

Resting Heart Rate Variability as a Predictor of Responses to Predictable and
Unpredictable Threat

BY

Stephanie M. Gorka
B.S., *University of Maryland, College Park*, 2008

THESIS

Submitted as partial fulfillment of the requirements
for the degree of Master of Arts in Psychology
in the Graduate College of the
University of Illinois at Chicago, 2011

Chicago, Illinois

Defense Committee:

Stewart A. Shankman, Ph.D., Chair and Advisor
Jon D. Kassel, Ph.D.
Stephen W. Porges, Ph.D.

TABLE OF CONTENTS

<u>CHAPTER</u>	<u>PAGE</u>
I. INTRODUCTION	1
A. HRV and Polyvagal Theory	3
B. Startle as an Index of Aversive States	5
C. Present Study	9
II. METHODS	10
A. Participants	10
B. Procedure	11
C. Stimulus Delivery	12
D. Shock Task	12
E. Measures	14
1. Anxiety Sensitivity Index (ASI)	14
2. Anxiety Control Questionnaire (ACQ)	14
3. Behavioral Inhibition and Behavioral Activation Scale (BIS/BAS)	15
4. General Temperament Survey (GTS)	15
F. HRV Data Processing	15
G. Startle Data Processing	16
H. Data Analysis Plan	17
III. RESULTS	17
A. Sample Characteristics and Descriptive Data	18
B. Baseline RSA	18
C. Shock Task Manipulation	19
D. Identification of Covariates	19
E. RSA and Startle Responses during the Shock Task	19
F. RSA and Self-Reported Anxiety during the Shock Task	20
G. Anxiety Disorder Risk Factor x RSA Interactions	22
IV. DISCUSSION	24
A. Self-Reported Anxiety	29
B. Personality Moderators	30
C. Limitations	31
D. Implications and Future Directions	32
REFERENCES	34
APPENDICES	52
Appendix A	52
Appendix B	53
Appendix C	57
Appendix D	59
VITA	68

LIST OF TABLES

<u>TABLE</u>		<u>PAGE</u>
I.	Descriptive statistics for RSA during baseline and self-report variables	45
II.	Results from Condition x Cue x RSA x Anxiety Disorder Risk Factor repeated measures ANOVAs	46

LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
1. Depiction of the neutral, predictable, and unpredictable study design	47
2. Mean RSA across time during the resting baseline recording period	48
3. Startle magnitude T-scores during the neutral, predictable, and unpredictable conditions (Left) and mean startle potentiation scores (Right; e.g., U-ITI minus N-ITI)	49
3b. Mean self-reported anxiety during the neutral, predictable, and unpredictable conditions and the ITI and countdown cues	51
4. Scatter plot of the relationship between resting RSA and startle potentiation during the unpredictable ITI	52

LIST OF ABBREVIATIONS

ANS	Autonomic Nervous System
SNS	Sympathetic Nervous System
PNS	Parasympathetic Nervous System
SA	Sinoatrial Node
HRV	Heart Rate Variability
RSA	Respiratory Sinus Arrhythmia
ECG	Electrocardiogram
NA	Nucleus Ambiguus
DMNX	Dorsal Motor Nucleus
PTSD	Posttraumatic Stress Disorder
AS	Anxiety Sensitivity
CeA	Central Nucleus of the Amygdala
BNST	Bed Nucleus of the Stria Terminalis
GAD	Generalized Anxiety Disorder
UIC	University of Illinois at Chicago
N	No shock condition
P	Predictable shock condition
U	Unpredictable shock condition
ITI	Intertrial Interval
ASI	Anxiety Sensitivity Index
ACQ	Anxiety Control Questionnaire

LIST OF ABBREVIATIONS (continued)

BIS/BAS	Behavioral Inhibition and Behavioral Activation Scale
GTS	General Temperament Survey
SNAP	Schedule for Non-Adaptive and Adaptive Personality
IBI	Inter-Beat-Interval
CD	Countdown
ANOVA	Analysis of Variance
CS	Condition Stimulus

SUMMARY

Prior research indicates that individual differences in RSA are an important predictor of aversive emotional responding. One indicator of aversive responding is an exaggerated potentiated startle to threat. While a few studies have shown an association between RSA and abnormal startle potentiation, no study to date has distinguished predictable from unpredictable threat. This is an important distinction given that separable aversive states are elicited by each type of stimulus. Thus, in the present study, we examined whether resting RSA predicts startle response and/or self-reported anxiety during threat of predictable and unpredictable shock in 92 college students. Resting RSA was collected for a total of 6 minutes. Afterwards, participants completed a 10 minute computerized shock task in which predictable and unpredictable electric shocks were delivered. Results indicated that those with lower resting RSA evidenced exaggerated potentiated startle in response to unpredictable, but not the predictable, threat. These findings are in line with a growing body of literature noting that individual differences in resting RSA are an important indicator of anxious responding and extend previous work by highlighting the specificity of the relationship between low RSA and contextual anxiety/unpredictable threat. These results also implicate potential shared underlying mechanisms between low RSA and clinical anxiety.

INTRODUCTION

In the U.S., anxiety disorders are associated with severe behavioral and economical consequences and have an estimated lifetime prevalence rate of approximately 29% (Kessler et al., 2005). As such, researchers have long been interested in examining the physiological substrates of anxiety and anxiety disorders. Specifically, there is a long history of experimental literature exploring potential autonomic nervous system (ANS) deficits in those with clinical anxiety (Stein, Tancer, & Uhde, 1992; Lader, 1980; Eysenck, 1970). Although pathological anxiety was initially thought to represent an autonomic system liability or hyperactivity (Cannon, 1939), more recent conceptualizations have taken a systems theory approach to classification which posits that biological flexibility among the elements of a living system, in response to a changing environment, is indicative of adaptive responding (Nesselroade, 1990). In other words, adaptive physiology is associated with high levels of variability. This perspective has significantly influenced current psychophysiological models of anxiety and has suggested that pathological anxiety may be viewed as an autonomic inflexibility or an inability to adaptively respond to environmental demands. Since the autonomic nervous system regulates cardiac functioning, several psychophysiological models of anxiety highlight the importance of cardiovascular activity (Friedman & Thayer, 1998; Thayer & Friedman, 1997). Specifically, deficits in autonomic nervous system cardiac control are thought to underlie pathological states and clinical anxiety.

The ANS is composed of two functionally unique branches, the acceleratory sympathetic nervous system (SNS) and the deceleratory parasympathetic (PNS) nervous system. The dynamic interplay between the SNS and the PNS results in the regulation of numerous bodily systems including cardiac activity. The vagus, or the 10th cranial nerve, is specifically responsible for the PNS influences on cardiac functioning. Structurally, the vagus is bidirectional, containing both afferent and efferent fibers. These fibers originate in the brainstem and terminate in the sinoatrial (SA) node forming a

sophisticated negative feedback loop which regulates heartbeat (Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). Deficits within this feedback loop results in low cardiac vagal tone or low influence of the vagus on the heart's pacemaker. These deficits result in a lack of flexible responding to environmental demands and an inability to effectively self-regulate (Thayer & Lane, 2000) which has been shown to be associated with numerous emotional deficits (Porges, 1995, 1997), including pathological anxiety (see Beauchaine, 2001 for a review).

One non-intrusive way to index these vagal deficits in humans is to measure individual's heart rate variability (HRV). More specifically, researchers have particularly focused on baseline respiratory sinus arrhythmia (RSA) or the fluctuation of heart rate during the respiratory cycle (Berntson et al., 1997). During exhalation, there is an increase in vagal efference resulting in a decrease in heart rate and during inhalation, there is a decrease in vagal efference resulting in an increase in heart rate. This trait-like beat-to-beat fluctuation in the length of the cardiac cycle is termed heart rate variability and can be measured using time-frequency analyses of the high frequency region (0.12-0.40 Hz) of electrocardiogram recordings (ECG). RSA calculations utilizing the high frequency power band of ECG recordings have demonstrated high test-retest correlations (.76-.92) ranging from 3 days to 3 years suggesting that individual differences in HRV are fairly stable across time (Goedhart, Van Der Sluis, Houtveen, Willemsen, & Geus, 2007; Kleiger et al., 1991; Stein, Rich, Rottman, & Kleiger, 1995). Because the primary influence on the cardiac cycle is due to efferent projections from the nucleus ambiguus (NA) in the medulla oblongata, RSA is considered an index of parasympathetic vagal control rather than capturing both the sympathetic and parasympathetic system output (Porges, 1995). Additionally, the fast-acting parasympathetic influences on the SA node mediate complex behaviors such as attention, emotion, and social communication. As such, RSA is of particular interest in psychophysiological research.

HRV and Polyvagal Theory

One well accepted theory on the psychological sequelae of HRV is Porges' (1995) Polyvagal Theory. This theory has been groundbreaking in the psychophysiological study of heart rate variability and its role in behavior and serves as an important theoretical framework for the current study. Porges (1995) outlined the evolution of the ANS and observed that the mammalian vagus has a bidirectional relationship between the central nervous system and the heart which is responsible for distinct autonomic system responding necessary for emotion. This collection of lateralized neural pathways, originating in the brainstem, contain both efferent (i.e., motor) and afferent vagal fibers allowing the heart to receive sensory processing information from the brain, and the brain to receive afferent stimulation from the heart. More specifically, within the autonomic nervous system, there are three phylogenetically-ordered neural circuits that form a hierarchy of physiological responding and regulate the heart (Porges, 1998, 2001, 2003). The "immobilization system" (i.e., freeze responses) is the most phylogenetically primitive and is governed by the unmyelinated "vegetative" vagus, originating in the dorsal motor nucleus (DMNX). Next to evolve was the "mobilization system" which is responsible for fight or flight behaviors and is dependent on the sympathetic-adrenal system. The phylogenetically newest circuit, termed the "social communication system," is responsible for adaptive social behaviors including facial expressions, vocalization, and listening. This circuit is unique to mammals and is dependent on the myelinated vagus, which originates in the NA.

When confronted with environmental challenges, the phylogenetically newest system is employed first, and if unable to adequately provide safety, the phylogenetically older systems are sequentially recruited. Thus, when the environment is perceived as safe, the social communication system inhibits the lower order systems by increasing the influence of the myelinated vagus on cardiac functioning (i.e., increase in vagal tone). This results in self-soothing or calming behaviors and allows

for spontaneous social communication. However, when danger or threat is perceived and the social communication system no longer provides safety, vagal influences are withdrawn and the organism exhibits the fight, flight, or freeze responses. Temporary withdrawal of the NA vagal “break” is seen as adaptive; however, long-term (or chronic) withdrawal may be detrimental to the organism and responsible for behavioral and emotional dysfunction.

Given the association between vagal tone and emotional dysfunction, previous research has examined the relationship between HRV and aversive responding in diverse populations. While prior investigations have demonstrated the effects of anxiogenic manipulations on state HRV (Asmundson & Stein, 1994; Yeragani et al., 1994a; George et al., 1989), resting HRV has also been examined as a predictor of emotional responsivity. For example, lower resting HRV has been found to be associated with an attentional bias towards threat-related stimuli among those with pathological anxiety (Johnsen et al., 2003) and associated with significantly more self-reported anxiety among phobic flyers in response to phobic stimuli (i.e., flight related pictures and/or sounds) (Bornas et al., 2005). Further, among highly rejection sensitive individuals, those with lower resting RSA reported less emotional control and more hostility during conflicts with romantic partners than those with higher RSA (Gyurak & Ayduk, 2008). Resting HRV has also been shown to be associated with increased self-reported negative emotion when presented with ambiguous stimuli (Kettunen, Ravaja, Naatanen & Keltikangas-Jarvinen, 2000) and during conversations about a negative film (Butler, Wilhelm, & Gross, 2006). Moreover, those with lower resting HRV have been shown to evidence longer cardiac recovery from an acute psychological stressor relative those with higher resting HRV (Souza et al., 2007) and have been shown to have an increased cortisol response to a cognitive stressor (Johnsen, Hansen, Sollers, Murison, & Thayer, 2001). Similarly, among those with posttraumatic stress disorder (PTSD), lower resting HRV has been associated with significantly prolonged arousal to trauma scripts compared to those with higher HRV

suggesting that even among those with an anxiety disorder, HRV is an important moderator of aversive responding (Sack, Hopper, & Lamprecht, 2004). Taken together, these studies suggest that individual differences in HRV are an important predictor of aversive and anxious responding.

Startle as an Index of Aversive States

The startle response is another widely used psychophysiological measure of aversive responding that is specifically sensitive to internal affective states. Startle response has been repeatedly used in investigations of emotional processes and is commonly operationalized as the reflexive eyeblink response (i.e., rapid contraction of the orbicularis oculi muscle below the eye) to a brief, unexpected intense stimulus (e.g., a broadband white noise at 90-110dB). The eyeblink response is one of the most consistent components of the human startle response and is relatively easy to record; thus, contributing to its widespread use in psychophysiology (Blumenthal et al., 2005).

Previous research has also consistently demonstrated an affect-modulated startle response (Lang, 1995). More specifically, research has shown that during activation of appetitive motivational states (e.g., approach, reward), the startle response is inhibited and during activation of aversive motivational states (e.g., withdrawal, threat), the startle response is potentiated (Bradley, Cuthbert, & Lang, 1999). Thus, the affective modulation of the startle response can be used as an index of internal affective states. The affect-modulation of startle has been observed using numerous emotional stimuli/inductions including the passive viewing of pictures (Bradley, Cuthbert, & Lang, 1993), film clips (Jansen & Frijda, 1994), listening to emotional sounds (Bradley & Lang, 2000), and during threat of shock (Grillon et al., 2008). Moreover, unlike other psychophysiological markers of arousal (e.g., skin conductance), startle modulation is particularly sensitive to changes in the valence (i.e., positive vs. negative) of the individual's emotional state (Lang, Bradley, & Cuthbert, 1990).

Individual differences in startle response have also been examined among those with anxiety disorders. Specifically, exaggerated startle responses have been found in those with PTSD (Metzger et al., 1999), phobias (de Jong, Visser, & Merckelbach, 1996), and panic disorder (Grillon et al., 2008) suggesting trait-like affective differences between these groups and normal controls. Further, anxiolytic drugs (i.e., benzodiazepines) have been shown to depress baseline startle (Rodriguez-Fornells, Riba, Gironell, Kulisevsky, & Barbano, 1999). These findings are consistent with the idea that changes in state anxiety should reflect changes in startle reactivity and supports the rationale for using startle methodology as an index of aversive states.

Given that both HRV and startle have been shown to be important in affective behavior, research has begun to explore the relationship between resting HRV and the startle response. In one study, females were shown pleasant, neutral, and unpleasant pictures while acoustic startle probes were delivered during both picture viewing and between trials (Ruiz-Padial, Sollers, Vila, & Thayer, 2003). Results indicated that lower resting HRV was related to increased startle reactivity during the affective stimuli and between trials. Additionally, those with the highest HRV evidenced the expected pattern of startle potentiation to the unpleasant pictures and startle inhibition to the pleasant pictures in comparison to the neutral stimuli. However, those with the lowest HRV evidenced potentiated startle in response to both the neutral and the pleasant pictures. The authors argued that these findings may suggest a higher overall startle sensitivity among those with lower baseline HRV.

A more recent report by Melzig, Weike, Hamm, & Thayer (2009) expanded on these findings by examining the relationship between trait HRV and startle reactivity in two studies. Using a threat of shock paradigm, the authors conducted one study with college students with varying levels of anxiety sensitivity (AS; a putative risk factor for panic disorder; Schmidt, Lerew, & Jackson, 1999) and a second with unmedicated panic disorder patients. Given that threat of shock paradigms have been shown to

elicit more robust affect-modulation than affective picture viewing (Lissek, Orme, McDowell, Johnson, & Grillon, 2004), these studies were an important extension of Ruiz-Padial et al. (2003). Results from both studies indicated no differences in startle potentiation due to levels of AS or panic diagnoses. However, lower baseline HRV was associated with increased startle response during threat of shock, independent of group for both studies. Results from these studies are consistent with Ruiz-Padial et al. (2003) and provide support for exaggerated fear-potentiated startle among those with lower resting HRV.

Although Melzig et al. (2009) demonstrated an important relationship between HRV and startle responsivity, certain aspects of their methodology prevent it from being a definitive test of this association. First, both studies contained relatively small sample sizes. Study 1 included 22 individuals high in AS and 21 individuals low in AS while Study 2 included 9 unmedicated panic patients and 15 healthy controls. Second, participants were dichotomized into high AS versus low AS rather than examining the variable continuously. As discussed in Maxwell & Delaney (1993), categorizing a continuous variable results in a loss of power and ability to detect true statistical differences. Further, such techniques can significantly distort relationships and subsequently create spurious results. Thus, the fact that Melzig et al. (2009) did not find significant differences in startle-potentiation among those with high versus low AS may have been because they examined AS dichotomously rather than as a continuous variable.

Most importantly, Melzig et al.'s (2009) threat of shock manipulation failed to address the important distinction between the emotions of fear and anxiety. Fear has been defined as a phasic response to an identifiable stimulus (and the "fight or flight" response) while anxiety is considered to be a generalized feeling of apprehension which is not associated with any clearly identifiable source (Davis, 1998; Grillon, 2002; Barlow, 2000). Another useful way of conceptualizing fear versus anxiety

is that they are emotions induced by predictable and unpredictable aversive stimuli, respectively (Grillon et al., 2008). Therefore, within a threat of shock paradigm, two distinct aversive states can be elicited. Fear in response to a predictable threat and anxiety in response to an unpredictable threat (Grillon, 2002). Moreover, a growing body of literature supports this distinction. Grillon et al. (2008) found that those with panic disorder and healthy controls displayed comparable potentiated startle in response to neutral and predictable threat of shock cues. However, those with panic disorder evidenced exaggerated potentiated startle in response to an unpredictable threat of shock suggesting a vulnerability to unpredictability among those with panic disorder. In line with these findings, a prior investigation reported that in comparison to a placebo, a benzodiazepine (i.e., sedative) was shown to reduce anxiety-potentiated but not fear-potentiated startle (Grillon et al., 2006). Neurobiological research using rodents corroborates this distinction by identifying separate neurological pathways for the emotions of fear and anxiety (Davis, 1998). Although both pathways are associated with the amygdala and are responsible for startle modulation, fear is more related to the central nucleus (CeA) of the amygdala while anxiety is more related to the bed nucleus of the stria terminalis (BNST).

Although the distinction between predictability and unpredictability is necessary for the proper interpretation of research findings, the shock manipulation in Melzig et al. (2009) does not clearly make this distinction. During their task, participants were told that different colored slides represented safe periods where no shocks would be delivered (i.e., blue slides) or threat of shock periods in which 1-3 shocks would be administered (i.e., yellow slides). Therefore, the threat of shock slides were both predictable in that participants knew they would receive at least 1 shock, and also unpredictable in that they did not know how many shocks or at which time point the shocks would be delivered. As such, this design confounds fear and anxiety and leaves the relationship between trait HRV and predictable and unpredictable aversive cues unexplored.

Present Study

The current study will address this important distinction between fear and anxiety in an attempt to further elucidate the relationship between resting HRV and aversive responding. In addition, the current study will aim to replicate and expand prior investigations by utilizing a significantly larger sample size ($N = 92$) and explore AS continuously as a potential moderator of the relationship between resting HRV and aversive responding. Given the exploratory aims of the current study, we did not form specific hypotheses about the nature of the relationship between RSA and predictable or unpredictable threat. It is possible that those with lower resting RSA will evidence exaggerated startle-potential in response to the unpredictable condition only, the predictable condition only, or both the predictable and unpredictable conditions.

In addition, prior investigations have suggested that anxiety disorders may moderate the relationship between HRV and aversive responding. For example, although panciogenic manipulations such as sodium lactate administrations and controlled ventilation have been shown to be marked by decreases in HRV in healthy individuals, these effects seem to be larger in those with panic disorder (Yeragani et al., 1993; Yeragani, Srinivasan, Balon, Ramesh, & Berchou, 1994b). Therefore, low HRV is more correlated with panciogenic manipulations in those with panic disorder than in healthy controls. Additionally, those with generalized anxiety disorder (GAD), in comparison to controls, have been shown to have significantly lower vagal tone in response to baseline, relaxation, and worry laboratory conditions (Thayer, Friedman, & Borkovec, 1996). Moreover, individuals with PTSD have been shown to have greater reductions in HRV in response to both trauma recall and mental arithmetic tasks whereas no group differences were found during a resting baseline recording period (Keary, Hughes, & Palmieri, 2009).

It is also possible that personality factors that predispose individuals for anxiety disorders may also moderate the association between HRV and aversive responding. Within the literature, there are several personality risk factors that have been shown to predict the onset of anxiety disorders. As previously mentioned, AS has predicted the onset of panic attacks (Schmidt et al., 1997) and is considered a putative risk factor for panic disorder (McNally, 2002; Schmidt, Lerew, & Jackson, 1999). Similarly, trait negative emotionality, or one's tendency to experience negative affect, in late adolescence has been shown to predict the onset of anxiety disorders in adulthood (Krueger, 1999; Angst & Vollrath, 1991). Another well known risk factor, behavioral inhibition, has also been shown to predict anxiety disorder onset and is associated with greater familial loadings of anxiety disorders (Rosenbaum, Biederman, Bolduc-Murphy, & Faraone, 1993). Lastly, one's perceived control over anxiety-related events is associated with susceptibility to anxiety disorders and has been shown to be predictive of anxiety symptoms and anxiety-related distress (Chorpita & Barlow, 1998; Zvolensky, Eifert, Lejuez, Hopko, & Forsyth, 2000). In particular, perceived control is considered to be a risk factor for panic-spectrum disorders (Barlow, 2002). As such, the current study will explore whether these personality risk factors (AS, negative emotionality, behavioral inhibition, and perceived control over anxiety-related events) moderate the relationship between HRV and aversive responding.

METHODS

Participants

A total of 110 introductory psychology students at the University of Illinois at Chicago (UIC) participated for course credit. However, 18 participants were excluded from analyses for producing less than 4 blinks (50% of startle data) in any one condition. As such, the final $N = 92$. Participants were 57.6% female with an average age of 19.4 years ($SD = 2.0$). Eligibility included right handedness and no history of head trauma. Consistent with the demographics of undergraduates at UIC, the sample was

ethnically diverse with 37.0% Caucasian, 29.3% Latino, 18.5% Asian, 7.6% African American, and 7.6% “Other.”

Procedure

Data collection took place from February, 2009 to March, 2010. Upon arrival to the testing session, participants provided written informed consent. All aspects of the study and the consent form were approved by the University Institutional Review Board. Following informed consent, electrodes were placed on the individual. After electrode placement, participants were seated in an electrically-shielded, sound-attenuated booth approximately 3.5 feet from a 19-inch computer monitor where visual stimuli were presented. Next, baseline ECG data was collected during alternating 90 second, eyes open versus eyes closed recording conditions for a total of 6 minutes (counterbalanced: OCCO vs. COOC). After collection of the resting HRV data, two electrodes were placed on the participants’ wrist of their left hand for administration of the electrical shocks. In order to allow participants to habituate to the acoustic noise probes and prevent early exaggerated startle responses, participants completed a 2.5 minute baseline task in which 9 acoustic startle stimuli were presented. Next, a work-up shock procedure, consistent with prior studies (Grillon, Baas, Lissek, Smith, & Milstein, 2004), was completed in which participants received increasing levels of shock intensity until they reached a level which they described as being “highly annoying but not painful.” We determined shock level ideographically to be consistent with prior studies (Grillon et al., 2004), and given the large individual differences in perceived aversiveness of shocks (Rollman & Harris, 1987), to ensure that subjects experienced the shocks as equally aversive. Following the work up, the shock task (described below) was administered for a total of 10 minutes. Afterwards, participants completed a battery of self-report measures assessing personality risk factors for anxiety disorders.

Stimulus Delivery

Stimuli were administered using PSYLAB (Contact Precision Instruments, London, UK) and baseline ECG and startle data were acquired using Neuroscan 4.3 (Compumedics, Charlotte, NC). The acoustic startle probe was a 40-ms duration, 103 dB burst of white noise with near instantaneous rise time presented binaurally through headphones. Two 4-mm Ag/AgCl electrodes were placed over the orbicularis oculi muscle below the right eye for startle blink measurement. As per published guidelines (Blumenthal et al., 2005), one electrode was placed 1 cm below the pupil and the other electrode was placed 1 cm lateral. One electrode was also placed on the participant's sternum and another below the left clavicle to record heart rate. Data was collected using a bandpass filter of DC-200 Hz at a sampling rate of 1000 Hz. The ground electrodes were placed along the midline of the anterior scalp and the reference was located between electrodes CZ and CPZ. The electric shocks lasted 40-ms and were administered to the wrist of the participants' left hand. The maximum shock level a participant could achieve was 5 μ A and within our sample, the mean shock level was 2.42 μ A ($SD = 1.28$).

Shock Task

The threat of shock task was modeled after earlier studies investigating the role of predictability versus unpredictability using a threat of shock paradigm (Grillon et al., 2004; Grillon et al., 2008). The task included three conditions - no shock (N), predictable shock (P), and unpredictable shock (U). During each condition, text was continuously displayed at the bottom of the computer screen which indicated either "no shock", "shock at 1", or "shock anytime," ensuring participants were always aware of the current type of trial (see **Figure 1**). In addition to the text at the bottom of the screen, a countdown was intermittently displayed for 6-seconds, five times within each 90-second condition. Startle probes were delivered and subsequent blink reflexes were recorded during and between countdowns, across all trials. During predictable conditions, the countdown signaled exactly when the shock would occur (i.e.,

when the countdown reached 1) and therefore the shock was completely predictable. During the unpredictable conditions, the countdown was meaningless and shocks could occur at anytime, including when the countdown was not on the screen (i.e., intertrial intervals). During the no shock conditions, no shocks were delivered. Prior investigations using this paradigm (i.e., Grillon et al., 2004; Grillon et al., 2006; Moberg & Curtin, 2009) have utilized various 8-s geometric shapes as threat cues. For the present investigation, we instead chose to use a countdown. The reason for this change was to make shocks during the P condition *completely* predictable. That is, whereas an 8-s geometric cue provides more predictability compared to no cue, it does not provide complete predictability as participants do not know exactly when the shock will occur while the cue is on the screen. By using a countdown as the threat cue, shock timing was either completely predictable (as the countdown signaled exactly when the shock would occur) or completely unpredictable (as the countdown did not signal when the shock would occur). The intertrial intervals (ITIs) ranged from 7-17 s ($M = 12.4s$) and the time interval between a shock and a subsequent startle probe was always greater than 10-seconds to ensure that startle responses were not affected by an immediately preceding shock. Each of the three conditions was administered twice, in the following order (counterbalanced): PNUPNU or UNPUNP. All participants received 20 electric shocks (10 during P and 10 during U), and 48 startle probes (16 during N, 16 during P, and 16 during U).

After the task, participants rated their level of anxiousness during the countdown and ITI for each condition. The self-report response scales ranged from 1 (Not at all) to 7 (Extremely). Similarly, participants rated how intense, annoying, and anxiety provoking, on a scale ranging from 1 (Not at all) to 7 (Extremely), and the degree to which they would avoid the shocks, on a scale ranging from 1 (Would definitely not avoid) to 7 (Would definitely avoid).

Measures

Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky, & McNally, 1986; Taylor & Cox, 1998; Taylor et al., 2007). The ASI is a widely used self-report measure assessing one's fear of anxiety related sensations. Within the current study, we used the 36-item revised version of the original ASI (ASI-R; Deacon, Abramowitz, Woods, & Tolin, 2003; Taylor & Cox, 1998) plus the six items from the original Anxiety Sensitivity Index (ASI-O) that were dropped from the ASI-R. This allowed us to construct all three versions of the ASI: the 16-item ASI-O (Reiss, Peterson, Gursky, & McNally, 1986), the 36-item ASI-R, and the recently developed 18-item ASI-III (Taylor et al., 2007), which consists of a subset of items from the ASI-R. Participants are instructed to rate their beliefs about the consequences of different anxiety symptoms on a 5-point Likert scale with 0 indicating "not at all" and 4 indicating "very much". Sample items include "It scares me when my heart beats rapidly" and "It is important for me not to appear nervous." The ASI has been shown to have good reliability and validity (Peterson & Kirsten, 1999).

Anxiety Control Questionnaire (ACQ; Rapee, Craske, Brown, & Barlow, 1996). The ACQ is a 30-item self report questionnaire used to assess perceived control over anxiety-related events. Participants are instructed to rate their degree to which they agree with each item on a 6-point Likert scale ranging from 0 ("strongly disagree") to 5 ("strongly agree"). Sample items include "My emotions seem to have a life of their own" and "I can usually stop my anxiety from showing." In addition to a total score, subscales including reactions to internal stimuli and perceived control over external events can also be calculated. Total scores range from 0 to 150. The ACQ has been shown to have excellent internal consistency and good test-retest reliability in both clinical and non-clinical populations (Rapee et al., 1996).

Behavioral Inhibition and Behavioral Activation Scale (BIS/BAS; Carver & White, 1994). The BIS/BAS is a 24-item self report measure of two broad motivational constructs, behavioral inhibition and behavioral activation. For the current study, only the 7-items pertaining to the behavioral inhibition scale (BIS), including dispositional response to threat and novelty, were used in analyses. Participants are instructed to rate the extent to which they agree with each item on a 4-point Likert scale with 1 indicating “strongly disagree” and 4 indicating “strongly agree.” Sample items include “I worry about making mistakes” and “Criticism or scolding hurts me quite a bit.” The BIS has been shown to have adequate internal consistency and test-retest reliability and good convergent and discriminate validity (Carver & White, 1994). Prior research has also demonstrated an association between the BIS and measures of anxiety symptoms, negative affect, and neuroticism (Carver & White, 1994; Huebeck, Wilkinson, & Cologan, 1998).

General Temperament Survey (GTS; Watson & Clark, 1993). The GTS is a 90-item true/false self-report measure used to assess three broad dimensions of personality including positive temperament, negative temperament, and disinhibition-constraint. Given the aims of the current project, only the negative temperament subscale was used in analyses. This scale assesses ones’ tendency to experience negative emotions including anxiety, anger, and sadness. Sample items include “I am often nervous for no reason” and “I am often troubled by guilt feelings.” The GTS is widely used in empirical research and has been shown to have good reliability and validity (Watson & Clark, 1993). Additionally, the GTS was incorporated into the Schedule for Non-adaptive and Adaptive Personality (SNAP; Clark 1993) self-report personality inventory.

HRV Data Processing

As previously mentioned, resting ECG was acquired using Neuroscan 4.3 (Compumedics, Charlotte, NC). Data was initially processed using QRSTool (Allen, Chambers, & Towers, 2007) and all

artifacts were identified and corrected by hand. After initial correction, inter-beat-interval (IBI) series were extracted for each 90s eyes open vs. eyes closed recording block. Each block was then inputted into CardioEdit (Brain-Body Center, University of Illinois at Chicago) for further artifact correction. After data was processed, average RSA was calculated for each condition using CardioBatch (Brain-Body Center, University of Illinois at Chicago). Based on methods developed by Porges (1985), RSA was calculated using the following procedures. First, IBIs were resampled into 500 ms intervals to produce time-based data and a 21-point moving polynomial cubic filter was stepped through the time-based data to produce a smoothed template series. Next, the template was subtracted from the original time series and a digital bandpass filter was applied to this detrended time series to extract variance in the frequency band associated with spontaneous breathing in adults (.12-.40 Hz). Lastly, the amplitude of RSA was calculated using the natural logarithm (\ln) of the bandpassed time series.

Startle Data Processing

Blinks were scored according to guidelines provided by Blumenthal et al. (2005). Data was first rectified and then smoothed using a FIR filter with a band pass of 28-40 Hz. Peak amplitude of the blink reflex was defined within the 20-100 ms time frame following the startle probe onset relative to baseline (average baseline EMG level for the 50 ms preceding the startle probe onset). Blinks were scored as non-responses if EMG activity during the 20-100 ms post-stimulus time frame did not produce a blink peak that was visually differentiated from baseline activity. Blinks were scored as missing if the baseline period was contaminated with noise, movement artifact, or if a spontaneous or voluntary blink began before minimal onset latency and thus interfered with the startle probe-elicited blink response. Eighteen participants were classified as non-responders and were excluded from analyses because they did not produce at least 4 blinks during each condition (50% of the blinks in a condition). We chose to analyze blink magnitude (i.e., condition averages include values of 0 for non-response trials), as this is a more

conservative estimate of blink response (Blumenthal et al., 2005). Blink magnitudes were also standardized within-subjects using a *t transformation*, which reduces the influence of an individual's outlier blink responses. *T* scoring blinks also provides for better comparison between-subjects, as changes in blink magnitude amongst 'big blinkers' can be better compared to changes in blink magnitude amongst 'small blinkers'.

Data Analysis Plan

Analyses were conducted with startle magnitude *t* scores and self-reported anxiety as the dependent variables. Similar to other studies (e.g., Moberg & Curtain, 2009), we created four separate potentiation scores to capture the unique influence of predictable and unpredictable threat on startle magnitude and self-reported anxiety. Specifically, we subtracted responses during the neutral ITI from both the predictable and unpredictable ITI (i.e., P-ITI minus N-ITI and U-ITI minus N-ITI) and responses during the neutral countdown from the predictable and unpredictable countdown (i.e., P-CD minus N-CD and U-CD minus N-CD).

All continuous predictors were mean centered. Baseline demographic variables and shock level were first examined for associations with startle magnitude. We then conducted separate repeated measures ANOVAs to examine the unique and interactive effects of RSA on startle magnitude and self-reported anxiety. In line with our secondary aims, we conducted six additional repeated measures ANOVAs to examine the moderating effect of RSA on anxiety disorder risk factors (i.e., ACQ total score, ASI original total score, ASI-R total score, ASI-III total score, BIS total score, and the GTS negative emotionality subscale) and startle magnitude.

Results

Sample Characteristics and Descriptive Data

Descriptive data for RSA values during the eyes open and eyes closed baseline recording blocks and self-report anxiety disorder risk factors including the ASI, ACQ, BIS, and GTS negative emotionality subscale are displayed in **Table 1**. All skewness values were below 0.97 and kurtosis values were below 2.30 for RSA, self-report measures, and startle magnitude during each condition, suggesting that no variable required transformation.

Baseline RSA

To examine whether there were any significant differences in baseline RSA during the eyes open versus the eyes closed recording blocks, we conducted a repeated measures ANOVA with the average of the two eyes open blocks and the two eyes closed blocks entered as within-subjects variables. Results indicated that there was no statistically significant difference in RSA when eyes were open and when eyes were closed [$F(1,91) = 2.01, p = .159, \eta_p^2 = .02$]. As such, we were able to ignore the eyes open vs. closed variable during the baseline recording session.

Prior to calculating average RSA, we also examined whether there were differences in RSA across time. Specifically, we conducted a repeated measures ANOVA with the 4 (2 eyes open and 2 eyes closed) 90-second blocks entered as within-subject variables. Our results revealed that RSA significantly decreased during each of the four recording periods [$F(3,273) = 13.19, p = .000, \eta_p^2 = .13$]. This natural decrease in RSA over the experimental session has been attributed to sustained attention (Suess, Porges, & Plude, 1994; Porges & Raskin, 1969, see **Figure 2**). Pearson's correlations among the 4 blocks revealed high rank-order stability of participant's RSAs across the four blocks (all r 's $> .81, p < .001$). Thus, given that each participant evidenced a similar decrease in RSA over time, we were able to collapse all four blocks and use the average RSA score in subsequent analyses.

Shock Task Manipulation

Participants rated the shocks as moderate to extremely intense ($M = 4.57$, $SD = 1.07$), annoying ($M = 5.85$, $SD = 1.24$), and anxiety provoking ($M = 4.95$, $SD = 1.51$). Participants also rated that they would avoid receiving the shocks again to a high degree ($M = 5.24$, $SD = 1.60$). These results indicate that shocks were successfully perceived as aversive. RSA was not significantly associated with any of the self-report shock ratings (all p 's $> .26$).

Identification of Covariates

In order to identify potential covariates, we conducted separate Condition x Cue x potential covariate (i.e., gender, age, race and shock level) repeated measures ANOVAs where Condition and Cue were entered as within-subjects variables, potential covariates were entered as a between-subject variables, and startle magnitude was the dependent variable. If we found any significant Condition x Cue x covariate interactions, these variables would be included as covariates in subsequent analyses. These results revealed that there were no significant 3-way interactions for any of the above covariates (all p 's $> .318$).

RSA and Startle Responses during the Shock Task

Mean startle magnitude t scores and startle potentiation scores (e.g., P-ITI minus N-ITI and U-ITI minus N-ITI) are displayed in **Figure 3**. To examine the unique and interactive effects of RSA on startle magnitude, we conducted a Condition (N vs. P vs. U) x Cue (ITI vs. countdown) x RSA repeated measures ANOVA with Condition and Cue entered as within-subjects variables and RSA entered as a (continuous) between-subjects variable. Findings indicated there was a main effect for Condition [$F(2,180) = 142.95$, $p = .000$, $\eta_p^2 = .61$] in that startle magnitude was significantly higher during the unpredictable condition in comparison to the neutral condition [$F(1,90) = 240.81$, $p = .000$, $\eta_p^2 = .73$], and significantly higher during the predictable condition in comparison to the neutral condition [$F(1,90)$]

= 14.14, $p = .000$, $\eta_p^2 = .14$]. In addition, startle was significantly higher during the unpredictable condition than in the predictable condition [$F(1,90) = 152.08$, $p = .000$, $\eta_p^2 = .63$] (i.e., $U > P > N$). There was also a main effect for Cue with startle being significantly higher in response to the countdowns than the ITIs [$F(1,90) = 67.71$, $p = .000$, $\eta_p^2 = .43$]. However, there was no significant main effect for RSA [$F(1,90) = 3.10$, $p = .082$, $\eta_p^2 = .03$].

Most importantly, results also indicated that there was a significant Condition x Cue x RSA interaction [$F(2,180) = 3.81$, $p = .024$, $\eta_p^2 = .04$]. Follow-up analyses were conducted for RSA x Condition at each level of Cue to determine whether there were significant two-way interactions during the ITI and/or countdowns. During the ITI, results indicated that there was a significant Condition x RSA interaction [$F(2,180) = 5.13$, $p = .007$, $\eta_p^2 = .05$]. However, there was no significant Condition x RSA interaction during the countdown cues [$F(2,180) = 1.85$, $p = .161$, $\eta_p^2 = .02$].

Given the significant Condition x RSA interaction during the ITI, we conducted follow-up Pearson's correlations between the predictable and unpredictable potentiation scores and RSA. Results indicated that there was a significant negative correlation between startle magnitude during the unpredictable ITI and resting RSA ($r = -.29$, $p = .004$). Specifically, those with lower resting RSA evidenced significantly higher startle potentiation during the unpredictable ITI. RSA was not significantly associated with startle potentiation during the unpredictable countdown ($r = -.05$, $p = .661$), predictable countdown ($r = .17$, $p = .116$), and predictable ITI ($r = -.15$, $p = .149$). The significant relationship between lower RSA and increased startle potentiation during the unpredictable ITI is displayed in **Figure 4**.

RSA and Self-Reported Anxiety during the Shock Task

In addition to startle responses, we also examined the unique and interactive effects of RSA on self-reported anxiety during the shock task (see **Figure 3b**). Specifically, we conducted a Condition (N

vs. P vs. U) x Cue (ITI vs. countdown) x RSA repeated measures ANOVA with Condition and Cue entered as within-subjects variables and RSA entered as a (continuous) between-subjects variable, with self-reported anxiety as the primary dependent variable. Results indicated that there was a significant main effect for Condition [$F(2,180) = 161.40, p = .000, \eta_p^2 = .64$] such that self-reported anxiety was significantly higher during the unpredictable condition in comparison to the neutral condition [$F(1,90) = 219.93, p = .000, \eta_p^2 = .71$], and significantly higher during the predictable condition in comparison to the neutral condition [$F(1,90) = 123.09, p = .000, \eta_p^2 = .58$]. In addition, self-reported anxiety was significantly higher during the unpredictable condition in comparison to the predictable condition [$F(1,90) = 78.97, p = .000, \eta_p^2 = .47$] (i.e., $U > P > N$). Moreover, results indicated that there was a main effect for Cue in that self-reported anxiety was significantly higher during the countdown in comparison to the ITI [$F(1,90) = 14.53, p = .000, \eta_p^2 = .14$].

Results revealed a significant Condition x Cue interaction [$F(2,180) = 9.53, p = .000, \eta_p^2 = .10$]. To follow-up the significant interaction, we conducted two additional repeated measures ANOVAs for Condition at each level of Cue. During the ITI, there was a significant effect for Condition [$F(2,180) = 138.95, p = .000, \eta_p^2 = .61$] with higher self-reported anxiety during the unpredictable condition in comparison to the neutral [$F(1,90) = 219.39, p = .000, \eta_p^2 = .71$] and predictable [$F(1,90) = 75.30, p = .000, \eta_p^2 = .46$] conditions and higher reported anxiety during the predictable condition in comparison to the neutral [$F(1,90) = 84.48, p = .000, \eta_p^2 = .48$] condition. Similarly, during the countdown, there was also a significant effect for Condition [$F(2,180) = 117.26, p = .000, \eta_p^2 = .57$] with higher self-reported anxiety during the unpredictable condition in comparison to the neutral [$F(1,90) = 155.01, p = .000, \eta_p^2 = .63$] and predictable [$F(1,90) = 24.99, p = .000, \eta_p^2 = .22$] conditions and higher reported anxiety during the predictable condition in comparison to the neutral [$F(1,90) = 124.43, p = .000, \eta_p^2 = .58$] condition. Thus, the task successfully induced anxiety in the predicted direction.

In regard to RSA, there was no significant main effect [$F(1,90) = 0.16, p = .687, \eta_p^2 = .00$], Condition x RSA, or Cue x RSA interactions. There was also no significant Condition x Cue x RSA interaction [$F(2,180) = 0.87, p = .420, \eta_p^2 = .01$] with self-reported anxiety as the dependent variable. However, we chose to follow-up this interaction to fully describe the relationship between RSA and self-reported anxiety during the shock task and as a comparison to the startle results. Results indicated that during the ITIs and countdowns, there was no significant Condition x RSA interaction, $F(2,180) = 0.261, p = .771, \eta_p^2 = .01, F(2,180) = 0.400, p = .671, \eta_p^2 = .00$, respectively.

We also conducted Pearson's correlations between RSA and each self-report change score (i.e., P-ITI minus N-ITI and U-ITI minus N-ITI). Results indicated that RSA was not associated with self-reported anxiety during the predictable countdown ($r = .00, p = .982$), predictable ITI ($r = -.08, p = .474$), unpredictable countdown ($r = -.07, p = .523$), or unpredictable ITI ($r = -.03, p = .804$).

Anxiety Disorder Risk Factor x RSA Interactions

For our secondary aims, we conducted Condition (N vs. P vs. U) x Cue (text vs. countdown) x RSA x Anxiety Disorder Risk Factor (ACQ total score, ASI original total score, ASI-R total score, ASI-III total score, BIS total score, and the GTS negative emotionality subscale) repeated measures ANOVAs with startle magnitude as the primary dependent variable and each of the anxiety disorder risk factors in separate models. Condition and Cue were entered as within-subject factors and RSA and Anxiety Disorder Risk Factors entered as continuous between-subjects factors. Results indicated that there were no significant 4-way interactions. Results from each model are presented in **Table 2**.

Given that the BIS total score and the GTS negative emotionality subscale were highly correlated ($r = .58, p = .000$) and similarly represent the broad construct of negative emotionality/neuroticism (Elliot & Thrash, 2002), we averaged the two scales and examined whether overall neuroticism moderated the relationship between resting RSA and startle. Specifically, we computed z-scores for each

scale and then averaged them together to create a composite neuroticism score. Next, we conducted a Condition x Cue x RSA x Neuroticism repeated measures ANOVA with startle magnitude as the dependent variable. Similar to our previous analyses, there was a significant main effect for both Condition [$F(2,176) = 143.63, p = .000, \eta_p^2 = .62$] and Cue [$F(1,88) = 65.80, p = .000, \eta_p^2 = .43$]. However, there was no main effect for RSA [$F(1,88) = 1.92, p = .170, \eta_p^2 = .02$] or Neuroticism [$F(1,88) = 0.02, p = .887, \eta_p^2 = .00$].

Results indicated that there were no significant two-way or three-way interactions with the exception of a significant Condition x RSA effect [$F(2,176) = 4.17, p = .017, \eta_p^2 = .05$]. Of interest, results revealed that the Condition x Cue x RSA x Neuroticism interaction approached significance [$F(2,176) = 2.51, p = .084, \eta_p^2 = .03$]. Even though this only approached significance, we chose to follow-up this interaction given the exploratory nature of the question. Specifically, we conducted a median split and examined whether there was a significant Condition x Cue x RSA interaction at high versus low levels of neuroticism¹. At high levels of neuroticism, the three-way interaction was not significant [$F(2,88) = 0.11, p = .897, \eta_p^2 = .00$]. In contrast, at low levels of neuroticism, the Condition x Cue x RSA interaction was significant [$F(2,88) = 5.87, p = .004, \eta_p^2 = .12$]. Similar to the overall RSA model above, we followed-up the significant three-way interaction by testing whether there was a Condition x RSA interaction at each level of Cue. Results indicated that during the ITIs there was a significant Condition x RSA interaction [$F(2,88) = 5.29, p = .007, \eta_p^2 = .11$]. However, during the countdowns, the two-way interaction was not significant [$F(2,88) = 0.77, p = .469, \eta_p^2 = .02$].

Parallel to our primary analyses, we then conducted Pearson's correlations between RSA and startle potentiation during predictable and unpredictable threat at low levels of Neuroticism. During both the predictable ($r = -.33, p = .023$) and unpredictable ($r = -.38, p = .009$) ITIs, lower resting RSA was significantly associated with increased startle potentiation. As expected from the higher order analyses,

RSA was not significantly associated with the predictable ($r = .18, p = .230$) or unpredictable ($r = .06, p = .816$) countdowns.

Discussion

Prior research indicates that individual differences in RSA are an important predictor of aversive responding (Souza et al., 2007; Bornas et al., 2005; Johnsen et al., 2001). Further, some studies suggest that lower resting RSA predicts exaggerated fear-potentiated startle to threat (Ruiz-Padial et al., 2003, Melzig et al., 2009). However, no study to date has distinguished predictable from unpredictable threat which is an important distinction given that separable aversive states are elicited by each stimulus (see Davis, 1998). Thus, the aim of the current study was to examine whether resting RSA predicts startle response to predictable and unpredictable threat during a shock task. Results indicated that those with lower resting RSA evidenced significantly exaggerated startle-potential during the unpredictable condition. However, there was no significant association between resting RSA and startle during the predictable condition. Therefore, although it has been suggested that lower resting RSA may be associated with overall threat sensitivity (Ruiz-Padial et al., 2003), our findings suggest that this relation may be specific to unpredictable threat.

There are several potential mechanisms through which low RSA may affect aversive responding to unpredictable threat. Within the literature, RSA is often considered an index of self-regulation with lower levels of vagal tone indicating more difficulties regulating stress, emotional states, and attention (Friedman & Thayer, 1998; Thayer & Layne, 2000; Porges et al., 1996; Porges et al., 1994) and a vulnerability to sustained and prolonged dysregulation in response to aversive stimuli (Berntson et al., 1998). Therefore, given that unpredictable threat elicits heightened contextual anxiety (i.e., sustained apprehension in response to the experimental context), it is possible that those with low RSA are unable to effectively self-regulate and thus, evidence exaggerated aversive responding.

However, predictable threat does not produce sustained anxiety (Grillon, 2008) but rather a phasic fear response which does not necessarily require self-regulation capabilities (or at least requires less self-regulation) due to the limited period of danger. As such, in response to predictable threat, regardless of high or low resting RSA, all individuals are able to exhibit the normative (and evolutionarily adaptive) response of exaggerated startle.

It is also possible that low RSA, or an increased vulnerability to sustained dysregulation, may result in chronic heightened vigilance to unpredictable threat due to the limited environmental information provided during these conditions (Porges, 1992; D'Amato, 1974). In other words, individuals that are vulnerable to dysregulation may exhibit exaggerated aversive responding in situations in which the environment provides little (or no) information as to the presence of danger/threat (Berlyne, 1960). However, during the predictable conditions, sufficient environmental information is provided which may reduce vigilance, resulting in an appropriate startle response.

The specificity of this relationship to unpredictable stimuli is notable given the well-replicated finding that predictable aversive stimuli is preferable to unpredictable aversive stimuli (Badia, Harsh, & Abbott, 1979). Furthermore, animal research has long demonstrated that unpredictable aversive stimuli are associated with maladaptive behavioral responses which are consistent with symptoms of mood and anxiety disorders (Imada and Nageishi, 1982; Maier, 1991; Mineka & Kihlstrom, 1978). For example, unpredictable aversive events have been shown to be associated with heightened muscle tension, ulceration, and increased avoidance behavior in animals (Mineka & Kihlstrom, 1978; Seligman & Meyer, 1970; Weiss, 1970). However, these effects are not seen when aversive stimuli are made predictable (Mineka, Cook, & Miller, 1984; Mineka & Kihlstrom, 1978). Similarly, research involving humans suggests that unpredictable aversive stimuli are associated with greater levels of anxious responding (Grillon et al., 2004) and that when given a choice, individuals will choose predictable over

unpredictable aversive events (Lejuez, Eifert, Zvolensky, & Richards, 2000; Abbott & Badia, 1979).

Taken together, the predictability of an aversive stimulus is an important determinant of behavioral and psychological outcomes, with evidence suggesting that unpredictable threat may be more intrinsically aversive than predictable threat.

There have been several proposed theoretical explanations for the preference of predictable over unpredictable stimuli (see Imada & Nageishi, 1982 for review). For instance, the safety signal hypothesis (Seligman & Binik, 1977) posits that the aversive nature of unpredictability stems from the sustained level of anxiety it engenders and that predictable stimuli are less aversive due to periods of relief when the cue is not present (see Grillon et al., 2004). Therefore, during predictable conditions, the absence of the conditioned stimulus signals periods of safety. However, during unpredictable conditions, the conditioned stimulus does not convey reliable information which subsequently elicits contextual anxiety. Another theoretical explanation is the information hypothesis (D'Amato, 1974) which theorizes that the less information that is available about an environmental situation, the more aversive the situation becomes. In contrast, when any information can be gathered from the environment and uncertainty is reduced, the situation becomes more preferable. In regard to the current study, both of these theories may apply given that our unpredictable conditions did not include cued periods of relief and contained no environmental information as to when the shock would occur.

It is also important to consider the role of predictability in human anxiety disorders. Although anxiety disorders are heterogeneous and have both distinct and overlapping features, unpredictability is considered an important component of the development and maintenance of several disorders (Craske, Glover, & DeCola, 1995; Foa, Zinbarg, & Rothbaum, 1992). For example, a hallmark feature of panic disorder is the experience of recurrent unpredictable panic attacks and persistent apprehension of future attacks (American Psychiatric Association, 1994). Similarly, PTSD is thought to be the result of

unpredictable traumatic events and is associated with sustained heightened arousal (American Psychiatric Association, 1994). Both extant research and theory have supported the role of unpredictability in these disorders (Mineka & Zinbarg, 2006; Bouton et al., 2001; Foa et al., 1992), and it has been demonstrated that those with panic disorder and PTSD evidence exaggerated startle potentiation in response to unpredictable, but not predictable, threat (Grillon et al., 2008; Grillon et al., 2009). As such, some have suggested that contextual anxiety, not explicit fear, is what differentiates clinically anxious from non-anxious individuals (Grillon et al., 2008; Pole, Neylan, Best, Orr, & Marmar, 2003). Given that we found a relationship between RSA and startle during the unpredictable condition only, our findings suggest that similar to those with clinical anxiety, those with lower RSA may have a heightened sensitivity to unpredictable, rather than predictable, threat. Taken further, it is possible that low RSA may be a risk factor for the development of anxiety disorders.

Interestingly, in one of the few other studies that has examined the relation between startle and RSA, Melzig et al. (2009) found that lower resting RSA was associated with potentiated startle during a threat of shock task in which predictability was not clearly manipulated. Specifically, the threat of shock conditions within this study were both predictable in that participants knew they would receive at least 1 shock during a condition stimulus (CS), and also unpredictable in that they did not know how many shocks or at which time point the shocks would be delivered during the CS. Our current findings suggest that although the Melzig et al. (2009) threat of shock condition contained elements of predictability, there may have been enough unpredictability in the amount and timing of the shocks to elicit significant contextual anxiety.

In the present study, it is important to note that although both cues (i.e., ITI and countdown) during the unpredictable condition had the same meaning, our results indicated that resting RSA was associated with startle during the unpredictable ITI but not the unpredictable countdown. There are

several possible explanations for this finding. First, given our use of a within-subjects design, it is possible that the countdown became at least partially paired with the phasic fear response elicited during the predictable condition which resulted in carry-over effects (Macfie, Bratchell, Greenhoff, & Vallis, 1989). In other words, the countdown became a conditioned stimulus and subsequently induced similar startle responding in the predictable and unpredictable conditions. Notably, other studies utilizing a similar design have also reported carry-over effects during the startle task (Grillon et al., 2008; Grillon et al., 2004).

It is also important to consider how the situational strength of our task conditions may have influenced our ability to detect individual differences (Lissek, Pine, & Grillon, 2006; Cooper & Withey, 2009). A strong situation is an experimental condition in which an unambiguous cue is reliably paired with a hedonic or aversive outcome. A weak situation, on the other hand, is a condition in which the cue is ambiguous, unreliable, or associated with an outcome of low value or proximity. This distinction is important given that research indicates that strong situations tend to result in more uniform responses while weak situations allow individual difference factors (such as RSA) to influence behavioral and physiological responses (Lissek et al., 2006; Snyder & Ickes, 1985). Within the current study, the countdown may have become a strong situation in that an unambiguous cue (i.e., when the countdown reaches “1”) was reliability associated with receiving a shock in the predictable condition and this carried over to the unpredictable condition. However, the ITI did not signal reliable information and was relatively ambiguous in all three conditions, resulting in a weaker situation. Given that individual difference factors play more of a role in responding to weak versus strong situations, the difference in situational strength between the separate cues may have influenced our current results.

As was briefly discussed, other studies that have used this paradigm (i.e., Grillon et al., 2004; Moberg & Curtin, 2009) have utilized geometric shapes (e.g., 8-second square) as threat cues instead of

countdowns. While a geometric cue provides more predictability compared to no cue, the threat is not completely predictable as participants do not know exactly when it will occur while the cue is present. By using a countdown as the threat cue, our predictable condition was completely predictable, thus reducing any physiological anxiety that may be present during the ITI of the predictable condition. In other words, we were clearly able to distinguish predictability from unpredictability within the current study (see Nelson & Shankman, 2011).

Self-Reported Anxiety

Even though the task was effective in inducing changes in self-reported anxiety, unlike our findings for startle, our results indicated that there was no significant relationship between RSA and self-reported anxiety during any of the threat conditions. Although previous studies have reported an association between low RSA and self-reported anxiety during laboratory tasks (Butler et al., 2006; Bornas et al., 2005; Kettunen et al., 2000), it is possible that the extremely high levels of anxiety the shock paradigm produces, prevented us from detecting a significant relationship. Notably, when participants were asked to report how anxiety provoking they found the shocks on a scale of 1 (Not at all) to 7 (Extremely), 65.2% indicated scores greater than or equal to 5. Therefore, within the current study, there was a narrow range of responding. In addition, prior research has shown that electric shocks are highly anxiogenic and are considered more aversive than other unpleasant stimuli such as blasts of air (Grillon et al., 2004). Therefore, similar to the discussion above, the situational strength of our paradigm may have influenced our results and lead to the uniform responding amongst participants. Future research examining the association between RSA and self-reported anxiety may benefit by using a weaker anxiogenic stimulus.

Personality Moderators

For our secondary aims, we also examined whether anxiety disorder risk factors moderated the relationship between resting RSA and startle responses. Although previous studies have demonstrated a moderating effect of anxiety disorders on RSA and aversive responding (Keary et al., 2009; Yeragani et al., 1993), our results indicate that personality factors that may predispose individuals for anxiety disorders including anxiety sensitivity, trait negative emotionality, behavioral inhibition, and perceived control over anxiety related events may not have the same effect on startle. However, using a composite neuroticism score, we found some evidence that individuals with low neuroticism, but not high, evidenced a significant relationship between RSA and startle (although the omnibus test for interaction only approached significance). More specifically, among those with low neuroticism, lower resting RSA was significantly associated with increased startle potentiation to both the predictable and unpredictable ITIs. Since the observed findings were consistent across both the predictable and unpredictable ITIs even though the cues represented different meaning, we believe that there may have been carry-over effects from the ITI during the unpredictable condition, resulting in heightened contextual anxiety during both conditions. Therefore, these findings may add additional support to our primary analyses by demonstrating a significant relationship between low RSA and exaggerated startle in response to contextual anxiety.

Notably, few studies have examined whether resting RSA and personality factors interact to predict negative outcomes. However, one recent study by Ode, Hilmert, Zielke, & Robinson (2010), found that in a small sample of undergraduates ($N = 38$), resting HRV was *positively* associated with numerous problematic outcomes including daily stressful events, stress reactivity, negative affect, somatic symptoms, cognitive failures, and impulsivity among those with low, but not high, neuroticism. Although we also found this moderating effect of neuroticism, our results were in the opposite direction

such that resting RSA was *negatively* associated with startle magnitude in response to contextual anxiety. These discrepant results suggest that the relation between neuroticism, RSA, and problematic outcomes is complex and that there may be unique pathways and relationships depending on the observed outcomes (e.g., startle vs. daily self-report mood ratings). Interesting, our study and Ode et al. (2010) failed to find a relationship between HRV and negative outcomes at high levels of neuroticism which suggests that HRV may have less of an influence on aversive responding among these individuals. However, further research is needed to clarify these potential relationships.

It is also interesting to consider why we found these effects using a broad construct of negative emotionality/neuroticism, but were unable to demonstrate this relationship using more distinct risk factors such as anxiety sensitivity (i.e., a risk factor for panic disorder) or perceived control over anxiety related events. Although speculative, it is possible that the current findings are specific to more global indices of negative affect such as neuroticism or trait anxiety and thus, the other risk factor constructs may have been too narrow to influence the relationship between resting RSA and startle. Future work is needed to continue to elucidate the mechanism underlying the association between anxiety, low RSA, and aversive responding to unpredictable threat.

Limitations

Although these findings address important gaps within the literature, there are several limitations of note. First, our sample consisted of undergraduate college students and thus, our findings may not be generalizable across all populations. Moreover, given that RSA has been shown to decrease with age (Yeragani, Pohl, Berger, Balon, & Srinivasan, 1994c; Schwartz, Gibb, & Tran, 1991), it is unknown whether these findings apply to younger or older individuals. Second, although RSA has demonstrated relatively high test-retest correlations (.76-.92) ranging from 3 days to 3 years (Goedhart et al., 2007; Kleiger et al., 1991; Stein et al., 1995), it has been shown to be influenced by several state

factors including exercise, attention, and emotional states (Porges, 2001, 2007; Casadei et al., 1996). As such, we are unable to conceptualize resting RSA as a trait factor but rather an assessment of vagal efference on heart rate while at rest (Porges, 2007). Third, respiration rate was not controlled or monitored in the current study which has been suggested to influence RSA (Grossman & Taylor, 2007; Houtveen, Rietveld, & De Geus, 2002; Berntson, Cacioppo, & Quigley, 1993). However, it has been noted that respiration is less likely to be a confound during periods of rest. Additionally, prior investigations have found no association between respiration frequency and RSA amplitude (Denver, Reed, & Porges, 2007; Hatfield et al., 1998) and it has been suggested that controlled respiration (i.e., paced breathing) may introduce additional confounds, such as cortical influence on brain stem structures, which subsequently influences RSA (Porges, 2007, 1995; Sargunraj et al., 1996).

Implications and Future Directions

With these limitations in mind, there are several important implications of these findings. First, our results add to a growing body of literature noting that individual differences in resting RSA are an important indicator of anxious and aversive responding (Melzig et al., 2009; Souza et al., 2007; Bornas et al., 2005). Further, these findings extend prior research by highlighting the specificity of the relationship between low RSA and contextual anxiety/unpredictable threat. More specifically, the current study suggests that excessive vagal withdrawal or low levels of vagally mediated HRV may be a marker for sensitivity to unpredictability. These findings are notable given that it has similarly been suggested that those with anxiety disorders have a heightened sensitivity to unpredictability and low vagal tone is thought to characterize those with anxiety disorders (Cohen et al., 2000; Friedman & Thayer, 1998). Taken together, evidence suggests that RSA may be an important mechanism in the relationship between anxiety and sensitivity to unpredictable events, which is thought to underlie the development and maintenance of anxiety disorders (Craske et al., 1995). Further, these results implicate

potential dysfunction in both of the neurobehavioral circuitry underling vagal tone and sensitivity to unpredictability (i.e., the vagus nerve and the bed nucleus of the stria terminalis) and may subsequently shed light on the psychophysiology of clinical anxiety.

Given that individual differences in RSA are not only an important predictor of aversive responding but of emotion dysregulation more broadly, it is possible that RSA might also be associated with sensitivity to unpredictable reward. Individuals with low RSA are at risk for emotional dysregulation or liability (see Beauchaine, 2001), and therefore, may show deficits in self-regulation during anticipation of an unpredictable reward. Similar to threat, unpredictable reward produces a sustained hedonic apprehension which is associated with both perceived and physiological arousal (Kirsch et al., 2003; Knutson, Adams, Fong, & Hommer, 2001). Individuals that are unable to successfully modulate these emotions due to vagal deficits may exhibit prolonged arousal and abnormal responding. Moreover, this inability to self-regulate in response to unpredictable reward may lead to maladaptive coping behaviors such as substance use or engagement in risk behaviors. However, future research is needed to explore whether RSA is associated with unpredictable reward or threat (within the same study) and examine potential behavioral consequences of this relationship.

In sum, the findings from the current study help to clarify the existing relationship between RSA and fear-potentiated startle. Specifically, our results suggest that this association may be specific to unpredictable threat, such that individuals with low vagal tone exhibit normative fear responses yet elevated contextual anxiety. These findings are in line with research noting that individuals with low RSA experience difficulties in regulating emotional states (see Porges et al., 1994) and highlights the need for continued research on the pathways between vagal tone, clinical anxiety, and sensitivity to unpredictability.

REFERENCES

- Abbott, B., & Badia, P. (1979). Choice for signaled over unsignaled shock as a function of signal length. *Journal of the Experimental Analysis of Behavior*, *32*, 409–417.
- Allen, J.J.B., Chambers, A.S., & Towers, D.N. (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics. *Biological Psychology*, *74*, 243-262.
- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorder* (4th ed.). Washington, DC: Author.
- Angst, J., & Vollrath, M. (1991) The natural history of anxiety disorders. *Acta Psychiatrica Scandinavica*, *84*, 446-452.
- Asmundson, G.J.G., & Stein, M.B. (1994). Vagal attenuation in panic disorder: An assessment of parasympathetic nervous system function and subjective reactivity to respiratory manipulations. *Psychosomatic Medicine*, *56*, 187-193.
- Badia, P., Harsh, J., & Abbott, B. (1979). Choosing between predictable and unpredictable shock conditions: Data and theory. *Psychological Bulletin*, *86*, 1107-1131.
- Barlow, D. H. (2000). Unraveling the mysteries of anxiety and its disorders from the perspective of emotion theory. *American Psychologist*, *55*, 1247-1263.
- Barlow, D.H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2nd ed.). New York, NY: The Guilford Press.
- Beauchaine, T. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, *13*, 183-214.
- Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: McGraw-Hill.
- Berntson, G.G., Bigger, J.T., Cacioppo, J.T., Eckberg, D.L., Grossman, P., Kaufmann, P.G., Malik, M., Nagaraja, H.N., Porges, S.W., Saul, J.P., Stone, P.H., & van der Molen, M.W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, *34*, 623-648.
- Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology*, *30*, 183–196.
- Berntson, G.G., Sarter, M. & Cacioppo, J.T. (1998) Anxiety and cardiovascular reactivity: the basal forebrain cholinergic link. *Behavioural Brain Research*, *94*, 225–248.
- Blumenthal, T.D., Cuthbert, B.N., Filion, D.L., Hackley, S., Lipp, O.V., & van Boxtel, A. (2005).

Committee report: Guidelines for human startle eyeblink electromyographic studies. *Psychophysiology*, 42, 1-15.

- Bornas, X., Liabres, J., Noguera, M., Lopez, A.M., Barcelo, F., Tortella-Feliu, M., & Fullana, M.A. (2005). Self-implication and heart rate variability during simulated exposure to flight-related stimuli. *Biological Psychology*, 70, 182-187.
- Bouton, M. E., Mineka, S., & Barlow, D. H. (2001). A modern learning theory perspective on the etiology of panic disorder. *Psychological Review*, 108, 4–32.
- Bradley, M.M., Cuthbert, B.N., & Lang, P.J. (1993). Pictures as prepulse: Attention and emotion in startle modification. *Psychophysiology*, 30, 541-555.
- Bradley, M.M., Cuthbert, B.N., & Lang, P.J. (1999). Affect and the startle reflex. In: Dawson M.E., Schell A.M., Bohmet, A.H. (Eds). *Startle modification: Implication for neuroscience, cognitive science, and clinical science*. New York: Cambridge University Press, 157-193.
- Bradley, M.M., & Lang, P.J. (2000). Affective reactions to acoustic stimuli. *Psychophysiology*, 37, 204-215.
- Butler, E.A., Wilhelm, F.H., & Gross, J.J. (2006). Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction. *Psychophysiology*, 43, 612-622.
- Cannon, W.B. (1939). *The Wisdom of the Body*. Norton, New York. Carver, C.L., & White, T.L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, 67, 319-333.
- Casadei, B., Moon, J., Johnston, J., Caiazza, A., & Sleight, P. (1996). Is respiratory sinus arrhythmia a good index of cardiac vagal tone in exercise? *Journal of Applied Physiology*, 81, 556-564.
- Chorpita, B.F., & Barlow, D.H. (1998). The development of anxiety: The role of control in the early environment. *Psychological Bulletin*, 124, 3-21.
- Clark, L.A. (1993). Schedule for nonadaptive and adaptive personality (SNAP). Manual for administration, scoring, and interpretation. Minneapolis: University of Minnesota Press.
- Cohen, H., Benjamin, J., Geva, A. B., Matar, M. A., Kaplan, Z., & Kotler, M. (2000). Autonomic dysregulation in panic disorder and in post-traumatic stress disorder: Application of power spectrum analysis of heart rate variability at rest and in response to recollection of trauma or panic attacks. *Psychiatry Research*, 96, 1–13.
- Cooper, W.H., & Withey, M.J., (2009). The strong situation hypothesis. *Personality and Social Psychology Review*, 13, 62–72.

- Craske, M. G., Glover, D., & DeCola, J. (1995). Predicted versus unpredicted panic attacks: Acute versus general distress. *Journal of Abnormal Psychology, 104*, 214–223.
- D'Amato, M. R. (1974). Derived motives. *Annual Review of Psychology, 25*, 83-106.
- Davis, M. (1998). Are different parts of the extended amygdala involved in fear versus anxiety? *Biological Psychiatry, 44*, 1239-1247.
- Deacon, B. J., Abramowitz, J. S., Woods, C. M., & Tolin, D. F. (2003). The Anxiety Sensitivity Index - Revised: Psychometric properties and factor structure in two nonclinical samples. *Behaviour Research and Therapy, 41*, 1427–1449.
- de Jong, P.J., Visser, S., Merckelbach, H. (1996). Startle and spider phobia: unilateral probes and the prediction of treatment effects. *Journal of Psychophysiology, 10*, 150-160.
- Denver, J. W., Reed, S. F., & Porges, S. W. (2007). Methodological issues in the quantification of respiratory sinus arrhythmia. *Biological Psychology, 74*, 286-294.
- Elliot, A. J., & Thrash, T. M. (2002). Approach-avoidance motivation in personality: Approach and avoidance temperaments and goals. *Journal of Personality and Social Psychology, 82*, 804–818.
- Eysenck, H.J. (1970). *The Structure of Human Personality*. Meuthen & Co., London.
- Foa, E. B., Zinbarg, R., & Rothbaum, B. O. (1992). Uncontrollability and unpredictability in post-traumatic stress disorder: An animal model. *Psychological Bulletin, 112*, 218–238.
- Friedman, B.H., & Thayer, J.F. (1998). Anxiety and autonomic flexibility: A cardiovascular approach. *Biological Psychology, 49*, 303-323.
- Fuller, B.F. (1992). The effects of stress-anxiety and coping styles on heart rate variability. *International Journal of Psychophysiology, 12*, 81-86.
- George, D.T., Nutt, D.J., Walker, W.V., Porges, S.W., Adinoff, B., & Linnoila, M. (1989). Lactate and hyperventilation substantially attenuate vagal tone in normal volunteers: A possible mechanism of panic provocation? *Archives of General Psychiatry, 46*, 153-156.
- Goedhart, A. D., Van Der Sluis, S., Houtveen, J. H., Willemsen, G., Geus, E.J.C. (2007). Comparison of time and frequency domain measures of RSA in ambulatory recordings. *Psychophysiology, 44*(2), 203-215.
- Grillon, C. (2002). Startle reactivity and anxiety disorders: Aversive conditioning, context, and neurobiology. *Biological Psychiatry, 52*, 958-975.
- Grillon, C. (2008). Models and mechanisms of anxiety: Evidence from startle studies. *Psychopharmacology, 199*, 421-437.
- Grillon, C., Baas, J.P., Lissek, S., Smith, K., & Milstein, J. (2004). Anxious responses to predictable and

unpredictable aversive events. *Behavioral Neuroscience*, *118*, 916-924.

Grillon, C., Baas, J.M.P., Pine, D.S., Lissek, S., Lawley, M., Ellis, V., Levine, J. (2006). The benzodiazepine alprazolam dissociates contextual fear from cued fear in humans as assessed by fear-potentiated startle. *Biological Psychiatry*, *60*, 760-766.

Grillon, C., Lissek, S., Rabin, S., McDowell, D., Dvir, S., & Pine, D.S. (2008). Increased anxiety during anticipation of unpredictable but not predictable aversive stimuli as a psychophysiologic marker of panic disorder. *American Journal of Psychiatry*, *165*, 898-204.

Grillon, C., Pine, D. S., Lissek, S., Rabin, S., & Vythilingam, M. (2009). Increased anxiety during anticipation of unpredictable aversive stimuli in posttraumatic stress disorder but not in generalized anxiety disorder. *Biological Psychiatry*, *66*, 47-53.

Grossman, P., & Taylor, E. W. (2007). Toward understanding respiratory sinus arrhythmia: Relations to cardiac vagal tone, evolution and biobehavioral functions. *Biological Psychology*, *74*, 263–285.

Gyurak, A., & Ayduk, O. (2008). Resting respiratory sinus arrhythmia buffers against rejection sensitivity via emotion control. *Emotion*, *8*, 458-467.

Hatfield, B. D., Santa Maria, D. L., Porges, S. W., Potts, J. T., Spalding, T., & Byrne, E. A. (1998). Respiratory sinus arrhythmia during exercise in aerobically trained and untrained men. *Medical and Science in Sports and Exercise*, *30*, 206–214.

Heubeck, B.G., Wilkinson, R.B., & Cologan, J. (1998). A second look at Carver and White's (1994) BIS/BAS scales. *Personality and Individual Differences*, *25*, 785-800.

Houtveen, J. H., Rietveld, S., & Geus, E. J. C. de. (2002). Contribution of tonic vagal modulation of heart rate, central respiratory drive, respiratory depth, and respiratory frequency to respiratory sinus arrhythmia during mental stress and physical exercise. *Psychophysiology*, *39*, 427–436.

Imada, H., & Nageishi, Y. (1982). The concept of uncertainty in animal experiments using aversive stimulation. *Psychological Bulletin*, *91*, 573-588.

Jansen, D.M., & Frijda, N.H. (1994). Modulation of the acoustic startle response by film-induced fear and sexual arousal. *Psychophysiology*, *37*, 515-522.

Johnsen, B.H., Hansen, A.L., Sollers, J.J., Murison, R., & Thayer, J.F. (2001). Heart rate variability is inversely related to cortisol reactivity during cognitive stress. *Psychosomatic Medicine*, *64*, 148.

Johnsen, B.H., Thayer, J.F., Laberg, J.C., Wormnes, B., Raadal, M., Skaret, E., Kvale, G., & Berg, E. (2003). Attentional and physiological characteristics of patients with dental anxiety. *Anxiety Disorders*, *17*, 75-87.

- Keary, T.A., Hughes, J.W., & Palmieri, P.A. (2009). Women with posttraumatic stress disorder have larger decreases in heart rate variability during stress tasks. *International Journal of Psychophysiology*, *73*, 257-264.
- Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R., & Walters, E.E. (2005). Lifetime prevalence and age-of-onset distributions of *DSM-IV* Disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*, 593-602.
- Kettunen, J., Ravaja, N., Näätänen, P., & Keltikangas-Järvinen, L. (2000). The relationship of respiratory sinus arrhythmia to the co-activation of autonomic and facial responses during the Rorschach test. *Psychophysiology*, *37*(2), 242-250.
- Kirsch, P., Schienle, A., Stark, R., Sammer, G., Blecker, C., Walter, B., Ott, U., Burkart, J., & Vaitl, D. (2003). Anticipation of reward in a nonaversive differential conditioning paradigm and the brain reward system: An event related fMRI study. *Neuroimage*, *20*, 1086-1095.
- Kleiger, R. E., Bigger, J. T., Bosner, M. S., Chung, M. K., Cook, J. R., Rolnitzky, L. M., Steinman, R., & Fleiss, J. (1991). Stability over time of variables measuring heart rate variability in normal subjects. *American Journal of Cardiology*, *68*, 626–630.
- Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *The Journal of Neuroscience*, *21*, RC159.
- Krueger, R.F. (1999). Personality traits in late adolescence predict mental disorders in early adulthood: A perspective-epidemiological study. *Journal of Personality*, *67*, 39-65.
- Lader, M.H. (1980). The psychophysiology of anxiety. In: van Praag, H., Lader, M.H., Rafaelson, O., Sachar, E. (Eds.), *Handbook of Biological Psychiatry*. Marcel Dekker, New York, 225-247.
- Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1990). Emotion, attention, and the startle reflex. *Psychological Review*, *97*, 1–19.
- Lang, P.J. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist*, *50*, 372-385.
- Landis, C., & Hunt, W.A. (1993). *The startle pattern*. New York: Farrar and Rinehart Inc.
- Lejuez, C. W., Eifert, G. H., Zvolensky, M. J., & Richards, J. B. (2000). Preference between onset predictable and unpredictable administrations of 20% carbon-dioxide-enriched air: Implications for better understanding the etiology and treatment of panic disorder. *Journal of Experimental Psychology: Applied*, *6*, 349–358.
- Lissek, S., Orme, K., Mcdowell, D.J., Johnson, L.L., & Grillon, C. (2004). Effects of emotional regulation on startle potentiation to the threat of electric shocks, *Poster presented at the 44th Annual Meeting of the Society for Psychophysiological Research*, Santa Fe, NM.

- Lissek, S., Pine, D.S., & Grillon, C. (2006). The strong situation: A potential impediment to studying the psychobiology and pharmacology of anxiety disorders. *Biological Psychology, 72*, 265-270.
- Macfie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. Y. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies, 4*, 129–148.
- Maxwell, S.E., & Delaney, H.D. (1993). Bivariate median splits and spurious statistical significance. *Psychological Bulletin, 113*, 181-190.
- McNally, R.J. (2002). Anxiety sensitivity and panic disorder. *Biological Psychiatry, 52*, 938-946.
- Melzig, C.A., Weike, A.I., Hamm, A.O., & Thayer, J.F. (2009). Individual differences in fear-potentiated startle as a function of resting heart rate variability: Implications for panic disorder. *International Journal of Psychophysiology, 71*, 109-117.
- Metzger, L.J., Orr, S.P., Berry, N.J., Ahern, C.E., Lasko, N.M., & Pitman, R.K. (1999). Physiological reactivity to startling tones in women with posttraumatic stress disorder. *Journal of Abnormal Psychology, 108*, 347-352.
- Maier, S. F. (1991). Stressor controllability, cognition and fear. In J. I. Madden (Ed.), *Neurobiology of learning, emotion and affect* (pp. 159– 193). New York: Raven Press.
- Mineka, S., Cook, M., & Miller, S. (1984). Fear conditioned with escapable and inescapable shock: Effects of a feedback stimulus. *Journal of Experimental Psychology: Animal Behavior Processes, 10*, 307–323.
- Mineka, S., & Kihlstrom, J.F. (1978). Unpredictable and uncontrollable events: a new perspective on experimental neurosis. *Journal of Abnormal Psychology, 87*, 256-271.
- Mineka S, & Zinbarg R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist, 61*, 10–26.
- Moberg, C.A., & Curtin, J.J. (2009). Alcohol selectively reduces anxiety but not fear: Startle response during unpredictable vs. predictable threat. *Journal of Abnormal Psychology, 118*, 335-347.
- Nelson, B. D., & Shankman, S. A. (2011). Does intolerance of uncertainty predict anticipatory startle responses to uncertain threat? *International Journal of Psychophysiology, 81*, 107-115.
- Nelson, B.D., Shankman, S.A., Sarapas, C., Nelson, M., Altman, S.E., & Robinson-Andrew, J. (2010). Are distinct symptoms of anxiety and depression related to emotional responding while anticipating predictable vs. unpredictable threat? *Poster presented at the 24th annual meeting of the Society for Research in Psychopathology, Seattle, WA.*
- Nesselroade, J.R. (1990). Adult personality development: Issues in assessing constancy and change. In

- Rubin, A.I., Zucker, R.A., Emmons, R.A., Frank, S. (Eds.), *Studying Persons and Lives*. Springer, New York, 41-85.
- Ode, S., Hilmert, C. J., Zielke, D. J., & Robinson, M. D. (2010). Neuroticism's importance in understanding the daily life correlates of heart rate variability. *Emotion, 10*, 536-543.
- Peterson, R.A., & Kirsten, P. (1999). Measuring anxiety sensitivity. In S. Taylor (Ed.) *Anxiety sensitivity: Theory, research, and treatment of the fear and anxiety* (pp. 61-81). Mahwah, NJ, USA: Lawrence Erlbaum Associates Inc.
- Pole, N., Neylan, T. C., Best, S. R., Orr, S. P., & Marmar, C. R. (2003). Fear-potentiated startle and posttraumatic stress symptoms in urban police officers. *Journal of Traumatic Stress, 16*, 471-479.
- Porges, S. W. (1985). Method and apparatus for evaluating rhythmic oscillations in aperiodic physiological response systems. US patent, 4,510,944.
- Porges, S.W. (1992). Autonomic regulation and attention. In: Campbell, B.A., Hayne, H. and Richardson, R., Editors, 1992. *Attention and Information Processing in Infants and Adults*, Erlbaum, Hillside, NJ, pp. 201-223.
- Porges, S.W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage, A Polyvagal Theory. *Psychophysiology, 32*, 301-318.
- Porges, S.W. (1997). Emotion: An evolutionary by-product of the neural regulation of the autonomic nervous system. *Annals of New York Academy of Sciences, 807*, 62-77.
- Porges, S.W. (1998). Love: an emergent property of the mammalian autonomic nervous system. *Psychoneuroendocrinology 23*, 837-861.
- Porges, S.W. (2001). The polyvagal theory: phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology 42*, 123-146.
- Porges, S.W. (2003). *Social engagement and attachment: a phylogenetic perspective. Roots of mental illness in children*. Annals of the New York Academy of Sciences 1008, 31-47.
- Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74*, 116-143.
- Porges, S. W., Doussard-Roosevelt, J. A., & Maiti, A. K. (1994). *Vagal tone and the physiological regulation of emotion*. In N. A. Fox (Ed.), *Monographs of the Society for Research in Child Development* (Vol. 59, pp. 167-186). Boston: Blackwell Publishing.
- Porges, S.W., Doussard-Roosevelt, J., Portales, A.L., & Greenspan, S.I. (1996). Infant regulation of the vagal "brake" predicts child behavior problems: A psychobiological model of social behavior. *Development and Psychopathology, 29*, 697-712.

- Rapee, R. M., Craske, M. G., Brown, T. A., & Barlow, D. H. (1996). Measurement of perceived control over anxiety-related events. *Behavior Therapy, 27*, 279-293.
- Reiss, S., Peterson, R.A., Gursky, D. M., & McNally, R. J. (1986). Anxiety sensitivity, anxiety frequency and the predictions of fearfulness. *Behaviour Research and Therapy, 24*, 1-8.
- Rodriguez-Fornells, A., Riba, J., Gironell, A., Kulisevsky, J., & Barbanoj, M. J. (1999). Effects of alprazolam on the acoustic startle response in humans. *Psychopharmacology, 143*, 280-285.
- Rollman, G.B., & Harris, G. (1987). The detectability, discriminability, and perceived magnitude of painful electrical shock. *Perception and Psychophysics, 42*, 257-268.
- Rosenbaum, J.F., Biederman, J., Bolduc-Murphy, E.A., Faraone, S.V. (1993). Behavioral inhibition in childhood: A risk factor for anxiety disorders. *Harvard Review of Psychiatry, 1(1)*, 2-16.
- Ruiz-Padial, E., Sollers, J.J., Vila, J., & Thayer, J.F. (2003). The rhythm of the heart in the blink of an eye: Emotion-modulated startle magnitude covaries with heart rate variability. *Psychophysiology, 40*, 306-313.
- Sack, M., Hopper, J.W., & Lamprecht, F. (2004). Low respiratory sinus arrhythmia and prolonged psychophysiological arousal in posttraumatic stress disorder: Heart period dynamics and individual differences in arousal regulation. *Biological Psychiatry, 55*, 284-290.
- Sargunaraj, D., Lehrer, P. M., Hochron, S. M., Rausch, L., Edelberg, R., & Porges, S. W. (1996). Cardiac rhythm effects of .125 Hz paced breathing through a resistive load: Implications for paced breathing therapy and the Polyvagal Theory. *Biofeedback and Self-Regulation, 21*, 131-147.
- Schmidt, N.B., Lerew, D.R., & Jackson, R.J. (1997). The role of anxiety sensitivity in the pathogenesis of panic: Prospective evaluation of spontaneous panic attacks during acute stress. *Journal of Abnormal Psychology, 106*, 355-364.
- Schmidt, N.B., Lerew, D.R., & Jackson, R.J. (1999). Prospective evaluation of anxiety sensitivity in the pathogenesis of panic: Replication and extension. *Journal of Abnormal Psychology, 108*, 532-537.
- Schwartz, J. B., Gibb, W. L., & Tran, T. (1991). Aging effects on heart rate variation. *The Journals of Gerontology, 46*, 99-106.
- Seligman, M. E. P., & Binik, Y. M. (1977). The safety signal hypothesis. In H. Davis & H. M. B. Hurwitz (Eds.), *Operant-Pavlovian interactions*. Hillsdale, N.J.: Erlbaum.
- Seligman, M. E. P., & Meyer, B. (1970). Chronic fear and ulcers in rats as a function of unpredictability of safety. *Journal of Comparative and Physiological Psychology, 73*, 202-207.

- Souza, G.G.L., Mendonca-De-Souza, A.C.F., Barros, E.M., Coutinho, E.F.S., & Oliveria, L., Mendlowicz, M.V., Figueira, I., & Volchan, E. (2007). Resilience and vagal tone predict cardiac recovery from acute psychological stress. *Stress, 10*, 374-386.
- Stein, M.B., Tancer, M.E., & Uhde, T.W. (1992). Heart rate and plasma norepinephrine responsivity to orthostatic challenge in anxiety disorders. *Archives of General Psychiatry, 49*, 311-316.
- Stein, P.K., Bosner, M.S., Kleiger, R.E., & Conger, B.M. (1994). Heart rate variability: a measure of cardiac autonomic tone. *American Heart Journal, 127*, 1376-1381.
- Stein, P.K., Rich, M.W., Rottman, J.N., & Kleiger, R.E. (1995). Stability of index of heart rate variability in patients with congestive heart failure. *American Heart Journal, 129*, 975-981.
- Snyder, M., & Ickes, W., (1985). *Personality and social behavior*. In: Lindzey, G., Aronson, E. (Eds.), *Handbook of Social Psychology*, 3rd ed., vol. 2. Random House, New York.
- Taylor, S., & Cox, B. J. (1998). An expanded Anxiety Sensitivity Index: Evidence for a hierarchic structure in a clinical sample. *Journal of Anxiety Disorders, 12*, 463-483.
- Taylor, S., Zvolensky, M.J., Cox, B.J., Deacon, B., Heimberg, R.G., Ledley, D.R., Abramowitz, J.S., Holaway, R.M., Sandin, B., Stewart, S.H., Coles, M., Eng, W., Daly, E.S., Arrindell, W.A., Bouvard, M., & Cardenas, S.J. (2007). Robust dimensions of Anxiety Sensitivity: Development and initial validation of the Anxiety Sensitivity Index-3. *Psychological Assessment, 19*, 176-188.
- Thayer, J.F., Friedman, B.H., & Borkovec, T.D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry, 39*, 255-266.
- Thayer, J.F., & Friedman, B.H. (1997). The heart of anxiety: A dynamical systems approach. In: Vingerhoets, A., van Bussel, F., Boelhouwer, J. (Eds.) *The (Non) Expression of Emotions in Health Disease*. Tilburg University Press, Tilburg, The Netherlands, 39-49.
- Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders, 61*, 201-216.
- Watson D., & Clark, L. A. (1993). Behavioral disinhibition vs. constraint: A dispositional perspective. In: Wegner DA, Pennebaker JW, editors. *Handbook of Mental Control*. Prentice-Hall; Englewood Cliffs, NJ: pp. 506-527.
- Weiss, J.M., (1970). Somatic effects of predictable and unpredictable shock. *Psychosomatic Medicine, 32*, 397-408.
- Yeragani, V.K., Pohl, R., Berger, R., Balon, R., Ramesh, C., Glitz, D., Srinivasan, K., & Weinberg, P. (1993). Decreased heart rate variability in panic disorder patients: A study of power spectral analysis of heart rate. *Psychiatry Research, 46*, 89-103.

- Yeragani, V.K., Srinivasan, K., Pohl, R., Berger, R., Balon, R., & Ramesh, C. (1994a). Sodium lactate increases sympathovagal ratios in normal controls: a study of spectral analysis of heart rate, blood pressure, and respiration. *Psychiatry Research*, *54*, 97-114.
- Yeragani, V.K., Srinivasan, K., Balon, R., Ramesh, C., & Berchou, R. (1994b). Lactate sensitivity and cardiac cholinergic function in panic disorder. *American Journal of Psychiatry*, *151*, 1226-1228.
- Yeragani, V. K., Pohl, R., Berger, R., Balon, R., & Srinivasan, K. (1994c). Relationship between age and heart rate variability in supine and standing postures: A study of spectral analysis of heart rate. *Pediatric Cardiology*, *15*, 14-20.
- Zvolensky, M.J., Eifert, G. H., Lejuez, C.W., Hopko, D. R., & Forsyth, J. P. (2000). Assessing the perceived predictability of anxiety-related events: A report on the Perceived Predictability Index. *Journal of Behavior Therapy and Experimental Psychiatry*, *31*, 201-218.

Footnote

¹ Given that one could also conceptualize RSA as the moderator in the relationship between neuroticism and startle, we examined whether there was a Condition x Cue x Neuroticism interaction at high and low levels of RSA. The three-way interaction was not significant at high levels of RSA [$F(2,88) = 1.00, p = .371, \eta_p^2 = .00$] or at low levels of RSA [$F(2,88) = 1.97, p = .145, \eta_p^2 = .00$]. Thus we chose to conduct follow-up analyses at high and low levels of neuroticism.

Table 1. Descriptive statistics for RSA during baseline and self-report variables.

Variable	M	SD
RSA Eyes Open	6.73	1.04
RSA Eyes Closed	6.66	1.09
ACQ Total	4.17	3.32
ASI Original Total	21.86	9.76
ASI-R Total	37.57	20.55
ASI-III Total	18.38	11.25
GTS NE	12.35	7.88
BIS Total	20.46	4.29

Table 2. Results from Condition x Cue x RSA x Anxiety Disorder Risk Factor repeated measures ANOVAs.

Source	<i>df</i>	MS	F	<i>p</i>	η_p^2
<u>ACQ Total</u>					
Cond x Cue x RSA x ACQ	2	16.37	1.16	0.32	0.01
<u>BIS Total</u>					
Cond x Cue x RSA x BIS	2	27.92	1.99	0.14	0.02
<u>GTS NE Total</u>					
Cond x Cue x RSA x GTS NE	2	25.21	1.79	0.17	0.02
<u>ASI Original Total</u>					
Cond x Cue x RSA x ASI Original	2	2.25	0.16	0.86	0.00
<u>ASI Revised Total</u>					
Cond x Cue x RSA x ASI Revised	2	5.00	0.35	0.71	0.00
<u>ASI-III Total</u>					
Cond x Cue x RSA x ASI-III	2	5.36	0.37	0.69	0.00

Note. For each ANOVA, condition (i.e., N, P, U) and cue (i.e., countdown and ITI) were entered as within-subject variables and RSA and anxiety disorder risk factors (i.e., ACQ, BIS, GTS, and ASI) were entered as between-subject variables.

Figure 1. Depiction of the neutral, predictable, and unpredictable study design.

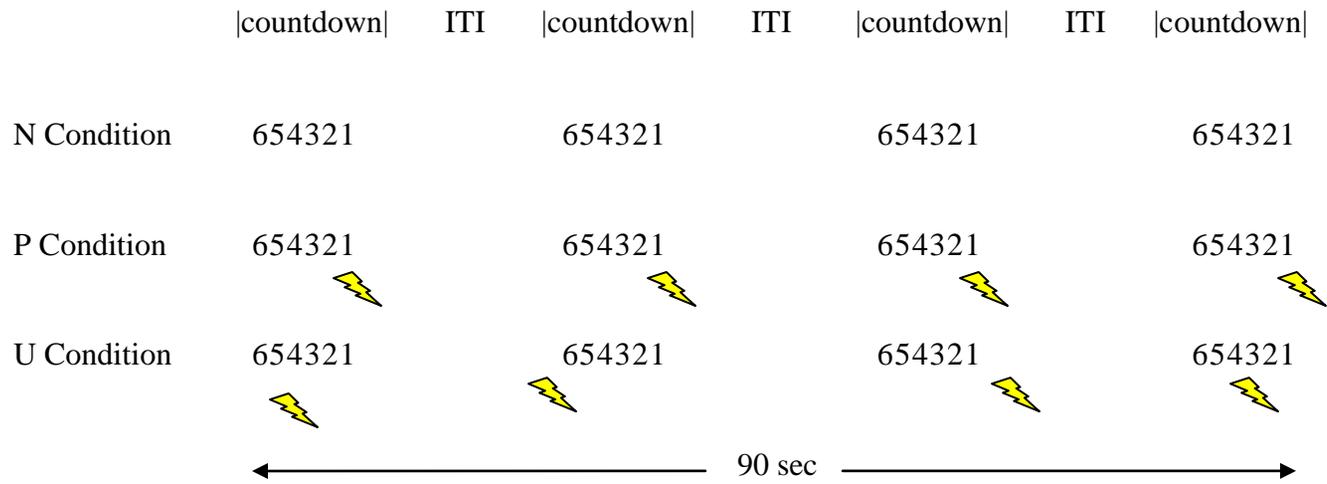
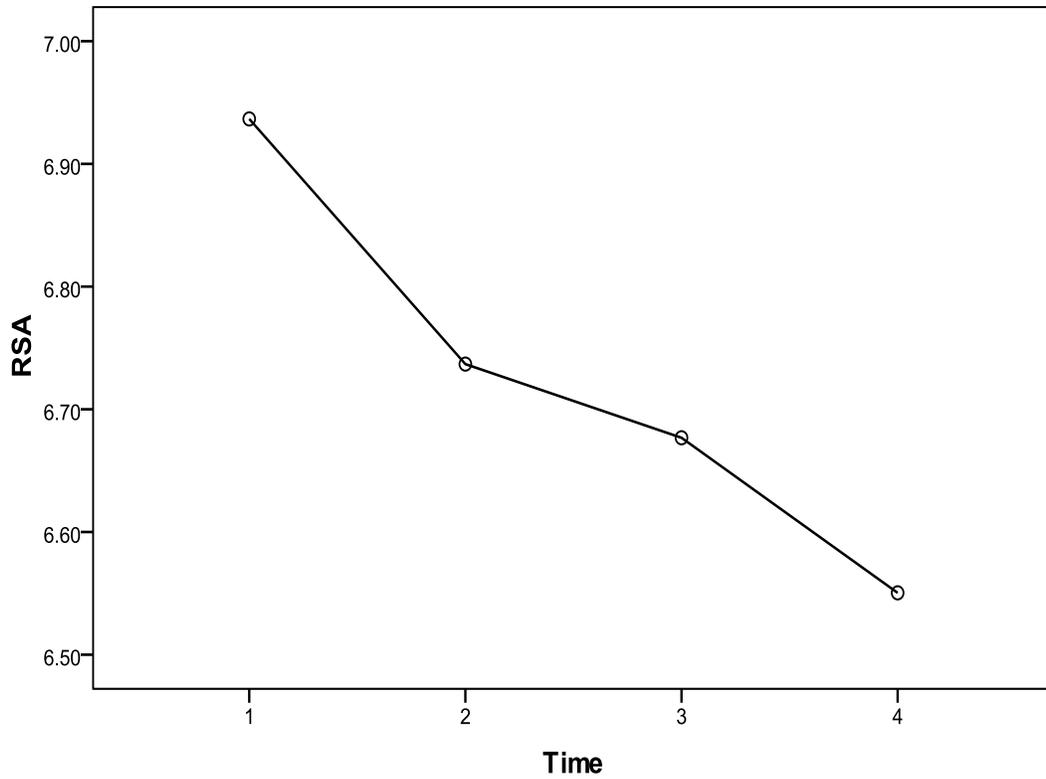


Figure 2. Mean RSA across time during the resting baseline recording period.



Note. RSA was averaged during 4 separate 90-second blocks across the 6 minute baseline recording period.

Figure 3. Startle magnitude T-scores during the neutral, predictable, and unpredictable conditions (Left) and mean startle potentiation scores (Right; e.g., U-ITI minus N-ITI).

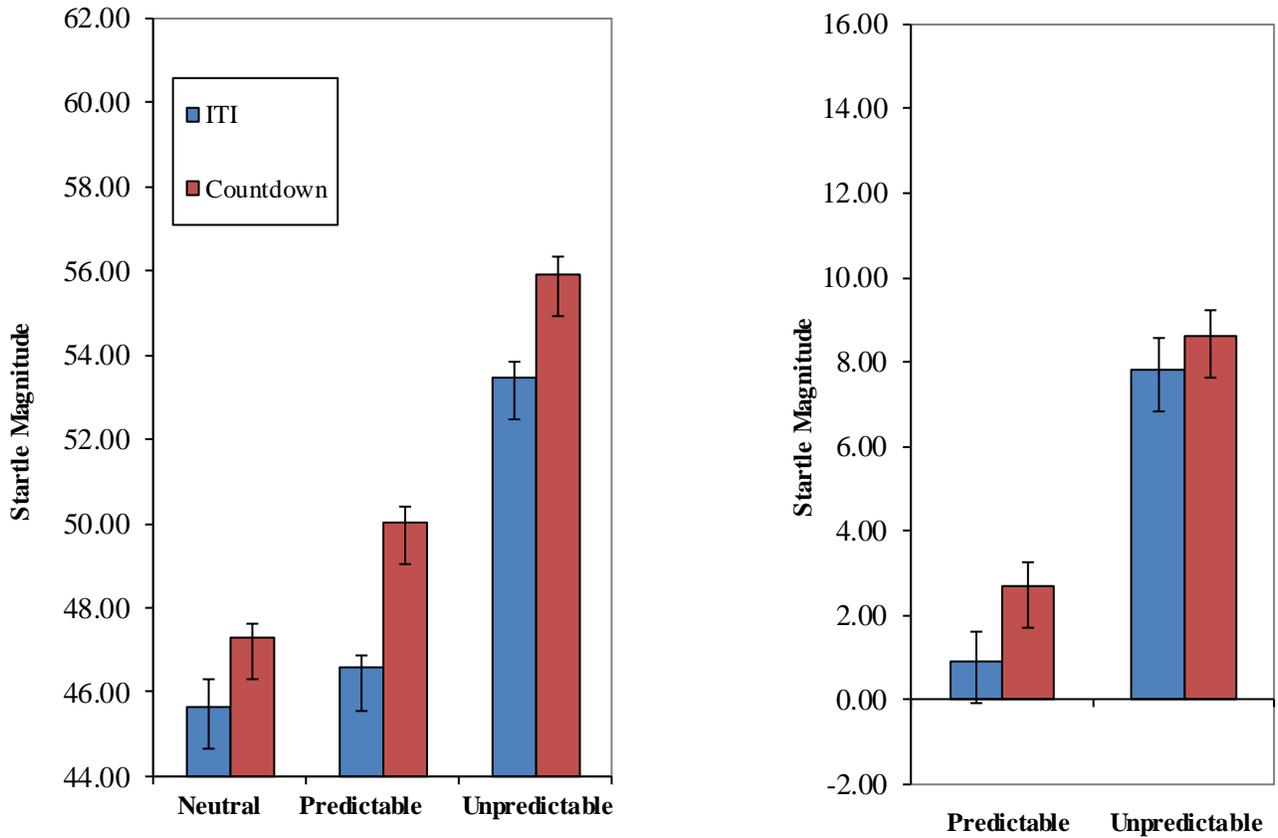


Figure 3b. Mean self-reported anxiety during the neutral, predictable, and unpredictable conditions and the ITI and countdown cues.

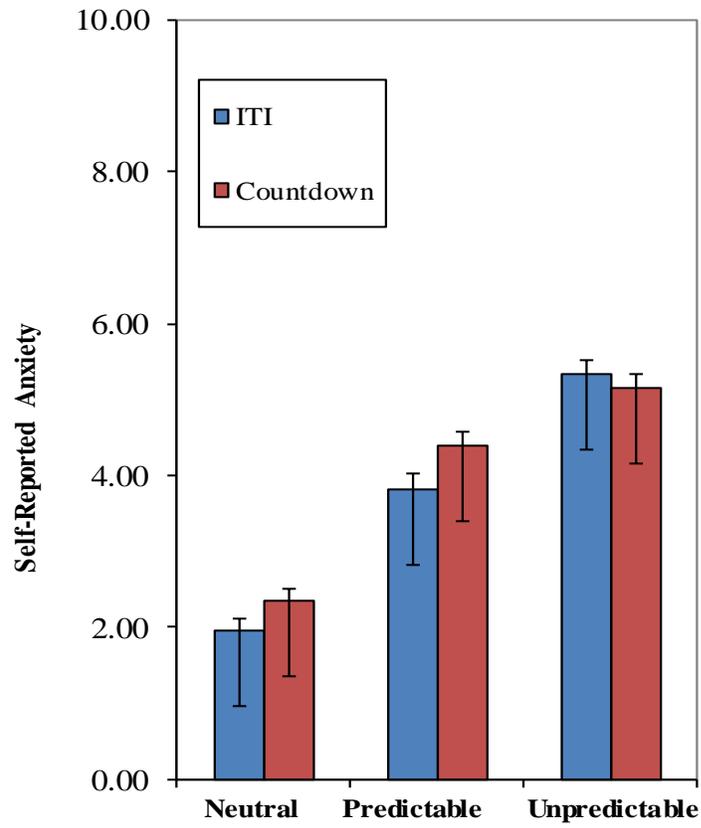
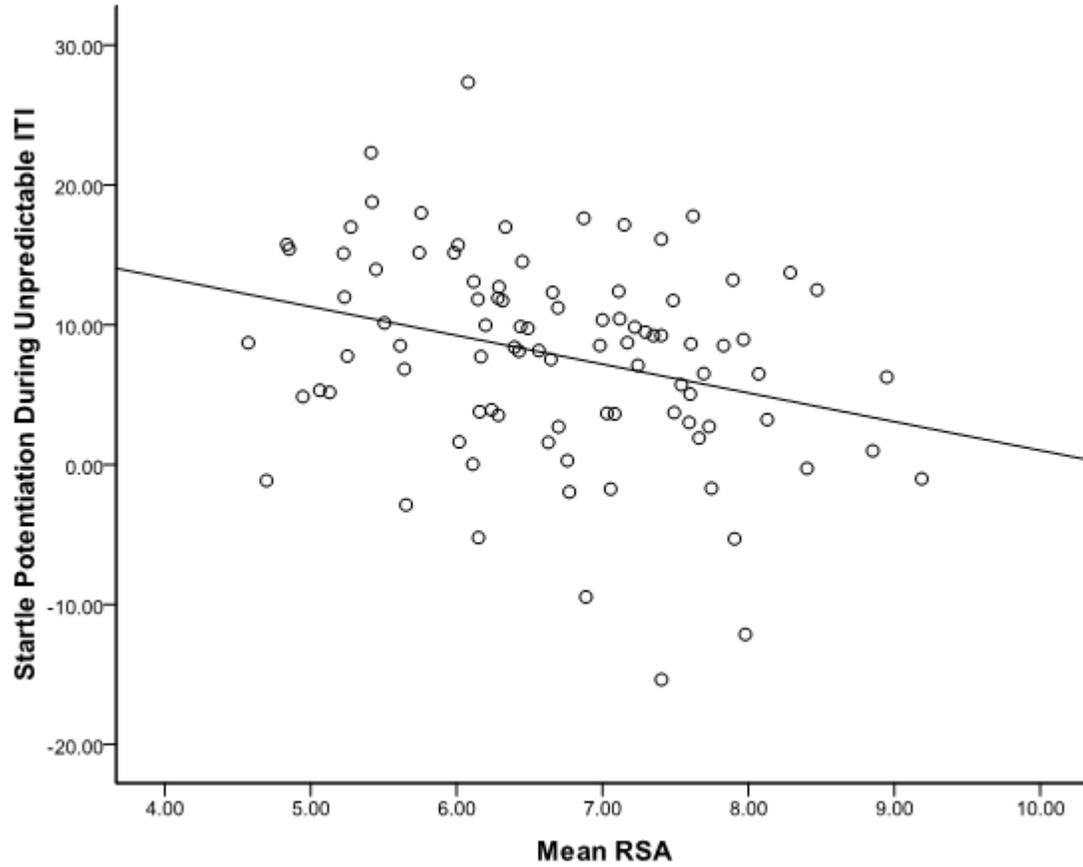


Figure 4. Scatter plot of the relationship between resting RSA and startle potentiation during the unpredictable ITI.



Appendix A:

BIS/BAS

Participant # _____

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me

2 = somewhat true for me

3 = somewhat false for me

4 = very false for me

1.	A person's family is the most important thing in life.	1	2	3	4
2.	Even if something bad is about to happen to me, I rarely experience fear or nervousness.	1	2	3	4
3.	I go out of my way to get things I want.	1	2	3	4
4.	When I'm doing well at something I love to keep at it.	1	2	3	4
5.	I'm always willing to try something new if I think it will be fun.	1	2	3	4
6.	How I dress is important to me.	1	2	3	4
7.	When I get something I want, I feel excited and energized.	1	2	3	4
8.	Criticism or scolding hurts me quite a bit.	1	2	3	4
9.	When I want something I usually go all-out to get it.	1	2	3	4
10.	I will often do things for no other reason than that they might be fun.	1	2	3	4
11.	It's hard for me to find the time to do things such as get a haircut.	1	2	3	4
12.	If I see a chance to get something I want I move on it right away.	1	2	3	4
13.	I feel pretty worried or upset when I think or know somebody is angry at me.	1	2	3	4
14.	When I see an opportunity for something I like I get excited right away.	1	2	3	4
15.	I often act on the spur of the moment.	1	2	3	4
16.	If I think something unpleasant is going to happen I usually get pretty "worked up."	1	2	3	4
17.	I often wonder why people act the way they do.	1	2	3	4
18.	When good things happen to me, it affects me strongly.	1	2	3	4
19.	I feel worried when I think I have done poorly at something important.	1	2	3	4
20.	I crave excitement and new sensations.	1	2	3	4
21.	When I go after something I use a "no holds barred" approach.	1	2	3	4
22.	I have very few fears compared to my friends.	1	2	3	4
23.	It would excite me to win a contest.	1	2	3	4
24.	I worry about making mistakes.	1	2	3	4

ASI

Please circle the phrase that best corresponds to how much you agree with each item. If any of the items concern something that is not part of your experience (for example, "It scares me when I feel shaky" for someone who has never trembled or felt shaky), answer on the basis of how you expect you might feel if you had such an experience. Otherwise, answer all items on the basis of your own experience.

1. It is important to me not to appear nervous.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
2. When I cannot keep my mind on a task, I worry that I might be going crazy.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
3. It scares me when I feel "shaky" (trembling).

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
4. It scares me when I feel faint.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
5. It is important to me to stay in control of my emotions.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
6. It scares me when my heart beats rapidly.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
7. It embarrasses me when my stomach growls.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
8. It scares me when I am nauseous.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
9. When I notice my heart is beating rapidly, I worry that I might have a heart attack.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
10. It scares me when I become short of breath.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------
11. When my stomach is upset, I worry that I might be seriously ill.

Very Little	A Little	Some	Much	Very Much
-------------	----------	------	------	-----------

12. It scares me when I am unable to keep my mind on a task.

Very Little A Little Some Much Very Much

13. Other people notice when I feel shaky.

Very Little A Little Some Much Very Much

14. Unusual body sensations scare me.

Very Little A Little Some Much Very Much

15. When I am nervous, I worry that I might be mentally ill.

Very Little A Little Some Much Very Much

16. It scares me when I am nervous.

Very Little A Little Some Much Very Much

17. When my head is pounding, I worry I could have a stroke.

Very Little A Little Some Much Very Much

18. When I tremble in the presence of others, I fear what people might think of me.

Very Little A Little Some Much Very Much

19. When I feel like I'm not getting enough air, I get scared that I might suffocate.

Very Little A Little Some Much Very Much

20. When I get diarrhea, I worry that I might have something wrong with me.

Very Little A Little Some Much Very Much

21. When my chest feels tight, I get scared that I won't be able to breathe properly.

Very Little A Little Some Much Very Much

22. When my breathing becomes irregular, I fear that something bad will happen.

Very Little A Little Some Much Very Much

23. It frightens me when my surroundings seem strange or unreal.

Very Little A Little Some Much Very Much

24. Smothering sensations scare me.

Very Little A Little Some Much Very Much

25. When I feel pain in my chest, I worry that I'm having a heart attack.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
26. I believe it would be awful to vomit in public.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
27. It scares me when my body feels strange or different in some way.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
28. I worry that other people will notice my anxiety.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
29. When I feel "spacey" or spaced out, I worry that I may be mentally ill.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
30. It scares me when I blush in front of people.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
31. When I feel a strong pain in my stomach, I worry that it could be cancer.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
32. When I have trouble swallowing, I worry that I could choke.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
33. When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
34. It scares me when I feel tingling or pricking sensations in my hands.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
35. When I feel dizzy, I worry there is something wrong with me.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
36. When I begin to sweat in social situations, I fear people will think negatively of me.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|
37. When my thoughts seem to speed up, I worry that I might be going crazy.
- | | | | | |
|-------------|----------|------|------|-----------|
| Very Little | A Little | Some | Much | Very Much |
|-------------|----------|------|------|-----------|

38. When my throat feels tight, I worry that I could choke to death.

Very Little A Little Some Much Very Much

39. When my face feels numb, I worry that I might be having a stroke.

Very Little A Little Some Much Very Much

40. When I have trouble thinking clearly, I worry that there is something wrong with me.

Very Little A Little Some Much Very Much

41. I think it would be horrible for me to faint in public.

Very Little A Little Some Much Very Much

42. When my mind goes blank, I worry that there is something terribly wrong with me.

Very Little A Little Some Much Very Much

Appendix C:

ACQ

Listed below are a number of statements describing a set of beliefs. Please read each statement carefully and, on the 0-5 scale given, indicate how much you think *each* statement is typical of *you*.

0	1	2	3	4	5
Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree

- ___ 1. I am usually able to avoid threat quite easily.
- ___ 2. How well I cope with difficult situations depends on whether I have outside help.
- ___ 3. When I am put under stress, I am likely to lose control.
- ___ 4. I can usually stop my anxiety from showing.
- ___ 5. When I am frightened by something, there is generally nothing I can do.
- ___ 6. My emotions seem to have a life of their own.
- ___ 7. There is little I can do to influence people's judgments of me.
- ___ 8. Whether I can successfully escape a frightening situation is always a matter of chance with me.
- ___ 9. I often shake uncontrollably.
- ___ 10. I can usually put worrisome thoughts out of my mind easily.
- ___ 11. When I am in a stressful situation, I am able to stop myself from breathing too hard.
- ___ 12. I can usually influence the degree to which a situation is potentially threatening to me.
- ___ 13. I am able to control my level of anxiety.
- ___ 14. There is little I can do to change frightening events.
- ___ 15. The extent to which a difficult situation resolves itself has nothing to do with my actions.
- ___ 16. If something is going to hurt me, it will happen no matter what I do.
- ___ 17. I can usually relax when I want.
- ___ 18. When I am under stress, I am not always sure how I will react.
- ___ 19. I can usually make sure people like me if I work at it.
- ___ 20. Most events that make me anxious are outside my control.
- ___ 21. I always know exactly how I will react to difficult situations.
- ___ 22. I am unconcerned if I become anxious in a difficult situation, because I am confident in my ability to cope with my symptoms.

- _____ 23. What people think of me is largely outside my control.
- _____ 24. I usually find it hard to deal with difficult problems.
- _____ 25. When I hear that someone has a serious illness, I worry that I am next.
- _____ 26. When I am anxious, I find it difficult to focus on anything other than my anxiety.
- _____ 27. I am able to cope as effectively with unexpected anxiety as I am with anxiety that I expect to occur.
- _____ 28. I sometimes think, "Why even bother to try to cope with my anxiety when nothing I do seems to affect how frequently or intensely I experience it?"
- _____ 29. I often have the ability to get along with "difficult" people.
- _____ 30. I will avoid conflict due to my inability to successfully resolve it.

Appendix D:

ID # _____

General Temperament Survey

Listed below are a series of statements a person might use to describe his/her attitudes, feelings, interests, and other characteristics. Read each statement and decide how well it describes you. If the statement is TRUE or MOSTLY TRUE, fill in the circle in the first column (under the T) in front of that item. If it is FALSE or MOSTLY FALSE, fill in the circle in the second column (under the F). There are no right or wrong answers, and no trick questions.

Please answer every statement, even if you are not completely sure of your answer. Read each statement carefully, but don't spend too much time deciding on the answer.

T F

- 1. I am able to approach tasks in such a way that they become interesting or fun.
- 2. I sometimes rush from one activity to another without stopping to rest.
- 3. I don't keep particularly close track of where my money goes.
- 4. I often have strong feelings such as anxiety or anger without really knowing why.
- 5. I lead an active life.
- 6. I will make almost any excuse to goof off instead of work.
- 7. I sometimes gets too upset by minor setbacks.
- 8. My good mood sometimes changes (for example, from happy to sad, or vice versa) without good reason.
- 9. I often stop in the middle of one activity to start another one.
- 10. Sometimes I feel "on edge" all day.
- 11. I lead a very interesting life.
- 12. I frequently find myself worrying about things.
- 13. If I had to choose, I would prefer having to sit through a long concert of music I dislike to being in a bank during an armed robbery.
- 14. My anger frequently gets the better of me.
- 15. I get excited when I think about the future.
- 16. Before making a decision I carefully considers all sides of the issue.
- 17. People would describe me as a pretty enthusiastic person.

T F

- 18. I can easily find ways to liven up a dull day.
- 19. I believe in playing strictly by the rules.
- 20. Small annoyances often irritate me.
- 21. Sometimes I suddenly feel scared for no good reason.
- 22. I work just hard enough to get by.
- 23. In my life, interesting and exciting things happen every day.
- 24. I sometimes get all worked up as he/she thinks about things that happened during the day.
- 25. I rarely, if ever, do anything reckless.
- 26. Other people sometimes have trouble keeping up with the pace I set.
- 27. The way I behave often gets me into trouble on the job, at home, or at school.
- 28. I get a kick out of really scaring people.
- 29. I can get very upset when little things don't go my way.
- 30. I live a very full life.
- 31. If I had to choose, I would prefer being in a flood to unloading a ton of newspapers from a truck.
- 32. I am often nervous for no reason.
- 33. I often take my anger out on those around me.
- 34. I greatly dislike it when someone breaks accepted rules of good behavior.
- 35. I am usually alert and attentive.
- 36. I would describe myself as a tense person.
- 37. I usually use careful reasoning when making up my mind.
- 38. I put a lot of energy into everything I do.
- 39. I often worry about things I have done or said.
- 40. I would much rather party than work.
- 41. I can make a game out of some things that others consider work.
- 42. It takes a lot to get me excited.
- 43. I like to take chances on something that isn't sure, such as gambling.
- 44. Sometimes life seems pretty confusing to me.

T F

- 45. I can work hard, and for a long time, without feeling tired.
- 46. When I resent having to do something, I sometimes make mistakes on purpose.
- 47. I am sometimes troubled by thoughts or ideas that I can't get out of my mind.
- 48. My pace is usually quick and lively.
- 49. I always try to be fully prepared before I begin working on anything.
- 50. I would not use others' weaknesses to my own advantage.
- 51. I often have trouble sleeping because of my worries.
- 52. I really enjoy beating the system.
- 53. Most days I have a lot of "pep" or vigor.
- 54. I don't get very upset when things go wrong.
- 55. I have been told that I work too hard.
- 56. People would describe me as a pretty energetic person.
- 57. I often feel nervous and "stressed."
- 58. He/She is not an "impulse buyer."
- 59. He/She has days that he/she is very irritable.
- 60. In my life, I would rather try to do too much than too little.
- 61. I am a serious-minded person.
- 62. I get pretty excited when I am starting a new project.
- 63. Little things upset me too much.
- 64. I like to show-off.
- 65. I am often troubled by guilt feelings.
- 66. I seem to be able to remain calm in almost any situation.
- 67. Lying comes easily to me.
- 68. I worry about terrible things that might happen.
- 69. I like to stir up some excitement when things are getting dull.
- 70. When I am having a good time, I don't worry about the consequences.
- 71. I am often playful around other people.
- 72. I worry too much about things that don't really matter.

T F

- 73. I am a cautious person.
- 74. I am sometimes “on the go” so much that I wear myself out.
- 75. I have done a lot of things for which I could have been (or was) arrested.
- 76. Often life feels like a big struggle for me.
- 77. I spend a good deal of my time just having fun.
- 78. When I decide things, I always refer to basic rules of right and wrong.
- 79. I have more energy than most of the people I know.
- 80. Taking care of details is not my strong point.
- 81. Things seem to bother me less than most other people.
- 82. I often get out of doing things by making up good excuses.
- 83. I sometimes feel angry for no good reason.
- 84. I get most fun out of things that others think are immoral or illegal.
- 85. I would never hurt other people just to get what I want.
- 86. I often feel lively and cheerful for no good reason.
- 87. I don’t ever like to stay in one place for long.
- 88. People sometimes tell me to slow down and “take it easy.”
- 89. I have stolen things from time to time.
- 90. I am usually enthusiastic about the things that I do.

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

**Approval Notice
Continuing Review**

July 13, 2011

Stewart Shankman, Ph.D.
Psychology
912 S. Wood Street, 4th Floor
M/C 285
Chicago, IL 60612
Phone: (312) 355-3812 / Fax: (312) 413-4122

RE: Protocol # 2005-0626
"Emotional Processing and Physiology"

Dear Dr. Shankman:

Your Continuing Review was reviewed and approved by the Expedited review process on July 7, 2011. You may now continue your research.

Please note the following information about your approved research protocol:

<u>Protocol Approval Period:</u>	July 7, 2011 - July 5, 2012
<u>Approved Subject Enrollment #:</u>	655
<u>Additional Determinations for Research Involving Minors:</u>	The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Therefore, in accordance with 45CFR46.408, the IRB determined that only one parent's/legal guardian's permission/signature is needed
<u>Performance Site:</u>	UIC
<u>Sponsor:</u>	NARSAD (Nat'l Alliance for Research on Schizophrenia and Depression), Office of Social Science Research (OSSR), NIMH - National Institute of Mental Health, Department of Psychology
<u>PAF#:</u>	2008-00188, Not available, Not available, 2008-05183
<u>Grant/Contract No:</u>	Not available, Not available, Not available, 1R21MH080689-01A2
<u>Grant/Contract Title:</u>	Neurobehavioral processes that are common and/or specific to major depression and anxiety: an fMRI study, Not available, Not

available, Anticipating reward & threat: A test of biobehavioral processes in MDD vs anxiety

Research Protocol:

- a) "Emotional Processing and Physiology", Version #6, 09/06/2010

Recruitment Materials:

- a) Recontact letter - Emotional Processing and Physiology-Recontact.G, Version 1, 10/16/2009
- b) Recontact script - Emotional Processing and Physiology-Recontact.G, Version 1, 10/16/2009
- c) Flyer with contact tags, Emotion and Brain (how your're feeling), Version #4, 09/06/2010
- d) Flyer with contact tags, Emotion and Brain (panic attacks), Version #4, 09/06/2010
- e) Flyer - no tags, Emotion and Brain (depression), Version #4, 09/06/2010
- f) Flyer - no tags, Emotion and Brain (panic attacks), Version #4, 09/06/2010
- g) Flyer - no tags, Emotion and Brain (how you're feeling), Version #4, 09/06/2010
- h) Flyer with contact tags, Emotion and Brain (depression), Version #4, 09/06/2010
- i) Re-contact information sheet - version #1 - 5/6/2009

Informed Consents:

- a) Emotional Processing, Informant, August 2009, Version #3, 08/04/2009
- b) Emotional Processing-fMRI, August 2009, Version #4, 08/04/2009
- c) Emotional Processing-Group PSY100.G, August 2009, Version #4, 08/04/2009
- d) Emotional processing-Group PSY100.NG, August 2009, Version #3, 08/04/2009
- e) Emotional processing-recontact.G, November 2009, Version 2, 11/23/2009
- f) Emotional processing-Retest, Version 3, 09/06/2010
- g) Emotional processing-Group C, Version #6, 09/06/2010
- h) Emotional processing-Group NC, Version #6, 09/06/2010
- i) Waiver of Signed Consent Document granted under 45 CFR 46.117 for telephone screening
- j) Waiver of Informed Consent granted under 45 CFR 46.116(d) only for recontacting previously enrolled subjects.

Parental Permission:

- a) A waiver of parental permission has been granted under 45 CFR 46.116(d) and 45 CFR 46.408(c); however, as per UIC Psychology Subject Pool policy, as least one parent must sign the Blanket Parental Permission document prior to the minor subject's participation in the UIC Psychology Subject Pool.

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific categories:

(4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving X-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.)

Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

(7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
06/29/2011	Continuing Review	Expedited	07/07/2011	Approved

Please remember to:

→ Use your **research protocol number** (2005-0626) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,
"UIC Investigator Responsibilities, Protection of Human Research Subjects"

Please note that the UIC IRB has the right to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 355-2764. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Betty Mayberry, B.S.
IRB Coordinator, IRB # 3
Office for the Protection of Research

Subjects

Enclosures:

- 1. UIC Investigator Responsibilities, Protection of Human Research Subjects**
- 2. Data Security Enclosure**
- 3. Informed Consent Documents:**
 - a) Emotional Processing, Informant, August 2009, Version #3, 08/04/2009
 - b) Emotional Processing-fMRI, August 2009, Version #4, 08/04/2009
 - c) Emotional Processing-Group PSY100.G, August 2009, Version #4, 08/04/2009
 - d) Emotional processing-Group PSY100.NG, August 2009, Version #3, 08/04/2009
 - e) Emotional processing-recontact.G, November 2009, Version 2, 11/23/2009
 - f) Emotional processing-Retest, Version 3, 09/06/2010
 - g) Emotional processing-Group C, Version #6, 09/06/2010
 - h) Emotional processing-Group NC, Version #6, 09/06/2010
- 4. Recruiting Materials:**
 - a) Recontact letter - Emotional Processing and Physiology-Recontact.G, Version 1, 10/16/2009
 - b) Recontact script - Emotional Processing and Physiology-Recontact.G, Version 1, 10/16/2009
 - c) Flyer with contact tags, Emotion and Brain (how your're feeling), Version #4, 09/06/2010
 - d) Flyer with contact tags, Emotion and Brain (panic attacks), Version #4, 09/06/2010
 - e) Flyer - no tags, Emotion and Brain (depression), Version #4, 09/06/2010
 - f) Flyer - no tags, Emotion and Brain (panic attacks), Version #4, 09/06/2010
 - g) Flyer - no tags, Emotion and Brain (how you're feeling), Version #4, 09/06/2010
 - h) Flyer with contact tags, Emotion and Brain (depression), Version #4, 09/06/2010
 - i) Re-contact information sheet - version #1 - 5/6/2009

cc: Gary E. Raney, Psychology, M/C 285
OVCR Administration, M/C 672

STEPHANIE M. GORKA

DEPT. OF PSYCHOLOGY ♦ UIC ♦ 1007 WEST HARRISON ST. ♦ CHICAGO, IL ♦ 60607
312-412-2681(W) 609-462-2019(C) ♦ SGORKA2@UIC.EDU

EDUCATION

- 2010-Present UNIVERSITY OF ILLINOIS AT CHICAGO Chicago, IL**
Doctoral Program in Clinical Psychology
 M.A. in Clinical Psychology (September 2011)
 Ph.D. in Clinical Psychology (August 2015)
- 2004 - 2008 UNIVERSITY OF MARYLAND College Park, MD**
Bachelor of Science
 Major: Psychology

AWARDS/HONORS

- 2004-2008 *Dean's Honor List, University of Maryland*
 2005–Present *The National Society of Collegiate Scholars*
 2007 *MCUR Senior Summer Scholars Grant Recipient*
 2008 *Awarded funding by MCUR to present research at ACC Meeting of the Minds*
 2008 *Mark S. Harper Award for Excellence in Psychology by an Undergraduate*

PUBLICATIONS

1. Daughters, S.B., Richards, J.M., **Gorka, S.M.**, & Sinha, R. (2009). HPA axis response to psychological stress and treatment retention in residential substance abuse treatment: A prospective study. *Drug and Alcohol Dependence, 105*, 202-208.
2. McHugh, R.K., Daughters, S.B., Lejuez, C.W., Murray, H.W., Hearon, B.A., **Gorka, S.M.**, & Otto, M.W. (2010). Shared variance among self-report and behavioral measures of distress intolerance. *Cognitive Therapy and Research, 35*, 266-275.
3. Magidson, J. F., **Gorka, S. M.**, MacPherson, L., Hopko, D. R., Blanco, C., Lejuez, C. W., & Daughters, S. B. (2011). Examining the Effect of the Life Enhancement Treatment for Substance Use (LETS ACT) on Residential Substance Abuse Treatment Retention. *Addictive Behaviors Special Issue: Evidence-Based Policy and Practice, 36*, 615-623.
4. **Gorka, S. M.**, Ali, B., Daughters, S. B. (in press). The role of distress tolerance in the relationship between depressive symptoms and problematic alcohol use. *Psychology of Addictive Behaviors*.

SUBMITTED MANUSCRIPTS

5. Daughters, S.B., Richards, J.M., **Gorka, S.M.**, & Marks, K. Adolescent distress tolerance and HPA axis response to stress. Manuscript Submitted for Publication.
6. Daughters, S.B., **Gorka, S.M.**, Matusiewicz, A., & Anderson, K. Gender specific effect of salivary cortisol response to stress on adolescent risk taking. Manuscript Submitted for Publication.
7. Ehrlich, K. B., Cassidy, J., **Gorka, S. M.**, Lejuez, C. W., & Daughters, S. B. Negative parental response to adolescent distress and low adolescent distress tolerance: Adolescent peer relationships in the context of dual risk. Manuscript Submitted for Publication.

8. Daughters, S.B., Magidson, J. F., **Gorka, S. M.**, MacPherson, L., Kahler, C. W., & Seitz-Brown, C. Gender and ethnicity as moderators in the relationship between adolescent distress tolerance and externalizing and internalizing psychopathology. Manuscript Submitted for Publication.

MANUSCRIPTS IN PREPARATION

1. Magidson, J. F., **Gorka, S. M.**, Lejuez, C. W., & Daughters, S. B. Targeting depression in the context of inner-city, residential drug treatment: A Case study of the LET'S ACT Behavioral Activation Treatment. Manuscript in preparation.
2. Daughters, S. B., **Gorka, S. M.**, Bornovalova, M., & Kochanska, K. Emotional abuse as a risk factor for poor treatment outcomes in residential substance abuse treatment. Manuscript in preparation.
3. **Gorka, S.M.**, Nelson, B.D., Porges, S.W., Sarapas, C., Campbell, M.L., Lewis, G.F., & Shankman, S.A. Resting heart rate variability as a predictor of startle responses to predictable and unpredictable threat. Manuscript in preparation.

RESEARCH EXPERIENCE

August 2010 – AFFECTIVE SCIENCE AND PHYSIOLOGY LABORATORY

Chicago, IL

Present *Graduate Research Assistant, Department of Psychology*

- Master's Thesis project examining heart rate variability (HRV) as a predictor of startle response during a threat of shock task.
- Experimenter for a federally funded study on the biobehavioral processes in the anticipation of reward and threat in a sample of community individuals with depression and/or panic disorder. Responsibilities include phone screen interviews and the administration of the *Structured Clinical Interview for DSM-IV (SCID)* to determine psychiatric diagnoses and study eligibility.
- Researcher in a supplemental fMRI study aimed at understanding the neural indices of anticipation of reward and threat in those with depression and/or panic disorder. Responsibilities include participant recruitment, fMRI data collection and management, and data processing and analysis.

Supervisor: *Stewart Shankman, Ph.D.*

May 2008 – THE NATIONAL INSTITUTE ON DRUG ABUSE (NIDA)

Baltimore, MD

July 2010 *Guest Researcher, Neuroimaging Research Branch*

- Lead research assistant on a cross-sectional study to identify the neural indices of distress tolerance utilizing functional magnetic resonance imaging (fMRI).
- Prior, lead research assistant in the development and pilot test of two functional MRI distress tolerance tasks (PASAT and MTPT)
- Responsible for concept development, grant writing, preparation of IRB materials, and fMRI, GSR, and ECG data collection and analysis.

Supervisors: *Stacey Daughters, Ph.D., Elliot Stein, Ph.D., and Thomas Ross, Ph.D.*

April 2009 – STRESS, HEALTH, AND ADDICTION RESEARCH PROGRAM

College Park, MD

July 2010 *Research Assistant, Department of Public and Community Health*

- Project Coordinator for an R21 examining the role of distress tolerance in adolescent substance use. Responsibilities included overall study management, data collection and analysis, and manuscript preparation.
- Researcher for a R01 treatment outcome study assessing the effectiveness of a behavioral activation treatment for HIV positive inner-city drug users aimed at improving medication adherence and decreasing depressive symptoms and risky sexual behaviors. Responsibilities included participant recruitment and scheduling, data collection and management, assisting participants in scheduling physician's appointments, and data analysis.
- Researcher in a randomized controlled trial comparing a behavioral activation (BA) treatment aimed at reducing depressive symptoms to a supportive counseling control treatment among low-income substance users in residential treatment in Washington, D.C. Responsibilities included project start-up and concept development, grant writing, data collection and management, data analysis, and manuscript preparation.
- Administered the *Structured Clinical Interview for DSM-IV (SCID)* to residential substance use patients to

determine psychiatric diagnoses and study eligibility.

Supervisor: *Stacey Daughters, Ph.D.*

Dec. 2007 – April 2009 **CENTER FOR ADDICTIONS, PERSONALITY, AND EMOTION RESEARCH** **College Park, MD**
Research Assistant, Department of Psychology

- Project Coordinator of an R01 grant examining the role of social context, personality, and risk behaviors in determining drug of choice (heroin vs. crack/cocaine). Responsibilities included overall study management, participant recruitment, data collection, administration of study interviews, training and supervision of undergraduate research assistants, and data analysis.
- Experimenter in an additional R03 examining the role of distress tolerance in residential substance use treatment outcomes. Responsibilities included participant recruitment, data collection, data analysis, and co-authoring two publications.
- Research assistant in a pilot treatment outcome study on an exposure-based intervention specifically tailored to inner-city heroin users with heightened anxiety sensitivity, Anxiety Sensitivity Treatment for Heroin (AST-H). Involved in participant recruitment, data collection, and tracking and scheduling long-term follow-up sessions.
- Co-leader of a naturalistic study on the effects of alcohol use on participants' performance on a behavioral risk taking propensity task. Responsibilities included project design and development, scheduling and recruitment of participants, and data collection and management.
- Administered the *Structured Clinical Interview for DSM-IV (SCID)* to residential substance use patients to determine psychiatric diagnoses and study eligibility.

Supervisors: *Carl Lejuez, Ph.D., Stacey Daughters, Ph.D., Matthew Tull, Ph.D.*

May. 2007 – Sept. 2007 **MARYLAND CENTER FOR UNDERGRADUATE RESEARCH** **College Park, MD**
Grant Recipient, Senior Summer Scholars Program

- One of 30 University of Maryland seniors awarded \$3,000 grant to work on an independent research project.
- Project was a longitudinal study on Borderline Personality Disorder as a predictor of dropout among inner-city drug users in a residential substance use treatment center.
- Responsibilities included all aspects of experimentation including conceptual design, proposal writing, data collection and management, data analysis, and manuscript and poster preparation.
- Manuscript was submitted to the Maryland Center for Undergraduate Research and a project poster was presented at the University of Maryland's Undergraduate Research Day.

Supervisor: *Stacey Daughters, Ph.D.*

CLINICAL EXPERIENCE

October 2010 – Present **OFFICE OF APPLIED PSYCHOLOGICAL SERVICES** **Chicago, IL**
Clinical Practicum Student

- Conduct intake interviews with new patients at a community based outpatient psychology clinic.
- Engage in weekly supervision meetings which involve reviewing video recordings, receiving live feedback, and reviewing clinical readings.

Supervisors: *Gloria Balague, Ph.D.; Evelyn Behar, Ph.D.*

Sept. 2008 – July 2010 **SALVATION ARMY HARBOR LIGHT TREATMENT CENTER** **Washington, DC**
Research Therapist

- Therapist for the behavioral activation (BA) treatment, Life Enhancement Treatment for Substance Use (LET'S ACT), for inner-city residential substance users with elevated depressive symptoms.
- Therapy was part of a treatment outcome study assessing the effectiveness of LET'S ACT.
- Involved in weekly supervision meetings which included reviewing audio recordings and receiving live feedback.

Supervisors: *Stacey Daughters, Ph.D., Carl Lejuez, Ph.D.*

Oct. 2009 – July 2010 **SALVATION ARMY HARBOR LIGHT TREATMENT CENTER** **Washington, DC**
Research Therapist

- Therapist for a group smoking cessation treatment, Life Enhancement Treatment for Smoking (LET'S QUIT), for inner-city residential substance users.
- Included working with a registered nurse to determine the appropriate individual dose for the Nicoderm CQ patch to study participants.
- Therapy part for a pilot treatment outcome study assessing the effectiveness of LET'S QUIT.

Supervisor: *Laura McPherson, Ph.D.*

WORKSHOPS AND TRAININGS

Sept. 2009 – ANALYSIS OF FUNCTIONAL NEUROIMAGES (AFNI) BOOTCOMP

Bethesda, MD

The National Institutes of Health

- 5-day AFNI bootcamp which included lectures and hands-on training on topics such as fMRI data acquisition, AFNI program and features, individual and group statistical analyses with fMRI data, region of interest (ROI) drawing, and functional connectivity.

MEMBERSHIP IN PROFESSIONAL ASSOCIATIONS

- *Association for Behavioral and Cognitive Therapies (ABCT)*
- *Organization for Human Brain Mapping (OHBM)*

AD HOC STUDENT EDITORIAL EXPERIENCE

- *Addiction*
- *Psychology of Addictive Behaviors*
- *Journal of Anxiety Disorders*
- *Cognitive Therapy and Research*

ORAL PRESENTATIONS

1. Madgidson, J. F., Howard, S. L., **Gorka, S. M.**, Lejuez, C. W., & Daughters, S.B. (2010, October). Examining the effect of the Life Enhancement Treatment for Substance Use (LET'S ACT) on residential substance abuse treatment retention. Oral presentation at Addictions 2010: The New Frontier in Addiction Treatment: Evidence-Based Policy and Practice, Arlington, VA.
2. Daughters, S.B. Richards, J. M., **Gorka, S. M.**, Ross, T. J., & Stein, E. A. (2010, November). Neural Correlates of Distress Intolerance. In J. Richards & S. Daughters (Co-Chairs), *The neural mechanisms underlying emotion regulation and psychopathology: Bridging cognitive affective neuroscience and clinical research*. Symposium conducted at the 44th annual Association for Behavioral and Cognitive Therapies convention, San Francisco, CA.
3. Daughters, S. B., **Gorka, S. M.**, Howard, S. L., & Travers, R. M. (2010, November). Distress Tolerance and Adolescent Substance Use. In A. Bernstein & A. Vujanovic (Co-Chairs), *Distress tolerance: Emerging research and clinical applications across therapeutic contexts*. Symposium conducted at the 44th annual Association for Behavioral and Cognitive Therapies convention, San Francisco, CA.
4. Howard, S. L., Lavelle, A., Magidson, J. F., Hemberg, J., Wang, F., **Gorka, S. M.**, Safren, S., & Daughters, S. B. (2010, June). *ACT HEALTHY: Effectiveness of a behavioral activation treatment and HIV medication adherence treatment for African American low income HIV positive substance users*. Paper presented at the 72nd annual meeting of the College on Problems of Drug Dependence, Scottsdale, AZ.

POSTER PRESENTATIONS

1. Richards, J.M., **Gorka, S.M.**, & Daughters, S.B. (2011, November). *Hyperactive HPA axis response to stress predicts low distress tolerance among women*. Poster presented at the 2011 meeting of the Association for Behavioral and Cognitive Therapies, Toronto, Canada.
2. **Gorka, S. M.**, Nelson, B. D., Sarapas, C., Campbell, M. L., Robison-Andrew, E. J., Altman, S. E., & Shankman, S. A. (September, 2011). *Resting heartrate variability as a predictor of startle responses to predictable and unpredictable threat*. Poster presented at the 25th Annual Society for Research in

Psychopathology, Boston, MA.

3. McGowan, S.K., **Gorka, S. M.**, Nelson, B.D., & Shankman, S.A. (September, 2011) *Anxiety and Autonomic Flexibility in Conditions of Unpredictable Threat*. Poster presented at the 25th annual meeting of the Society for Research in Psychopathology, Boston, MA.
4. Nelson, B. D., Sarapas, C., Campbell, M. L., Robison-Andrew, E. J., Altman, S. E., Katz, A. C., **Gorka, S. M.**, McGowan, S. K., & Shankman, S. A. (September, 2011). Comparing sensitivity to unpredictable threat versus DSM defined panic disorder on how they predict family history of panic disorder. Poster presented at the 25th Annual Society for Research in Psychopathology, Boston, MA.
5. Sarapas, C., Bishop, J. R., Nelson, B. D., Campbell, M. L., Robison-Andrew, E. J., Altman, S. E., Katz, A. C., **Gorka, S. M.**, McGowan, S. K., & Shankman, S. A. (September, 2011). Indirect genetic effects on internalizing symptoms through frontal EEG asymmetry. Poster session presented at 25th annual meeting of the Society for Research in Psychopathology, Boston, MA.
6. Campbell, M. L., Nelson, B. D., McGowan, S. K., Robison-Andrew, E. J., Sarapas, C., Altman, S. E., **Gorka, S.**, Katz, A. C., Shankman, S. A. (September 2011). Startle Habituation in Individuals With Depression and/or Panic Disorder. Poster session presented at 25th annual meeting of the Society for Research in Psychopathology, Boston, MA.
7. Katz, A. C., Nelson, B. D., Robison-Andrew, E. J., Altman, S. E., Campbell, M. L., Sarapas, C., **Gorka, S. M.**, & Shankman, S. A. (September, 2011). The moderating effect of trait positive emotionality on EEG asymmetry recorded during a reward processing task. Poster session presented at 25th annual meeting of the Society for Research in Psychopathology, Boston, MA.
8. Daughters, S.B., **Gorka, S.M.**, Marks, K., Richards, J.M. (2011, June). Gender specific relationship between distress tolerance and HPA axis response to stress among adolescents. Poster presented at the 73rd annual meeting of the College on Problems of Drug Dependence, Hollywood, Florida.
9. **Gorka, S.M.**, Ross, T.J., Richards, J.M., Stein, E.A., & Daughters, S.B. (2011, June). Relationship between childhood abuse and cortico-limbic activation during a stressful task. Poster presented at the 17th annual meeting of the Organization for Human Brain Mapping, Quebec City, Canada.
10. Richards, J.M., Ross, T.J., **Gorka, S.M.**, Stein, E.A., & Daughters, S.B. (2011, June). Chronic psychosocial stress and acute stress-induced corticolimbic activation. Poster presented at the 17th annual meeting of the Organization for Human Brain Mapping, Quebec City, Canada.
11. Enrich, K.B., **Gorka, S. M.**, Jones, J. D., Cassidy, J. A., Lejuez, C. W., & Daughters, S. B. (2011, March). *Behavioral assessments of adolescent distress tolerance moderate the links between parenting and peer experiences for adolescents*. Poster presented at the 2011 Society for Research in Child Development Biennial Meeting, Montreal, Quebec, Canada.
12. Marks, K. M., **Gorka, S. M.**, & Daughters, S. B. (2010, October). *Distress tolerance in adolescence: A gender-specific biological stress response*. Poster presented at the annual meeting for the School of Public Health, University of Maryland, College Park.
13. **Gorka, S.M.**, Ross, T.J., Richards, J.M., Stein, E.A., Daughters, S.B. (2010, June). *Gender differences in neural correlates of cognitive emotional regulation techniques during a stressful task*. Poster presented at the 16th annual meeting of the Organization for Human Brain Mapping, Barcelona, Spain
14. Richards, J.M., Ross, T.J., **Gorka, S.M.**, Stein, E.A., Daughters, S.B. (2010, June). *Distress-induced neural activation predicts impulsivity*. Poster presented at the 16th annual meeting of the Organization for Human Brain Mapping, Barcelona, Spain.
15. Daughters, S.B., Ross, T.J., Richards, J.M., **Gorka, S.M.**, Stein, E.A. (2010, June). *Neural correlates of distress intolerance*. Poster presented at the 16th annual meeting of the Organization for Human Brain Mapping, Barcelona, Spain.

16. Daughters, S.B., **Gorka, S.M.**, Travers, R.M., Leonard, J., Smith, K. (2010, June). *Distress tolerance and adolescent substance use problem severity*. Poster presented at the 72nd annual meeting of the College on Problems of Drug Dependence, Scottsdale, Arizona.
17. Hemberg, J., Magidson, J.F., La Touche Howard, S., **Gorka, S.**, Lejuez, C.W., Daughters, S.B. (2010, April). *Examining the effect of behavioral activation on substance abuse treatment retention*. Poster presented at the 10th Annual Scientific Meeting of the American Academy of Health Behavior, Clearwater, FL.
18. **Gorka, S. M.**, Travers, R. M., Smith, K., Lejuez, C. W., & Daughters, S. B. (2009, November). *Gender differences in the effects of stress exposure on adolescent risk taking propensity*. Poster presented at the 2009 meeting of the Association for Behavioral and Cognitive Therapies, New York, New York.
19. Richards, J. M., Daughters, S. B., **Gorka, S. M.**, Ross, T., & Stein, E. (2009, November) *Development and pilot testing of two behavioral assessments of distress tolerance for use in fMRI*. Poster accepted for presentation at the 2009 meeting of the Association for Behavioral and Cognitive Therapies, New York, New York.
20. Magidson, J., Reynolds, E., Fuchs, C., **Gorka, S. M.**, Bornovalova, M., Daughters, S. B., & Lejuez, C. W. (2009, June) *Predicting recent event-level condom use using behavioral assessment among urban, minority substance users*. Poster presented at the 2009 meeting of the College on Problems of Drug Dependence, Reno, Nevada.
21. Daughters, S. B., Richards, J. M., **Gorka, S. M.**, & Sinha, R. (2009, June). *Biological stress response is predictive of treatment retention in residential substance abuse treatment*. Poster presented at the 2009 meeting of the College on Problems of Drug Dependence, Reno, Nevada.
22. **Gorka, S. M.**, Bornovalova, M.A., Kochanska, K., & Daughters, S. B. (2009, June). *Emotional abuse as a risk factor for treatment dropout from residential substance abuse treatment*. Poster presented at the 2009 meeting of the College on Problems of Drug Dependence, Reno, Nevada.
23. *Magidson, J. F., **Gorka, S. M.**, Lejuez, C. W., & Daughters, S. (2009, March). *Examining the effectiveness of integrating the LET'S ACT behavioral treatment for depression into an inner-city, residential drug treatment center*. Poster presented at the 9th annual scientific meeting of the American Academy of Health Behavior, Hilton Head, SC.
24. LaTouche-Howard, S. A., **Gorka, S.M.**, Travers, R. M., & Daughters, S. B. (2009, March). *A glimpse into their world: The acceptability and feasibility of an adolescent distress tolerance intervention*. Poster presented at the 9th annual scientific meeting of the American Academy of Health Behavior, Hilton Head, SC.
25. Richards, J., Tull, M.T., **Gorka, S. M.**, McDermott, M.J., Daughters, S.B., and Lejuez, C.W. (2008, June). *Examination of a brief adjunctive interoceptive-based intervention for heroin users with high anxiety sensitivity*. Poster presented at the 2008 meeting of the College on Problems of Drug Dependence, San Juan, Puerto Rico.
26. Magidson, J. F., Reynolds, L., **Gorka, S. M.**, Daughters, S. B., & Lejuez, C W. (2008, August). *The relationship between risk-taking propensity on the balloon analogue risk task (BART) and risky sexual behavior among inner-city, African-American illicit drug users*. Poster presented at the XVII International AIDS Conference, Mexico City, Mexico.
27. Magidson, J., Daughters, S.B., Lejuez, C.W., **Gorka, S.**, Sargeant, M., & Gholkar, R. (2008, November). *Behavioral activation as a mechanism of change following a brief behavioral intervention for depressed African American illicit drug users*. Poster presented at the 42nd annual convention of the Association for Behavioral and Cognitive Therapies, Orlando, FL.
28. Sargeant, M.N., Daughters, S.B., Schuster, R., **Gorka, S.**, & Lejuez, C.W. (2008, June). *ASPD and distress tolerance: The role of psychopathic traits in a substance use treatment-seeking sample*. Poster presented at the 70th annual meeting of the College on Problems of Drug Dependence, San Juan, Puerto Rico.

29. **Gorka, S. M.**, Daughters, S. B., & Lejuez, C. W. (2008, June). *Anxiety sensitivity as a predictor of treatment dropout among inner-city crack/cocaine and heroin user in a residential substance use treatment center*. Poster presented at the 70th annual meeting of the College on Problems of Drug Dependence, San Juan, Puerto Rico.
30. **Gorka, S. M.**, Bornoalova, M.A., & Daughters, S. B. (2008, April). *Borderline Personality Disorder as a predictor of dropout among inner-city drug users in a residential substance use treatment center*. Poster presented at the 4th Annual ACC Meeting of the Minds, Tallahassee, Florida.

* Distinguished student poster award