1988; McGue et al., 1999; McGue et al., 1997; Sher & Trull, 1994) and antisocial behavior (Krueger et al., 2001; Taylor & Iacono, 2007; Tremblay, Pihl, Vitaro, & Dobkin, 1994; Verona et al., 2001). However, few studies have focused on the interaction between CON and stress with regard to disinhibitory behaviors. In one study, Lightsey and Hulsey (2002) examined whether the personality trait of impulsiveness (which is inversely related to CON) and stressful life events interact to predict problem gambling (a disinhibitory behavior) in adults. As predicted, high impulsiveness was positively associated with gambling. Inconsistent with the SM model, stress did not predict gambling in adults high in

impulsiveness; however, stress was a significant predictor of gambling for individuals *low* in impulsiveness. These results not only suggest that personality traits play an important role in an individual's reactivity to stress (Bolger & Zuckerman, 1995; Flaa, Ekeberg, Kjeldsen, & Rostrup, 2007; Vollrath, 2001), but they emphasize the need for another perspective to account for personality's moderating role in the relationship between stress and behavioral disinhibition.

Thus, contrary to the SM model (which emphasizes the environment as the moderator), what we refer to as the Personality as Moderator (PM) model emphasizes individual differences as the moderator. In this framework, individuals with certain characteristics are more vulnerable to both positive and negative environmental effects, while other individuals are relatively unaffected by their environment (Belsky & Pluess, 2009). To return to the impulsive spending example, in the PM model it may be that individuals high in NEM will make more impulsive purchases under stress than under neutral conditions, while individuals low in NEM will make the same amount of impulse buys regardless of the presence or absence of stressors. Hence, knowledge about the susceptibility factors (e.g., level of personality) is necessary to understand how an individual will respond to stress. Of course, the SM and PM frameworks are not mutually exclusive, as personality and stress can both act as moderators on behavioral disinhibition. Still, both frameworks represent unique perspectives on the interaction between stress and personality.

Personality-Environment Interactions on Cortisol Reactivity

Consistent with the SM model, it is widely recognized that the stress response differs among individuals because the same individuals differ in their reactivity to different stressors (Sapolsky, 1994). However, individuals also respond differently to identical stressors (Chan, 1977), as personality traits likely modulate the physiological stress response (i.e., PM

framework). Because cortisol is the end-product of the HPA axis, it is often used as an index of general stress levels when examining the physiological stress response (Brannon & Feist, 2004).

Although previous studies have examined the relationship between personality traits and cortisol, the majority of these studies have not used psychosocial stressors to evoke stress. Instead, studies have focused on diurnal cortisol patterns (e.g., Hauner et al., 2008), basal cortisol (e.g., Madsen et al., 2012), and pharmacological challenge paradigms (e.g., Netter, Hennig, & Roed, 1996), and the results of these studies have been mixed. One possible explanation to account for these mixed findings is that when examining individual differences in the stress response, it is preferable to measure cortisol reactivity in comparison to basal cortisol, as it is a more precise and direct measure of HPA activity (O'Leary, Loney, & Eckel, 2007). In addition, none of the ways in which cortisol is assessed in these studies target the psychosocial nature of stress, which makes it difficult to examine how psychological processes like personality traits account for variability in cortisol. Because psychosocial stressors depend on an individual's appraisal of the stressor (Sapolsky, 2004), they therefore allow more room for personality traits to be expressed.

The few studies that have examined the relationship between personality traits and cortisol reactivity to a psychosocial stressor have produced mixed findings. For example, NEM has been both positively associated (Houtman & Bakker, 1991) and negatively associated (Oswald et al., 2006) with cortisol reactivity in adults. In addition, self-reported impulsivity (which is similar to low CON) has been shown to positively correlate with cortisol reactivity in adults (Hirvikoski, Lindholm, Nordenström, Nordström, & Lajic, 2009). These mixed findings may be due to several possible sources of variability (e.g., food intake, recent exercise, menstrual cycle phase, age) that can impact the measurement of cortisol (Alink et al., 2008; Hansen, Garde,

& Persson, 2008). Differences in the time of cortisol collection may also impact results due to the diurnal variation of cortisol (Alink et al., 2008; Hansen et al., 2008). In addition, the majority of existing studies have been conducted in adult samples. Because stress responses have been shown to vary by age (Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004), it is difficult to extend previous findings to adolescents. Moreover, previous research has shown that NEM decreases and CON increases during the transition from adolescence to adulthood (Hopwood et al., 2011); therefore, it is likely that personality-environment interactions on physiological stress responses differ for adolescents and adults.

CHAPTER 3: THE PRESENT STUDY

Considering that behavioral disinhibition is a risk factor for many problematic behaviors, particularly during the developmental period of adolescence (e.g., Caspi et al., 1996; Tarter et al., 2003; Vitacco & Rogers, 2001), the first goal of the present study was to examine behavioral disinhibition (as indexed by impulsivity and riskiness observed in laboratory tasks) as a function of acute stress and personality in a mixed-gender adolescent sample. Because acute stress can both increase (fight and flight) and decrease (freeze) behavioral disinhibition, it is possible that the exact effect of stress may depend on the facet of behavioral disinhibition (e.g., impulsivity, risk-taking). Specifically, fight and flight responses increase the propensity to respond; consequently, stress may increase behavioral disinhibition in the form of impulsivity (e.g., failing to inhibit responding). Conversely, because freeze responses increase attention to threat, stress may decrease behavioral disinhibition in the form of risky behavior (e.g., making less risky decisions). However, it is possible that distinct facets of behavioral disinhibition may be differentially affected by stress and personality traits. Consistent with the PM framework, the exact effect stress has on behavioral disinhibition should depend on the level of NEM and CON. Likewise, the personality traits of NEM and CON should be positively and negatively related to behavioral disinhibition, respectively. However, consistent with the SM model, the direction and the strength of the relationship should depend on the presence versus absence of psychosocial stress, as stress can accentuate or attenuate the relationship between personality and behavioral disinhibition.

Therefore, the current study examined the behavioral disinhibition facets of impulsivity and riskiness. Impulsivity was assessed using a go/no-go (GNG) task in which participants were asked to inhibit responding to a more rarely occurring non-target stimulus and to respond as

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quickly and accurately as possible to a target stimulus. Impulsivity was operationalized as high amounts of commission errors. Because stress may decrease an individual's capacity to inhibit behavior (e.g., Barkley, 1997; Muraven & Baumeister, 2000), we expected acute stress to increase impulsivity in the GNG task. Riskiness was assessed using the youth version of the Balloon Analogue Risk Task (BART-Y; Lejuez et al., 2007) in which participants were instructed to earn points by blowing up a computerized balloon, but the points would be lost if the balloon exploded. Riskiness was operationalized as the adjusted number of pumps across balloons. Given that stress can lead to increased attentional focus to threat (e.g., Lang, 2000), a process which may decrease riskiness, we hypothesized that acute stress would decrease riskiness in the BART-Y. In both disinhibitory behavior tasks, we expected these effects to interact with personality.

In terms of personality, NEM has been related to faster but less accurate performance in cognitive tasks (e.g., Flehmig, Steinborn, Westhoff, & Langner, 2010) and has also been associated with increased aggression under stress/provocation (e.g., Verona et al., 2002). Therefore, because NEM can be characterized by failure to inhibit responding (e.g., reactive aggression), especially in the context of stress, we expected there to be an interaction between NEM and psychosocial stress that would be specific to impulsivity (and not riskiness). Conversely, CON has been negatively associated with risky behaviors (e.g., tobacco use, excessive alcohol use, risky sexual behavior, risky driving, suicide, drug use; Bogg & Roberts, 2004) and can therefore be inversely characterized by the propensity to engage in behaviors in which the threat of potential risks/costs outweigh the potential rewards (Tellegen & Waller, 2008). Aspects of CON are also negatively associated with unplanned, spontaneous behavior, and thus inversely related to impulsivity (Tellegen & Waller, 2008). Therefore, we expected

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there to be an interaction between CON and psychosocial stress that would be related to both riskiness and impulsivity. Because it was unclear whether (a) psychosocial stress would moderate the relationship between personality traits (i.e., NEM and CON) and disinhibitory behaviors, and whether (b) personality would moderate the relationship between psychosocial stress and disinhibitory behaviors, we examined both of these moderation frameworks (i.e., SM and PM).

Although personality traits likely modulate the physiological stress response, a dearth of studies has examined the interaction between psychosocial stress and personality affecting cortisol reactivity to a psychosocial stressor. Therefore, to examine individual differences in the physiological stress response, our second goal was to examine cortisol reactivity (measured at the same time of day across participants and controlling for other possible sources of variability, such as food intake, recent exercise, menstrual cycle phase, age, and time of day) as a function of psychosocial stress and personality. Similar to the goals for behavioral disinhibition, we explored whether (a) psychosocial stress would moderate the relationship between NEM and CON and cortisol reactivity, and whether (b) personality would moderate the relationship between psychosocial stress and cortisol reactivity in an adolescent sample. However, because previous research is unclear regarding NEM's and CON's relationships to cortisol reactivity, it was not possible to formulate clear hypotheses regarding the direction of the expected associations between personality traits and cortisol reactivity in response to a psychosocial stressor among adolescents. Therefore, these analyses were considered exploratory.

CHAPTER 4: METHOD

Participants

Participants consisted of 88 male and female adolescents (55 males; 62.5%) ranging in age from 14 to 19 ($M = 16.1$, $SD = 1.64$), although the majority ($n = 68$; 77.4%) were between 14 and 17 years of age.[1] Parents identified 58 youth as European-American (65.9%), 21 as African-American or biracial (23.9%), and the remainder ($n = 9$; 10.2%) as Hispanic or other ethnicity. The sample was diverse in terms of income level, with parent-reported gross income as follows: $0-$30,000 ($n = 16$; 18.2%), $30,001-$45,000 ($n = 12$; 13.6%), $45,001-$60,000 ($n = 9$; 10.2%), $60,001-$75,000 ($n = 16$; 18.2%), and +$75,001 ($n = 30$; 34.1%). Five families (5.7%) did not respond to this question.

Recruitment involved two waves. Fifty of the youth (56.8%) and one parent or guardian (hereafter referred to as "parent") in the first recruitment wave had participated in a previous study in our laboratory (see Javdani, Sadeh, & Verona, 2011, for further details on this recruitment wave). Twenty of these participants (22.7%) reported a history of mental health treatment, while the other 30 youth (34.1%) reported no treatment history. The second recruitment wave involved adolescent participants ($n = 38$; 43.2%) and a parent recruited anew from the same community (but not from treatment centers) through advertisements or fliers asking for youth to participate in a study on decision-making.[2] Youth with psychotic symptoms

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[1] Additionally, there was one 12-year-old participant, but analyses did not change when the 12-year-old was excluded.

[2] There were three mean differences on variables of interest between the two subsamples (i.e., participants from the first recruitment wave versus participants from the second recruitment wave). First, the first subsample had a larger proportion of boys than did the second subsample (74% vs. 47.4%; χ^2 (1, N = 88) = 6.53, $p < .05$). Second, participants in the first subsample scored lower on NEM than participants in the second subsample (M = -.48, SD = 1.80; and M = .62, SD = 2.33, respectively; t (67.90) = -2.40, $p < .05$). Third, participants in the first subsample had higher baseline cortisol concentrations than participants in the second subsample (M = 9.15, SD = 3.83; and M = 4.56, SD = 3.44, respectively; t (85) = 5.78, $p < .05$). There were no differences in age, ethnicity, VAS mood composite scores, CON, impulsivity, riskiness, or cortisol reactivity between the subsamples.

or a pervasive developmental disorder (e.g., autism, mental retardation) determined from phone screenings with parents (comprising < 1% of the recruitment sample) from either wave were excluded from participating. In addition, females needed to be post-menarche in order to be eligible for the study (see below).

Procedure

Families were paid $25 for participating in the study, and adolescents could earn up to an additional $5 depending on choices they made during one of the computer tasks (see below). Adolescent participants were asked to avoid ingesting any type of food or caffeine and to abstain from vigorous exercise for at least two hours before the start of the experiment to help reduce the biological variability of hormone concentrations (Hansen et al., 2008). They were also asked to abstain from alcohol intake for at least 12 hours before the research appointment. In addition, female participants were scheduled for their appointments during the first three days of their menstrual period, after the onset of menstrual flow (i.e., within the early follicular phase of the menstrual cycle). This procedure allowed us to control for the effects of birth control medication and menstrual cycle phase on hormone concentrations in female participants (Pajer et al., 2006).

Participation took place during a single session that lasted between 1.5-2 hours, and only one participant was tested during each session. Due to the diurnal variation of cortisol (Hansen et al., 2008) and research suggesting a delayed circadian phase in adolescents (Crowley, Acebo, & Carskadon, 2007), participants were instructed to arrive to the laboratory at 6:00 PM on the day of the experiment. After obtaining informed assent or consent from the adolescent (depending on whether the youth was under or over age 18) and informed consent from the adolescent's parent, adolescents completed a battery of questionnaires (described below), including a Participant

Information Sheet to obtain basic demographic information (e.g., age) from the participant. Please refer to Table 1 at the end of this chapter, which details study procedures.

Stress manipulation. Participants were matched on gender, ethnicity, and relative age (e.g., within 1-2 years) before being assigned to a stress or no-stress condition. The psychosocial stressor used in this study was an adaptation of the Trier Social Stress Test for Children (TSST-C; Buske-Kirschbaum et al., 1997; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST-C has consistently been demonstrated as valid and reliably capable of inducing physiological stress responses in children (Kudielka et al., 2004). The stress condition consisted of a 5-minute preparation period, 5-minute public speaking task, and a 5-minute mental arithmetic task. During the preparation portion of the TSST-C, participants received the beginning of a story and were told that they would be audio recorded while telling their version to the ending of the story out loud in front of two judges, who would be judging their story based on stories from previous participants (Buske-Kirschbaum et al., 1997). Judges were undergraduate students of the same gender as the participant, who were instructed to remain neutral and passive throughout the task. In addition to remaining neutral throughout the entire task, judges were instructed to not provide feedback to the participants.

Those in the no-stress condition were asked to read a neutral passage from the text of three popular adolescent books (*The rescue*, by Kathryn Lasky; *The tenth city*, by Patrick Carman; *Finest kind*, by Lea Wait) that was provided to them by the experimenter for three 5-minute intervals. The experimenter told the participants in the no-stress condition that they could read at their leisure and would not be tested on the material in any way.

Impulsivity task. Youth completed a 10-min computerized go/no-go (GNG) task in which participants were instructed to respond as quickly and accurately as possible by responding to a

target stimulus consisting of the letter "X" and to refrain from responding to a more rarely occurring non-target stimulus consisting of the letter "K". As described by Groom and colleagues (2008), both stimuli were randomly presented on a computer monitor with duration of 250 msec and a randomly jittered inter-stimulus interval of between 1.5 and 2.5 sec. There were 304 GNG trials in total with 80% of the trials consisting of "go" trials.

The GNG task consisted of a short practice session and four experimental blocks of 2.5 min with a short rest period in between blocks. Participant impulsivity was indicated by high amounts of commission errors (false alarms; Krishnan-Sarin et al., 2007). The dependent measure for this task was the sum of commission errors in Blocks 1 and 2 only, because many studies have suggested that monotony contributes to hypovigilance in later blocks (e.g., Thiffault & Bergeron, 2003).

Risk-taking task. The youth version of the Balloon Analogue Risk Task (BART-Y; Lejuez et al., 2007) is a computer-based measure that assesses risk-taking propensity. Risk behavior on the BART-Y is correlated with real-world risk behavior and measures of risk-taking propensity (e.g., impulsivity and sensation seeking; Lejuez, Aklin, Zvolensky, & Pedulla, 2003). In this task, participants were instructed to inflate a computer-generated balloon to earn points, but the explosion threshold (which was paired with an adversive popping noise) varied across each of the 30 balloons. Participants were told that the more points they earned during the task, the more money they would receive, which would be determined by the position of the permanent bank's prize meter at the end of the task. However, if the balloon exploded before the points were transferred to the permanent bank, all the points stored in the temporary bank would be lost; participants moved on to the next balloon after a point transfer or after a balloon exploded (for more information, see Lejuez et al., 2007). The average number of pumps taken on

balloons that did not explode (i.e., the adjusted number of pumps across balloons) was used in analyses as the index of risk-taking behavior (Lejuez et al., 2002). Participants were paid between $1-$5 for their performance on the BART-Y (depending on the final position of the prize meter), on top of the standard $25 compensation for the family's participation.

Debriefing. At the end of the experiment, participants were thoroughly debriefed and given the opportunity to ask questions and discuss the psychosocial stressor. Each adolescent was told that the judges were required to look neutral and that the judges were not actually evaluating their performance. All procedures were approved by the university's Institutional Review Board.

Assessment of Cortisol Reactivity

Saliva samples were collected using sampling tubes (DRG Sali-Tubes, DRG International, Inc, Mountainside, NJ) and were stored at -20°C until assayed. Samples were thawed and centrifuged at 4°C at 2700 rpm for 7 min to separate the mucins. One hundred µL samples of the supernatant were then assayed for cortisol concentrations (ng/mL) in duplicate using an enzyme-linked immunosorbent assay (ELISA) purchased from DRG International, Inc (Mountainside, NJ). Samples were assayed in an endocrinology laboratory at the university. The average intra- and inter-assay coefficients of variation (CV) were 7.46 and 10.83, respectively, which are satisfactory CV values (Nicolson, 2008).

Four saliva samples were obtained from participants: (1) immediately before the TSST-C or control reading task (T0; baseline), (2) 15 minutes after the start of the TSST-C or control reading task, which coincided with when participants finished the TSST-C or control reading task (T1; +15 min), (3) 35 minutes after the start of the TSST-C or control reading task, which coincided with when participants finished the GNG task (T2; +35 min), and (4) 55 minutes after

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the start of the TSST-C or control reading task, which coincided with when participants completed the BART-Y (T3; +55 min).[3] Given that cortisol has been demonstrated to enter saliva approximately 15-20 min after a potential stressor is perceived, each salivary sample measured cortisol concentrations from approximately 15-20 min before collection (Stansbury & Gunnar, 1994). Consequently, the salivary samples we were most interested in were collected at T1 and T2, as these samples would be a reflection of the participants' cortisol reactivity immediately before the preparation of (T1) and immediately after (T2) the TSST-C or control reading task.

Cortisol values were log-transformed to obtain a normal distribution. Cortisol reactivity was operationalized as percentage change in cortisol from each sample collected after the TSST-C or control reading task (T1, T2, and T3) to baseline (T0), and was calculated by the following formula: [(cortisol at T1, T2, or T3 – baseline cortisol) / baseline cortisol] × 100 (Scarpa & Luscher, 2002). Percentage change scores were used in analyses to control for individual differences in baseline cortisol; therefore, cortisol reactivity was standardized across participants (Scarpa & Luscher, 2002).

Instruments

Multidimensional Personality Questionnaire – Simplified-Wording Form (MPQ-SF; Patrick, Kramer, Tellegen, Verona, & Kaemmer, 2011). Consistent with our goals of examining how psychosocial stress moderates the effects of personality on disinhibitory behaviors, the MPQ-SF, developed for youth and those with lower reading levels, was administered to index higher-order personality dimensions. In the present study, we used the original 155-item set of

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[3] However, one participant was unable to provide saliva, and therefore her data were excluded from all cortisol analyses.

the MPQ-SF developed for initial validation (see Patrick et al., 2011).[4] The MPQ-SF primary

scales converge into three higher-order dimensions: NEM (Aggression, Stress Reaction,

Alienation) assesses tendencies toward distress, anxiety, irritability, aggression, hostility, and

estrangement from/suspicion of others; Positive Emotionality (PEM; Well-Being, Social

Closeness, Social Potency, Achievement) assesses a positive disposition, sociability, agency, and

social dominance; and CON (Control, Harm Avoidance, Traditionalism) assesses impulsivity,

thrill-seeking/fearlessness, and conformity to social norms. Because our hypotheses were

relevant to stress reactivity and behavioral disinhibition, we only used the two higher-order

dimensions of NEM and CON in analyses.

In addition to the primary scales, three validity scales [Variable Response Inconsistency

(VRIN), True Response Inconsistency (TRIN), and Unlikely Virtues (UV)] were also

administered to measure lack of consistency in responding (VRIN and TRIN) and socially

desirable responding (UV). Two participants were excluded from analyses involving NEM and

CON due to aberrant scores on the validity scales established for the MPQ-Brief Form (Patrick,

Curtin, & Tellegen, 2002). However, because exclusionary criteria for the validity scales of the

MPQ-SF have not yet been established, analyses involving NEM and CON were also re-

conducted with these two participants included. The results of our analyses did not substantively

change with or without removal of these two participants. In addition to removing these two

participants from analyses involving personality traits, one participant did not complete the

MPQ-SF; therefore, our final sample for the MPQ-SF analyses consisted of 85 participants.

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[4] The discrepancy between the original MPQ-SF items and those assessed in Patrick and colleagues' (2011) cross-validation sample is mainly due to the fact that the version used in the current study does not include items used to increase Variable Response Inconsistency (VRIN) and True Response Inconsistency (TRIN) item pairs.

Visual Analog Scale (VAS; Aitken, 1969). The VAS is a self-rated mood scale consisting of nine words (i.e., tiredness, anxiety, confusion, sadness, anger, tension, relaxation, frustration, nervousness). Participants were asked to rate how they were currently feeling on a Likert scale from 1-10. Following the same procedures as the saliva collections, the VAS was administered before (T0; baseline) and immediately after (T1; +15 min) the TSST-C or control reading task, with further mood assessments taken between the behavioral disinhibition tasks (T2; +35 min) and at the end of the experiment (T3; +55 min). Because the VAS and saliva samples were taken in conjunction, the time frame of mood assessments and hormone collections was similar (see Table 1).

Given the number of mood ratings assessed by the VAS, a principal components analysis (PCA) with Promax rotation was conducted (using baseline VAS ratings) to concisely operationalize mood changes in the experiment. Two components were extracted (eigenvalues = 3.5 and 1.6). The first factor, termed VAS Distress Composite, explained 39% of the variance and was comprised of ratings on confusion, sadness, anger, and frustration. The second factor, termed VAS Anxiety Composite, explained 17% of the variance and was comprised of ratings on anxiety, tension, relaxation (reverse scored), nervousness, and tiredness.

Data Analysis

First, a stress manipulation check was conducted by analyzing mood responses to the psychosocial stressor across time. Due to the nested nature of the data (i.e., multiple observations nested within participants), we used Multi-Level Modeling (MLM; Singer & Willett, 2003), which was conducted using SAS 9.3 with the settings recommended by Singer (1998). We ran two separate models. In both models, the Level 1 (within-person) predictors were the linear effect of Time (coded as minutes from baseline: 0, 15, 35, 55) and quadratic effect of Time

(Time^2: 0, 225, 1225, 3025), and the Level 2 (between-person) predictor was Stress Group

(coded: no-stress condition = 0; stress condition = 1). Of more importance, the Stress Group ×

Time and Stress Group × Time^2 cross-level interactions were used in the prediction of both VAS

mood composite scores (in separate analyses). All effects were treated as fixed, with the

exception of the intercept (which was treated as random).

Second, to examine behavioral disinhibition as a function of psychosocial stress and

personality, we used separate linear regressions to examine impulsivity and riskiness as a

function of Stress Group, NEM, and CON. Because there are age differences in behavioral

disinhibition (e.g., Steinberg, 2004; Steinberg et al., 2008), age (mean centered) was included as

a covariate in analyses in Step 1, followed by the main effects of Stress Group, NEM, and CON

in Step 2, and the interactions between Stress Group and both NEM and CON in Step 3.

Consistent with our conceptual framework, we followed-up significant interactions in two ways.

First, we examined the relationship between the personality variable and behavioral disinhibition

within each Stress Group (i.e., SM). Second, we used simple slopes analyses (Aiken & West,

1991; Preacher, Curran, & Bauer, 2006) to examine the relationship between Stress Group and

behavioral disinhibition at high (+1 *SD*) and low (-1 *SD*) levels of the personality trait (i.e., PM).

Third, to examine cortisol reactivity as a function of psychosocial stress and personality,

we also used MLM as described above. To be consistent with the regression analyses, we

included both personality traits in the same model.[5] In this model, the Level 1 predictors were

Time and Time^2, and the Level 2 predictors were Stress Group, NEM, CON, and the three two-

way interactions (e.g., Stress Group × CON). Of more interest were the six two-way (e.g., CON

× Time) and four three-way (e.g., Stress Group × CON × Time) cross-level interactions. Due to

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[5] However, analyses were also conducted with NEM and CON in separate models, and the results were the same.

gender differences in cortisol reactivity to acute stress (e.g., Kirschbaum, Wust, & Hellhammer, 1992), gender (coded: female = 1, male = -1) was also included as a covariate. We again followed-up significant interactions in two ways. First, we examined the Time (and $Time^2$) × personality interactions separately by Stress Group. Second, we used simple slopes analyses (Preacher et al., 2006) to examine the Time (and $Time^2$) × Stress Group interactions at high (+1 *SD*) and low (-1 *SD*) levels of the personality trait. These follow-up tests examine stress and personality as moderators, respectively.

CHAPTER 4: TABLES AND FIGURES

Table 1. *Study Procedures and Time Points*

T0 (Baseline)	Condition Manipulation	T1 (+15 min)	Impulsivity Task	T2 (+35 min)	Risk-Taking Task	T3 (+55 min)
MPQ-SF, VAS #1, saliva sample #1	**Control reading task** _____ **Stress task (TSST-C)**	VAS #2, saliva sample #2	GNG	VAS #3, saliva sample #3	BART-Y	VAS #4, saliva sample #4

Note. The laboratory experience was the same across both Stress Groups to make them comparable, with the exception of the psychosocial stressor. The VAS and saliva samples were taken in conjunction 20 min apart; thus, the time frame of mood assessments and cortisol collections was similar. MPQ-SF = Multidimensional Personality Questionnaire – Simplified-Wording Form; VAS = Visual Analog Scale; TSST-C = Trier Social Stress Test for Children; GNG = Go/No-Go; BART-Y = Balloon Analogue Risk Task-Youth Version.

CHAPTER 5: RESULTS

Mood Manipulation Checks

The results for the MLM analyses for the mood manipulation checks are displayed in Table 2 at the end of this chapter.[6] Unstandardized regression coefficients are reported because there is no agreed upon way to calculate standardized coefficients for MLM (Raudenbush & Bryk, 2002). For the VAS Anxiety Composite, none of the main effects were significant; however, the Time × Stress Group, $F(1, 258) = 15.68$, $p < .001$, and Time^2 × Stress Group, $F(1, 258) = 19.24$, $p < .001$, interactions were significant. As shown in the estimated growth curve (see top panel of Figure 1 at the end of this chapter), these interactions indicated that for the stress condition, there were significant linear and quadratic effects of Time. However, there were no linear or quadratic effects of Time for the no-stress condition. These results were conceptually replicated with the VAS Distress Composite (see bottom panel of Figure 1). Similar to the results above, there were no significant main effects for Stress Group or Time, but both interactions were significant: Time × Stress Group, $F(1, 260) = 10.97$, $p = .001$, and Time^2 × Stress Group, $F(1, 260) = 15.24$, $p = .001$. In summary, adolescents in the stress condition reported more anxiety and more distress following the TSST-C than no-stress adolescents reported after the control reading task, with both anxiety and distress reduced to almost baseline levels by the end of the experiment. These results suggest that our stress manipulation was effective.

Personality Traits and Stress Effects on Behavioral Disinhibition Tasks

Impulsivity task (GNG). As shown in Table 3 at the end of this chapter, regression analyses revealed no significant main effects of Stress Group, NEM, or CON on the sum of

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[6] When NEM and CON were entered as Level 2 variables in the MLM analyses conducted on both VAS mood composite scores (in separate analyses), there were no significant linear or quadratic Time × NEM, Time × CON, Time × Stress Group × NEM, or Time × Stress Group × CON interactions for either mood composite (all p's > .05).

commission errors (all p's > .05). Consistent with our hypotheses, analyses revealed a significant interaction between Stress Group and NEM ($p = .01$) on impulsivity. However, there was a non-significant interaction between Stress Group and CON ($p = .08$) on impulsivity, which was inconsistent with our hypotheses. These results demonstrate that the correlation of trait NEM with impulsivity differed significantly between the two Stress Groups.

Consistent with the SM and PM frameworks, we interpreted the Stress Group × NEM interaction in two different ways. First, we examined the relationship between NEM and impulsivity separately within each Stress Group. In these analyses, NEM was associated with less impulsivity during the GNG among adolescents who were in the no-stress condition ($\beta = -.42$, $p = .01$) but related to a non-significant increase in impulsivity in the stress condition ($\beta = .26$, $p = .11$). These results suggest that NEM may be protective against behaving impulsively under non-stressful conditions in adolescents, but this protection is absent under stress.

Second, we used the regression equation to estimate impulsivity for youth low (-1 SD) versus high (+1 SD) in NEM for both the stress and no-stress conditions (Aiken & West, 1991; see Figure 2 at the end of this chapter). These simple slopes did not differ from 0 for adolescents low ($\beta = -.26$, $p = .09$) and high ($\beta = .23$, $p = .13$) in NEM. Taken together, these results suggest that psychosocial stress moderates the relationship between NEM and impulsivity; however, NEM does not moderate the relationship between stress and impulsivity.

Risk-taking task (BART-Y). There were no significant main effects of Stress Group, NEM, or CON on risk-taking during the BART-Y (all p's > .05; see Table 3). However, consistent with our hypotheses, analyses revealed a significant interaction between Stress Group and CON ($p = .01$), but not between Stress Group and NEM ($p = .10$) on riskiness. These results

demonstrate that the correlation of trait CON with riskiness differed significantly between the two Stress Groups.

Similar to the follow-up analyses for the Stress Group × NEM interaction above, we first examined the simple effect of CON on riskiness within each Stress Group. Follow-up regressions indicated that CON evidenced a significant negative association with riskiness during the BART-Y among adolescents in the no-stress condition (β = -.40, p = .01) but not among adolescents in the stress condition (β = .11, p = .49).

We also used the regression equation to estimate riskiness for adolescents low (-1 *SD*) versus high (+1 *SD*) in CON for both the stress and no-stress conditions (see Figure 3 at the end of this chapter). The estimated means revealed that for low CON (-1 *SD*) youth, Stress Group significantly predicted riskiness (β = -.33, p = .03); however, there was no significant relationship for youth with high CON (β = .16, p = .29). These results suggest that stress exposure predicted less riskiness only for youth with low CON (but not for adolescents with high CON). Therefore, not only do these results suggest that psychosocial stress moderates the relationship between CON and riskiness, but CON also moderates the relationship between stress and riskiness.

Personality Traits and Stress Effects on Cortisol Reactivity

MLM analyses conducted on cortisol reactivity revealed no linear or quadratic Time × NEM × Stress Group interactions (all p's > .05); however, there were significant Time × CON × Stress Group, $F(1, 156) = 4.44$, p = .04, and Time^2 × CON × Stress Group, $F(1, 156) = 4.22$, p = .04, interactions. The estimated growth curves based on the regression output for all participants are displayed in Figure 4 at the end of this chapter. Follow-up tests indicated that the Time × CON and Time^2 × CON interactions were not significant for either Stress Group (all p's > .05).

Hence, stress did not serve as a moderator of the relationship between CON and cortisol reactivity.

Follow-ups with personality as the moderator indicated that for low levels (-1 *SD*) of CON, the Time × Stress Group, $F(1, 156) = 6.86$, $p = .01$, and Time^2 × Stress Group, $F(1, 156) = 5.44$, $p = .02$, interactions were significant. These results suggest that there was a linear increase ($B = .017$, $p = .01$) and quadratic decrease ($B = -.0002$, $p = .01$) in cortisol reactivity across time only for youth with low CON in the stress condition (but not for adolescents with low CON in the no-stress condition; linear: $B = .00$, $p = .98$; quadratic: $B = .00$, $p = .94$). In other words, adolescents with low CON exhibited an increase in cortisol reactivity following the psychosocial stressor which decreased by the end of the experiment. However, for adolescents with high levels (+1 *SD*) of CON, there were no Time × Stress Group, $F(1, 156) = .05$, $p = .82$, or Time^2 × Stress Group, $F(1, 156) = .09$, $p = .76$, interactions, which indicates that youth with high CON did not have a significant cortisol response during the experiment, regardless of Stress Group.

Table 2. *Unstandardized Regression Coefficients and Variance Components for Multi-Level*

Modeling for Mood Scores and Cortisol Reactivity

	Anxiety[a]	**Distress**[a]	**Cortisol**[b]
Fixed Effects			
Intercept	12.50**	7.854**	-.027
Stress Group	1.224	.625	-.074
Time	.002	.009	.000
Time^2	.000	.000	.000
Time $\times$ Stress Group	.246**	.213**	.009
Time^2 $\times$ Stress Group	-.004**	-.004**	.000
Gender	---	---	.043
CON	---	---	-.021
NEM	---	---	.017
CON $\times$ NEM	---	---	-.002
CON $\times$ Stress Group	---	---	.035
NEM $\times$ Stress Group	---	---	.009
Time $\times$ CON	---	---	.001
Time^2 $\times$ CON	---	---	.000
Time $\times$ NEM	---	---	.000
Time^2 $\times$ NEM	---	---	.000

Table 2 (cont.)

|	Anxiety[a]	Distress[a]	Cortisol[b]
Fixed Effects			
Time × CON × Stress Group	---	---	-.005*
Time^2 × CON × Stress Group	---	---	.0001*
Time × NEM × Stress Group	---	---	.000
Time^2 × NEM × Stress Group	---	---	.000
Variance Components			
Level 1			
Within Person	10.873**	18.868**	.013**
Level 2			
Between Person	26.196**	11.755**	.044**

Note. CON = Constraint; NEM = Negative Emotionality. [a] $N = 88$. [b] $N = 85$. * $p < .05$. ** $p < .001$.

Table 3. *Linear Regression Analyses of Impulsivity and Riskiness as a Function of Stress Group, CON, and NEM*

	Impulsivity on GNG			Riskiness on BART-Y		
	β	R^2	ΔR^2	β	R^2	ΔR^2
Step 1		.08	--		.04	--
Age	-.29*			.19		
Step 2		.10	.02		.10	.06
Stress Group	-.02			-.09		
CON	-.12			-.16		
NEM	-.02			.13		
Step 3		.19	.09*		.18	.09*
Stress Group × CON	.23			.35*		
Stress Group × NEM	.36*			.23		

Note. CON = Constraint; NEM = Negative Emotionality; GNG = Go/No-Go; BART-Y = Balloon Analogue Risk Task-Youth Version. *N* = 85. * *p* < .05.

Figure 1. *Estimated Growth Curves for Mood Manipulation Checks on VAS Anxiety and Distress*

Composites by Stress Group
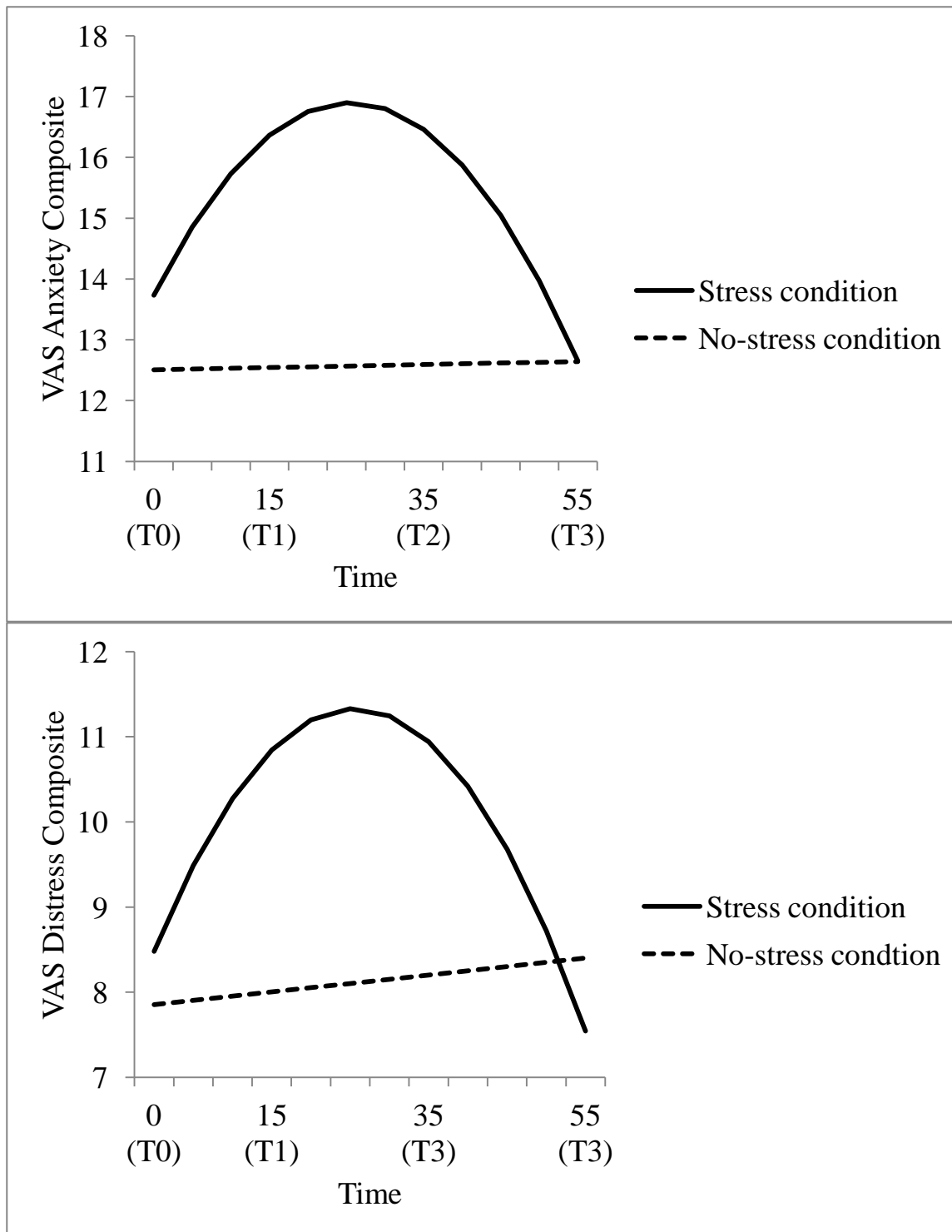
Note. VAS = Visual Analog Scale.

Figure 2. *Psychosocial Stress Moderating the Relationship between NEM and Impulsivity on the*

GNG
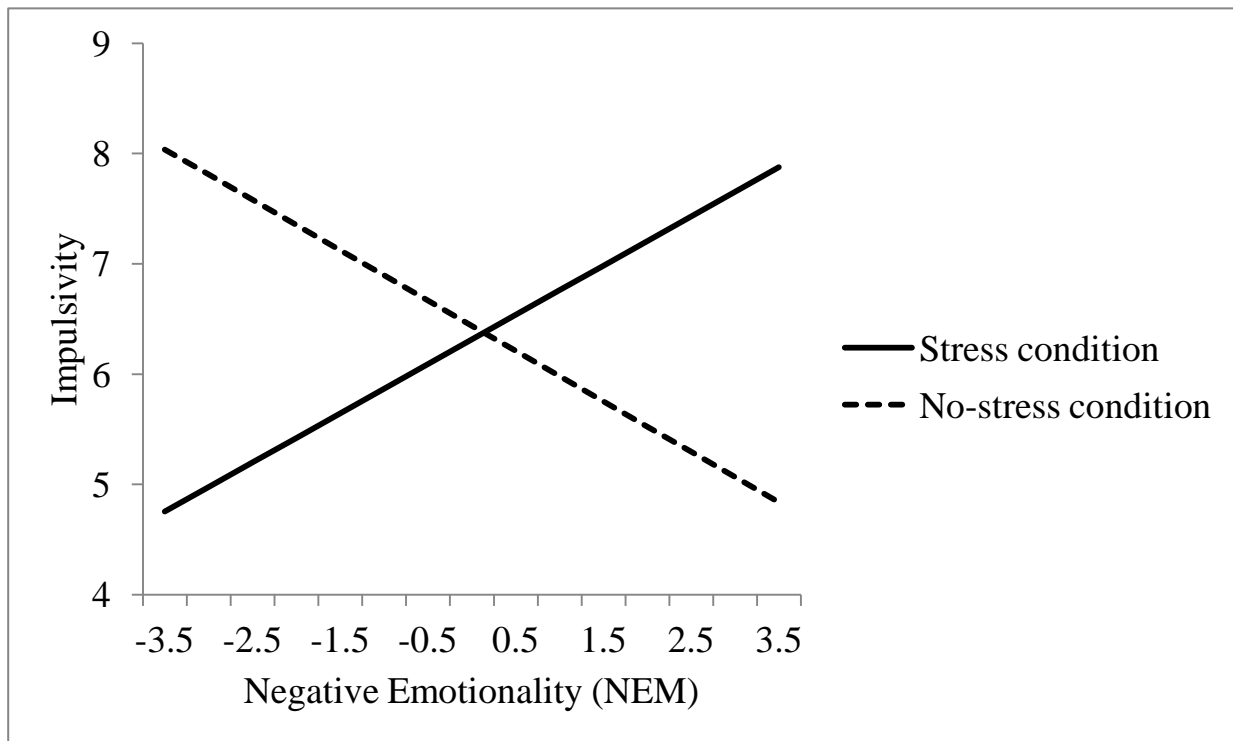
Note. NEM = Negative Emotionality; GNG = Go/No-Go.

Figure 3. *CON Moderating the Relationship between Psychosocial Stress and Riskiness on the BART-Y*
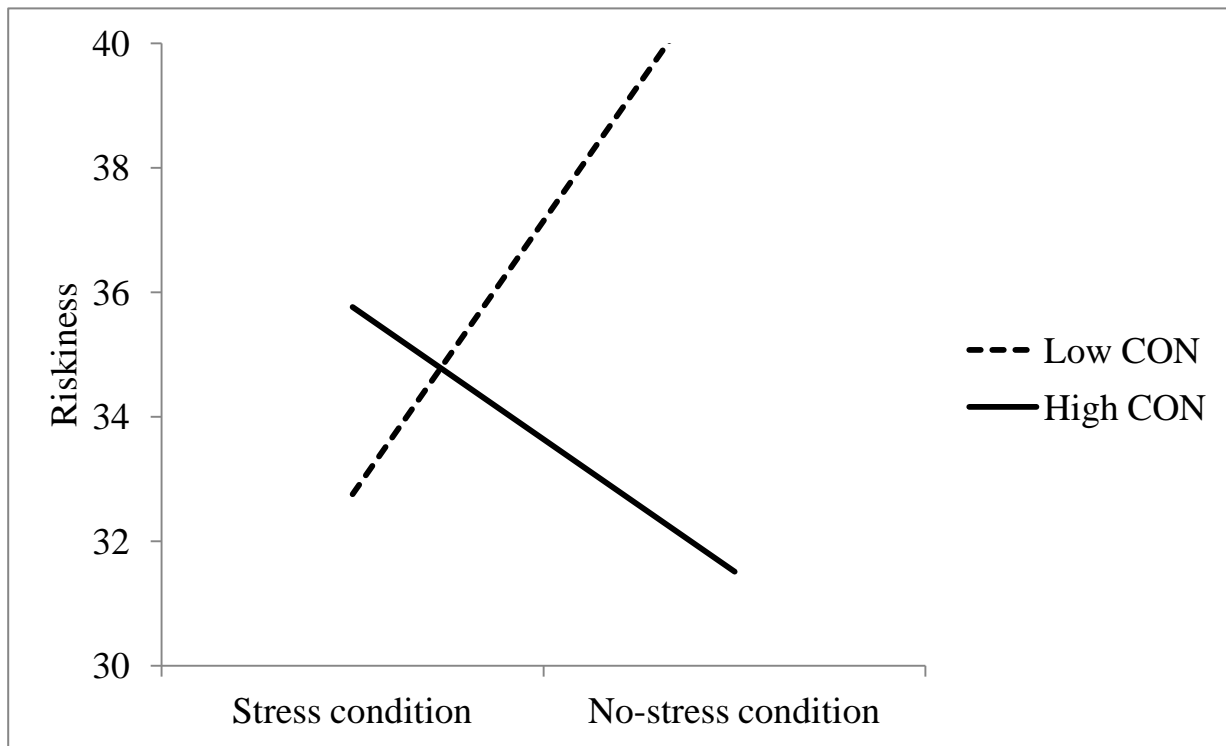
Note. CON was dichotomized in the graph for interpretation purposes, but continuous scores were used in analyses. CON = Constraint; BART-Y = Balloon Analogue Risk Task-Youth Version.

Figure 4. *Estimated Growth Curves for Cortisol Reactivity as a Function of Time, Stress Group,*

and CON
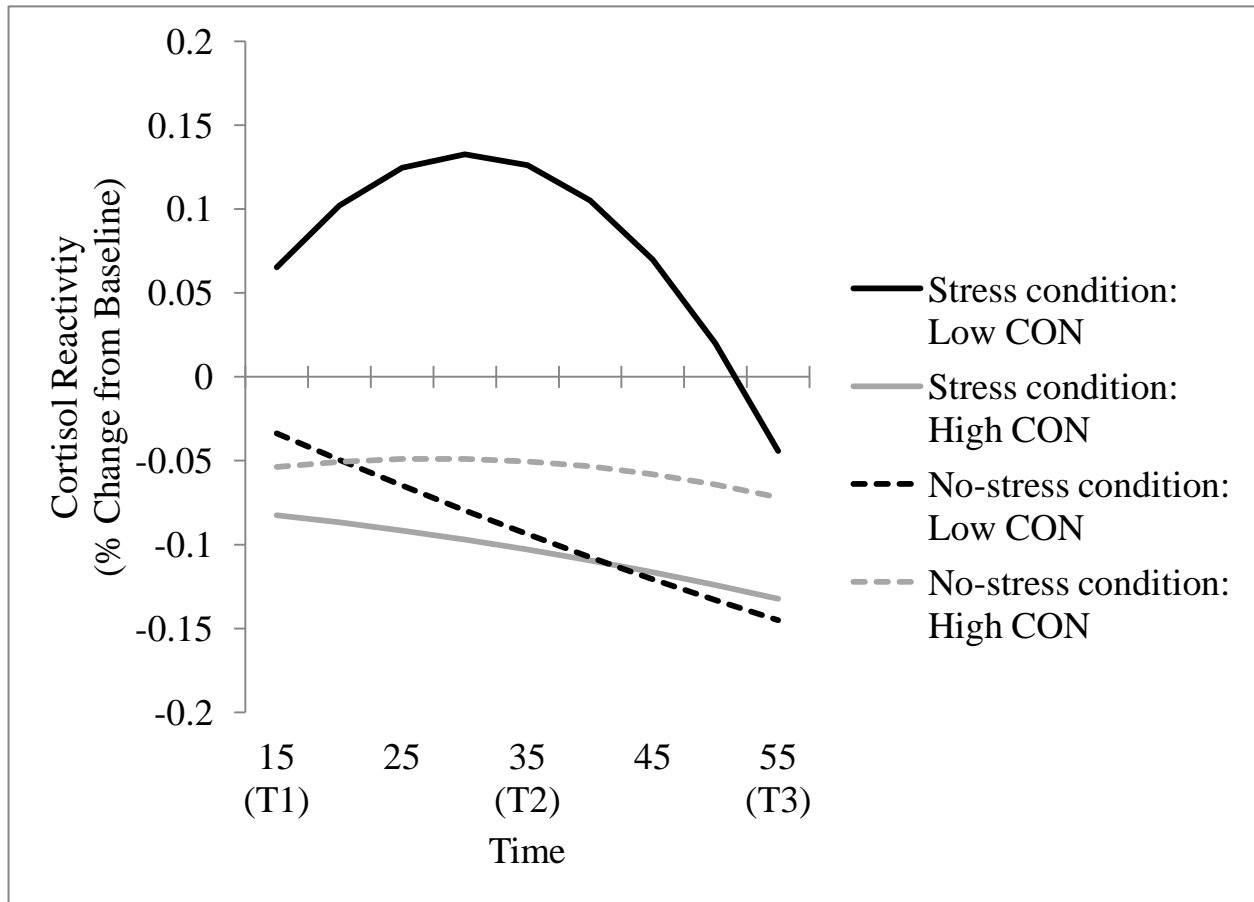
Note. CON was dichotomized in the graph for interpretation purposes, but continuous scores

were used in analyses. CON = Constraint.

CHAPTER 6: DISCUSSION

The first goal of the current study was to examine two facets of behavioral disinhibition (indexed by computerized tasks of impulsivity and riskiness) as a function of psychosocial stress and the personality traits of NEM and CON in adolescents. We tested two hypotheses: (a) psychosocial stress would moderate the relationship between the personality traits of NEM and CON and disinhibitory behaviors, and (b) personality would moderate the relationship between psychosocial stress and disinhibitory behaviors. We found support for both hypotheses that differed across disinhibition indices for NEM and CON. Our second goal was to examine cortisol reactivity as a function of psychosocial stress and the personality traits of NEM and CON, with similar hypotheses for interactions regarding the SM and PM frameworks. We only found support for the PM model with CON with regard to cortisol reactivity. The results of both of these goals will be further discussed in the subsequent sections.

Personality, Stress, and Behavioral Disinhibition

Consistent with the framework that psychosocial stress moderates the relationship between personality and impulsivity (i.e., SM), NEM was associated with less impulsivity during the GNG task among adolescents who were in the no-stress condition. These results are inconsistent with our hypotheses that stress would increase impulsivity and that NEM would be positively related to impulsivity. Because NEM has been associated with increased worry and nervousness even under neutral conditions (e.g., Trapnell & Campbell, 1999; Watson & Clark, 1984), it is possible that individuals with high NEM are more likely to exhibit cautious and thoughtful behavior (i.e., less impulsive behavior) in non-stressful situations. Therefore, NEM may protect against behaving impulsively under no-stress environments, as NEM may be beneficial to cognitive and behavioral performance (Tamir, 2005). In contrast, we also found that

the protective effects of NEM on impulsivity are absent during acute stress. Because we did not find evidence for the PM model in terms of the moderating role of NEM on stress-induced impulsivity, it appears that the relationship between NEM and impulsivity depends primarily on context (i.e., presence or absence of stress). Thus, it may be advantageous for impulsive youth to receive stress management training to help buffer the negative effects of stress (i.e., mimic the protective effects of NEM under non-stressful conditions).

With regard to riskiness, we found that psychosocial stress moderated the relationship between CON and riskiness (consistent with the SM framework), and CON moderated the relationship between psychosocial stress and riskiness (consistent with the PM framework). Therefore, it appears that youth riskiness depends on both context (i.e., presence or absence of stress) and levels of CON. Specifically, there was a negative relationship between CON and riskiness in the no-stress condition, which was absent in the stress condition (consistent with the SM framework). Thus, similar to NEM, higher scores of CON also served to protect youth from disinhibited behavior only under no-stress conditions. Moreover, consistent with the PM framework, low CON adolescents in the no-stress condition were more risky than low CON adolescents in the stress condition, while there was no effect of Stress Group for adolescents high in CON. In other words, although low CON was, as one would expect, a risk factor for risky behavior under no-stress, acute stress seemed to remove this liability of low CON (i.e., protect low CON youth from engaging in risk-taking behaviors).

These results may be understood in terms of CON and preparedness. On the one hand, high CON individuals are generally more vigilant and planful (Tellegen & Waller, 2008). Therefore, stressors may have less of an impact on high CON individuals' already-cautious behavior, which would explain why they were relatively unaffected by the psychosocial stressor

used in this study. On the other hand, stressors may have more of an impact on low CON individuals, as these individuals may be less prepared when stressors arise. Therefore, low CON individuals may be more reactive to stress. For example, they may attend more to threat when stressors arise (as a possible survival mechanism), which may lead to less risky behaviors. This explanation is consistent with other studies that have shown that individuals tend to be less risky after an unexpected event (Demaree, Burns, Dedonno, Agarwala, & Everhart, 2012).

These results can also be interpreted in the context of the freezing literature, as stress can decrease behavioral disinhibition by increasing caution and vigilant watchfulness of threat (Dandeneau et al., 2007; Marks, 1987). In the BART-Y, threat is apparent in at least two ways. First, there is the threat of not gaining money if the participant makes too many risky decisions. Second, each time the balloon explodes, the participant is subjected to an aversive popping noise. In contrast, there is no threat in the GNG task, which may explain why these results are specific to the BART-Y. If it is the case that increased attention to threat mediates the relationship between stress and riskiness, one possible clinical implication would be to train low CON adolescents to increase attention to threat via cognitive bias modification paradigms (e.g., Hallion & Ruscio, 2011).

Personality, Stress, and Cortisol Reactivity

Although there were no significant interactions involving NEM, the results for CON were consistent with the framework that personality moderates the relationship between psychosocial stress and cortisol reactivity (i.e., PM). Consistent with the above discourse that low CON adolescents may be more reactive to stress (and thus more vigilant and less risky under stressful conditions), low CON was associated with greater cortisol reactivity for adolescents in the stress condition. Interestingly, adolescents with high CON did not exhibit the typical cortisol response

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that would be expected in response to the psychosocial stressor. It is possible that individuals low in CON (in comparison to high CON individuals) may mobilize greater resources (e.g., cortisol reactivity, cognitive control) in stressful relative to non-stressful situations. Indeed, these results in an adolescent sample support other studies that have shown self-reported impulsivity (which is similar to low CON) to positively correlate with cortisol reactivity in adults (Fishbein, Lozovsky, & Jaffe, 1989; Hirvikoski et al., 2009). Further, this is consistent with theory and research suggesting that greater cortisol reactivity plays a role in the inhibition of behavior (Lighthall, Mather, & Gorlick, 2009; Zuckerman, 1994; 1995), which may explain why low CON adolescents exhibited more cautious behavior (less riskiness) in the stress relative to no-stress condition. Because we only examined cortisol reactivity and none of the other HPA axis hormones (e.g., ACTH), it will be beneficial for future research to examine the interaction between stress and personality on different stress hormones.

Limitations and Strengths

There are several limitations to the present study. First, we did not counterbalance the behavioral disinhibition tasks, so it is possible that the results from the impulsivity and riskiness tasks are simply an artifact of the order in which participants completed these tasks. Future studies should explore the temporal ordering of behavioral disinhibition tasks. Second, we used an acute psychosocial stressor in our study, so our results cannot be extended to chronic stressors. Third, a measure of pubertal development was not collected during the experiment. Because cortisol concentrations have been shown to be associated with pubertal stage (Kiess et al., 1995), it may have been useful to include pubertal stage in analyses. Nevertheless, we attempted to control for pubertal stage by requiring all female participants to be post-menarche,

and we matched all participants on relative age (e.g., within 1-2 years) before assigning them to Stress Group.

The present study is also characterized by several strengths. First, participants were a diverse group of adolescents with regard to gender and ethnicity; however, it cannot be assumed that the findings will generalize to younger children or adults. Second, in contrast to using one basal cortisol sample in analyses, we collected salivary cortisol concentrations at four time points to assess changes in cortisol reactivity during the experiment. Third, we controlled for multiple sources of variability (i.e., food intake, recent exercise, menstrual cycle phase, age, time of day) that can impact the measurement of cortisol (Alink et al., 2008; Hansen et al., 2008). Fourth, with a few notable exceptions (e.g., Böhnke, Bertsch, Kruk, & Naumann, 2010; Gerra et al., 1997), much of the prior research has relied on self- and observer-reports of behavioral disinhibition, whereas we assessed two aspects of behavioral disinhibition using impulsivity and riskiness laboratory tasks. Finally, because personality has been shown to influence the types of stress to which individuals are exposed (e.g., Bolger & Zuckerman, 1995), we were able to tease apart the effects of personality and stress by using both a standardized stressor and a standardized control group across participants.

Conclusions

To our knowledge, the present study is the first to examine the interactions between psychosocial stress exposure and the personality traits of NEM and CON on behavioral disinhibition (as indexed by impulsivity and riskiness tasks) and salivary cortisol reactivity in adolescents. Our study suggests that distinct facets of behavioral disinhibition are differentially affected by stress, NEM, and CON; therefore, future studies should continue to examine the role that multiple factors play in determining when impulsivity and riskiness are manifested among

youth. Understanding the various factors that lead to behavioral disinhibition is critical toward furthering prevention strategies aimed at both reducing and targeting behavioral disinhibition in adolescents. Although behavioral disinhibition is risk factor for many problematic behaviors in youth (e.g., Caspi et al., 1996; Tarter et al., 2003; Vitacco & Rogers, 2001), the individual components of behavioral disinhibition and personality traits have been shown to change throughout the developmental period of adolescence (Hopwood et al., 2011; Young et al., 2009); therefore, this may be a critical developmental period for intervention to prevent the development of problematic behaviors and psychopathology. Given that these results are novel and require replication, future studies should continue to examine the interplay among personality traits, stress, and behavioral disinhibition across adolescence.

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