

**Cardiovascular Activity During Laboratory Tasks  
in Individuals with High and Low Worry**

Michael Matthew Knepp

Thesis Submitted to the Faculty of the  
Virginia Polytechnic Institute and State University  
in partial fulfillment of the requirements for the degree of

Master of Science

in

Psychology

Bruce H. Friedman, Chair

David W. Harrison

Martha A. Bell

May 9, 2007

Blacksburg, Virginia

Keywords: Anxiety, Worry, Cardiovascular Reactivity, Cardiovascular Recovery, ANS

Copyright 2007, Michael Matthew Knepp

Cardiovascular Activity During Laboratory Tasks  
in Individuals with High and Low Worry

Michael Matthew Knepp

**(ABSTRACT)**

Anxiety and worry have been related to exaggerated cardiovascular reactivity and delayed recovery to laboratory stressors, and to increased risk of cardiovascular disease. This study examined cardiovascular responses in high and low worriers to a range of laboratory tasks. The aim of this study was to determine if there is a task-specific relationship between worry and aberrant cardiovascular responding. Forty-one undergraduate women were recruited online to form low and high worry groups by use of the Penn State Worry Questionnaire. Four common laboratory tasks and two conditions designed to elicit worry and relaxation were used: hand cold pressor, mental arithmetic, orthostatic position, supine position, worry imagery, and relaxation imagery. Heart rate, heart rate variability, impedance cardiography, and blood pressure indices were collected to assess task reactivity and recovery, particularly in relation to autonomic nervous system activity. The high worry group had significantly higher heart rates throughout the study. The low worry group presented increased cardiovascular recovery to various tasks. The high worry group during task and post-task periods also increased parasympathetic withdrawal and sympathetic activation. The results of the study suggest that high worriers have decreased vagal control of the heart. The implications of this study suggest a potential link between the post-task period in high worriers and cardiovascular disease. Further research is recommended.

## **DEDICATION**

This thesis is dedicated to my parents whose hard-work helped place me in school in the first place and encouragement kept me moving through it and to my fiancé, Kristen, whose worries I love the most.

## ACKNOWLEDGEMENTS

I would like to thank Dr. Bruce Friedman, my advisor, for helping with the development of this project and for answering any question, no matter how bizarre, along the way. I would like to thank my committee, Dr. Martha Ann Bell and Dr. David Harrison, for helping me with the refinement of my ideas as well as for their openness to have a proposal and a defense both during finals week. I could not have completed this project without the help of the undergraduates of the Mind-Body Lab, Laura Tiffin, Jenna Carpenter, and Megan Moore. Without running weekend subjects, I would have never completed their thesis. Finally, I would like to thank two people who are both friends and colleagues. Phil Lehman, whose great spreadsheet ideas streamlined my data analysis and overcompensated for his other time-wasting ideas and Calida Barboza, who will always be my personal librarian and copy-editor.

## TABLE OF CONTENTS

ABSTRACT.....	ii
DEDICATION.....	iii
ACKNOWLEDGEMENTS.....	iv
INTRODUCTION.....	1
Cardiovascular Reactivity, Recovery, and Heart Rate Variability.....	2
Cardiovascular Reactivity.....	2
Cardiovascular Recovery.....	3
Heart Rate Variability.....	3
Anxiety, Worry, and Cardiovascular Reactivity.....	4
Anxiety, Cardiovascular Disease, and Reactivity.....	4
Anxiety and Heart Rate Variability.....	5
Worry, Reactivity, and Cardiovascular Disease.....	6
Stress Tasks in the Laboratory.....	8
Stressors and the Cardiovascular System.....	8
Worry, Reactivity, and Recovery.....	8
Reactivity versus Recovery.....	9
The Present Study.....	10
Purpose of Research.....	10
Cardiovascular Measures.....	11
METHOD.....	12
Subjects.....	12
Materials.....	13
Design.....	14
Procedure.....	14
Task Descriptions.....	16
Data Analysis.....	19
Ethical Considerations.....	20
RESULTS.....	21
Primary Hypothesis Analysis.....	21
Anticipatory Baseline Analysis.....	22
Group Differences during the Laboratory Tasks.....	23
Manipulation Checks.....	26
DISCUSSION.....	27
Conclusions.....	32
REFERENCES.....	34
APPENDIX A: FIGURES	
Figure A-1. Heart Rate Differences Across Epochs by Group.....	44
Figure A-2. Anticipatory and First Acclimated Baseline HR Differences by Group.....	45
Figure A-3. Pre-ejection Period Differences During Orthostatic Post-Task by Group.....	46
Figure A-4. Low Frequency Power Reactivity during the Supine Task by Group.....	47
Figure A-5. Left Ventricular Ejection Time Differences during Cold Pressor Task by Group.....	48

Figure A-6. Pre-ejection Period Differences after Worry Task between 2 <sup>nd</sup> Half Post-Task and First Half Post-Task by Group.....	49
Figure A-7. Low Frequency Power Totals during the Relaxation Task by Group....	50
APPENDIX B: TABLES	
Table B-1. Systolic Blood Pressure Means and Standard Errors.....	51
Table B-2. Diastolic Blood Pressure Means and Standard Errors.....	52
Table B-3. Heart Rate Means and Standard Errors.....	53
Table B-4. rMSSD Means and Standard Errors.....	54
Table B-5. Low Frequency:High Frequency Ratio Means and Standard Errors.....	55
Table B-6. High-frequency Power (Normalized Units) Means and Standard Errors.....	56
Table B-7. Pre-ejection Periods Means and Standard Errors.....	57
Table B-8. Left Ventricular Ejection Time Means and Standard Errors.....	58
APPENDIX C: Penn State Worry Questionnaire.....	59
APPENDIX D: Mind-Body Laboratory Health History Questionnaire.....	60
APPENDIX E: Mind-Body Laboratory Short Health History Questionnaire.....	63
APPENDIX F: Order Definitions.....	64
APPENDIX G: Informed Consent Form.....	65
APPENDIX H: DASS 21 Item Scale.....	68
VITA.....	70

## INTRODUCTION

A variety of psychological traits have been associated with cardiovascular (CV) reactivity increases. This line of research stemmed from the suspicion that these traits relate to future CV disease through the mechanisms of excess CV reactivity. Early literature in this area examined the relationship between Type A personality and CV disease (see Friedman & Rosenman, 1971; Rosenman et al., 1975). Traits associated with the Type A personality include impatience, time-urgency, and workaholism. However, research on the link between Type A personality and CV disease has yielded some negative findings (e.g., Ragland & Brand, 1988; Shekelle, Gale, & Norusis, 1985), leading researchers to pursue components of personality such as hostility, anger-in versus anger-out, and anxiety to scrutinize the relationship between personality and CV disease and reactivity.

Although anxiety is a highly researched topic and much work has been done on the involvement of the autonomic nervous system (ANS) in anxiety, relatively few studies have investigated anxiety in the CV reactivity model (for review, see Friedman, 2007). The focus of this previous research has been on heart rate (HR) variability and the concept of vagal (i.e., parasympathetic) control of the heart. HR variability can be defined as the amount of variation in the cardiac interbeat intervals over time. The present study evolved from work by Friedman and colleagues on the autonomic characteristics of anxiety (Friedman & Thayer, 1998a; Friedman et al., 1993; Thayer, Friedman, & Borkovec, 1996; Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000). The current study is focused on worry, the primary cognitive feature of anxiety. The aim of this study was to determine if worry generally confers higher CV reactivity across various types of laboratory tasks or more specifically tasks that evoke worry. It has also been argued that CV recovery to stress may be delayed by perseverative negative cognition and this

more than reactivity per se might be the key link to future CV disease (Brosschot, Gerin, & Thayer, 2006; Brosschot & Thayer, 1998). As such, CV recovery to these laboratory tasks was also investigated in the present study.

### Cardiovascular Reactivity, Recovery, and Heart Rate Variability

#### *Cardiovascular Reactivity*

While exploring the foundations of the Type A personality, researchers began investigating CV reactivity, which was defined as the reaction of the CV system to stress (Krantz & Manuck, 1984). CV reactivity can be described as an individual's tendency to experience CV reactions when encountering engaging, challenging, or aversive behavioral stimuli (Manuck et al., 1989). In accord with standard practice, CV reactivity was operationally defined this study as the difference between measurements taken during a task and its preceding baseline period.

In the first line of research to relating high reactivity to disease, a mechanism linking the psychological and physical was discovered. Two studies noted greater reactivity in psychological risk factors of coronary heart disease: the Type A personality and two traits, anger and hostility (Harbin, 1989; Houston, 1992). From a physiological standpoint, higher CV reactivity was found in case-controlled studies of patients with coronary heart disease (e.g., Corse et al., 1982; Dembroski, MacDougall, & Lushene, 1979).

The question remained, however, whether reactivity was able to predict future disease. Keys and colleagues found that increased blood pressure reactivity to the cold pressor stress task was associated with an almost two-and-a-half times greater incidence of myocardial infarction or coronary heart disease mortality (Keys et al., 1971). CV reactivity to the cold pressor task was found to be a predictive of hypertension, with the strongest relationship in onset before 45 years of age (Menkes et al., 1989). CV hyperreactivity to a mental stressor was related to



catecholamine-sensitive coronary risk factors such as epinephrine and norepinephrine (Rostrup, Westheim, Kjeldsen, & Eide, 1993). Krantz et al. (1991) discovered that myocardial ischemia episodes were most severe in patients with the highest blood pressure reactivity to acute stressors. Each of these studies can be used as evidence for increased CV reactivity as a predictor variable for future disease.

### *Cardiovascular Recovery*

There is debate as to whether there is enough evidence to convict CV reactivity as a risk factor for CV disease due to small sample sizes, limited follow-ups, and the use of convenience samples (Manuck, 1994). As such, focus has been shifting from CV reactivity to recovery. CV recovery to stress may be of greater import as a predictor of CV disease. CV reactivity only yields information on the magnitude of responses, but recovery reflects magnitude, duration, and frequency of CV responses (Schwartz et al., 2003).

There are various ways in which CV recovery has been related to future disease. In studying “anger-in” individuals, Brosschot and Thayer (1998) postulated that delayed CV recovery through rumination was the means to CV disease. The CV disease risk factor of lower socioeconomic status correlates with delayed CV recovery during a mental stressor (Steptoe et al., 2002). Finally, individuals with a family history of CV disease were found to have less CV recovery than those lacking a family history of disease (Mezzacappa, Kelsey, Katkin, & Sloan, 2000). However, in contrast to reactivity, there is a lack of consensus on how to measure CV recovery, with difference from baseline, change from reactivity, and time to recover to baseline all serving as indices (Schwartz et al., 2003).

### *Heart Rate Variability*

HR variability has been studied as a factor related to both CV risk and mortality. Lower HR variability has been associated with increased risk for a cardiac event (Tsuji et al., 1996). Participants with low HR variability during a 24-hour period of study had a 2.6-fold increase in sudden death over a period of 2 years (Algra et al., 1993). Also, individuals with lower HR variability had an elevated risk for an initial incident of coronary heart disease (Dekker et al., 2000). In each of these studies, HR variability was used as a predictor for a later cardiac event.

The last piece of evidence to note is that vagal control of the heart seems to decrease with age (Ryan et al., 1994). Another study also examining age and HR variability found that although overall HR variability decreased with age, the relative measurements of vagal control remained constant (Kuo et al., 1999). This study also concluded that at middle age women have higher vagal control than men. If low vagal control or HR variability in general are potential risk factors, decreases in these factors with age could compound the risk of CV risk and mortality.

### Anxiety, Worry, and Cardiovascular Reactivity

#### *Anxiety, Cardiovascular Disease, and Reactivity*

Although the relationship between hostility and CV disease has been explored in depth, the connections between anxiety and CV disease along with the mechanism behind those relationships still need exploration. A correlation between individuals with panic disorder and an excess mortality from CV disease supports the hypothesis that anxiety relates to CV disease (Coryell, Noyes, & Clancy, 1982). Hypertension was found to have comparative levels of HR variability and reduced vagal tone to those found in individuals with panic disorders (Langewitz, Ruddle, & Schachinger, 1994).

While searching for a mechanism to explain the correlations between CV disease and anxiety, the previously research has indicated increased CV reactivity. High anxiety and

defensiveness have been associated with increased blood pressure (Shapiro, Goldstein, & Jamner, 1996). Anxiety has also been linked to decreased baroreceptor control (Watkins, Grossman, Krishnan, & Blumenthal, 1999). Decreased variance in CV function for individuals with anxiety will take precedence in the next section.

### *Anxiety and Heart Rate Variability*

Panic disorder and other forms of anxiety have often been thought to result from an ANS imbalance (Mitchell & Shapiro, 1991). This theory adheres to the notion that the body has a central ANS balance trait (e.g., as the sympathetic increases, the parasympathetic decreases and vice versa). However Berntson, Cacioppo, and Quigley (1991) have shown an ANS that is expressed in more complex patterns, including concordant and discordant activation and inhibition. One aspect of the CV system that exhibits this principle of complex patterns in ANS activity, yet was often overlooked until the last decade, is cardiac vagal control of the heart and the idea of autonomic flexibility (Friedman & Thayer, 1998a). Autonomic flexibility focuses more attention on problems in CV reactivity correlating with problems in inhibitory parasympathetic control rather than with the excitatory sympathetic system.

This autonomic flexibility approach looks at HR variability as a means of assessing cardiac vagal control. In HR variability, there are three major components: (1) a high-frequency component mediated by vagal activity and considered to be an index of vagal tone (Saul, 1990); (2) a low-frequency component that has been reported to have both sympathetic and vagal contributions, of which the relative contributions have been argued (Malliani, Pagani, Lombardi, & Cerutti 1991; Friedman, Thayer, & Tyrrell, 1996; Eckberg 1997; Porges, 2007); and (3) a very low-frequency band which has some autonomic underpinnings yet is still under investigation

(Cohen et al., 1999). To avoid current debates regarding the low-frequency band, this study focuses on the high-frequency component of vagal control of the heart.

HR variability has previously been studied with regard to anxiety through panic disorder. Panickers have displayed lower levels of vagal HR control when compared with normal controls (Friedman & Thayer, 1998a; Friedman & Thayer, 1998b). The reduced HR variability and low vagal tone in panic disorder is consistent with the CV symptoms of panic attacks and is further indicative of limited psychophysiological flexibility (Friedman & Thayer, 1998a). With regard to generalized anxiety disorder, clients have exhibited shorter cardiac interbeat intervals and lower high-frequency spectral power across all task conditions (Thayer, Friedman, & Borkovec, 1996).

#### *Worry, Reactivity, and Cardiovascular Disease*

Worry involves a predominance of verbal thought whose function appears to be the cognitive avoidance of threat (Borkovec, Ray, & Stober, 1998). One way that this cognitive component can be examined is through the relationship between worry and biases in memory. From the standpoint of explicit memory bias, there was a marked bias for the generalized anxiety disorder group to recall threat words in a free recall test and in a S1-S2 conditioning procedure that paired colored dots with threat and non-threat words that does not exist in the control group (Friedman, Thayer, & Borkovec, 2000). Moreover, anxious subjects have shown a marked attentional bias toward threat cues (Thayer, Friedman, Borkovec, Molina, & Johnsen, 2000). Both attention and memory have consistently shown threat biases in anxiety groups across a range of contexts (Coles & Heimberg, 2002; Mathews, 1990). Hence, anxiety by means of worry has been marked by aberrations in both attention and memory, two of the fundamental dimensions of cognition.

Generalized anxiety disorder is defined by excessive worry on most days for at least a six-month period with little control associated with that worry (American Psychiatric Press, 1994). This section will establish the relationship between worry and CV function to show the reasoning for its choice as an independent variable. Although most of the research on CV disease and worry has been done through anxiety investigations, much work has been done from a cognitive worry standpoint. One longitudinal study that evokes interest in the link between worry and CV problems found that men reporting higher levels of social worry possessed higher risks for nonfatal and fatal CV disease when compared with men who had reported lowered worry levels (Kubzansky et al., 1997). The Kubzansky group suggested that worry could also be investigated through a moderated or mediated relationship with traditional factors such as smoking. More research needs to be performed to determine if worry is the moderator that links CV problems and generalized anxiety disorder.

Worry as a variable in CV reactivity studies has yielded results mirroring those of generalized anxiety disorder. Glynn et al. (2002) provide evidence of slow blood pressure recovery due to emotional stress and worry during rumination periods. In relation to generalized anxiety disorder, worrisome thinking was related with phasic reductions in vagal tone (Lyonfields, Borkovec, & Thayer, 1995). Worry has also been used as a mediator of daily stressors, even into periods of sleep (Brosschot 2006).

As a task variable, worry has been linked to lower high-frequency spectral power, shorter interbeat intervals, and smaller mean successive differences for cardiac interbeat intervals when compared with relaxation and baseline periods (Thayer et al., 1996). In the present study, worry was examined from both the task perspective, as in Thayer et al. (1996), as well as through high and low worry group parings, and finally by the interaction effect between worry group and the

worry task. This study also investigated recovery across conditions to see if rumination is a key mechanism. Overall, the analysis possesses three dimensions of CV responding: anticipatory (during baseline), reactivity (during task), and recovery (after task). The next section will discuss the various tasks for determining if worry generalizes across conditions, only interacts with worry stimuli, or both.

### Stress Tasks in the Laboratory

#### *Stressors and the Cardiovascular System*

In previous works on the effects of stress on the body, two of the most frequently used stressors are the cold pressor and mental arithmetic (e.g., Carroll et al., 1996; Kamarck, Manuck, & Jennings, 1990; Kasagi, 1995; Krantz et al., 1991; Markovitz, Raczynski, Wallace, Chettur, & Chesney, 1998). However, these studies exploring whether CV reactivity to the cold pressor task can predict the development of hypertension have yielded both positive (Kasagi 1995) and negative findings (Carroll et al., 1996; Markovitz, Raczynski, Wallace Chettur, & Chesney, 1998). Another type of CV stress is the result of the manipulation of body position. Pagani et al. (1995) found that orthostatic stress evokes increased sympathetic activity and vagal withdrawal, while the supine position task results in vagal activation with sympathetic withdrawal (Fox, 1999). Multiple tasks were used in this study to examine the within-subjects differences among the various types of laboratory tasks as well as examine the between-subjects effects of worry during these tasks.

#### *Worry, Reactivity and Recovery*

Multiple tasks have predicted an increase in resting blood pressure level when used as CV reactivity challenges. Some examples of these tasks include the hand cold pressor task, mirror-image tracing, the use of video games, performing a social competence interview, and

mental arithmetic by means of a serial subtraction task (e.g., Borghi et. al., 1986; Markovitz et al., 1998; Matthews, Woodall, & Allen, 1993; Murphy, Alpert, & Walker, 1992; Treiber et. al., 2001). The tasks (stressor and nonstressor) were chosen to represent the standard CV stress tasks as well as two different groups that focus solely on physical-body-position stress and the type of stress brought about through worry rumination. By using a greater amount of tasks, this study was able to examine the relationships between worry and both top-down and bottom-up processes.

In addition to considering reactivity, this study investigated the effects of worry on CV recovery. By investigating recovery it was possible to see if worry manifests in tasks (stressor and nonstressor) equally in reactivity yet differently in recovery, if worry reacts with the CV system uniquely with respect to reactivity and recovery during different tasks, or if worry relates more with low CV recovery than reactivity across all tasks.

Risk factors such as hypertension and lack of fitness have been associated with delayed HR recovery (Schuler & O'Brian, 1997). CV recovery has been found to be a predictor of future systolic blood pressure baselines while controlling for the interference of CV reactivity (Stewart & France, 2001). High levels of anxiety have also been associated with slower systolic and diastolic blood pressure recovery (Vitaliano, Russo, Paulsen, & Bailey, 1995). To summarize, CV recovery was examined in more detail during this study to determine its interactions with worry level and to see which tasks are associated with lower CV recovery.

#### *Reactivity versus Recovery*

Currently there is a lack of consensus on the “gold standard” in quantifying cardiovascular recovery. Recovery can be examined as a difference score between the means at baseline and recovery periods, as the time it takes to recover, or even as the percentage return to

baseline by the end of the recovery period. Due to this lack of consistency in the literature, I will refer to what is usually called as the *recovery period* as a *post-task phase*. This neutral term avoids the implication that this experimental period, as defined in this study, unequivocally operationalizes true recovery period. However, in this post-task phase, the study examined how high and low worriers differ after a task has been completed. These results hold implications regarding recovery and are considered in this light in the discussion section. For the sake of consistency, baseline periods will be called *pretask*.

### The Present study

#### *Purpose of Research*

This study examined the stress-CV reactivity model in two parts. The first goal of this study was to examine in closer detail multiple laboratory tasks (stressor and nonstressor) to determine how and which laboratory stressors are related. The analysis was a comparison of three sets of stressor types (standard, physical, and mental) and an examination of the individual differences between the stressors. The second goal of this study was to investigate if the high worry group differed from the low worry group across all stressors equally or if reactivity and recovery differed for some stressors between the high and low worry groups.

The first observation was across all stressors for a main group effect. The primary hypothesis in this examination was that individuals with high worry should have an increase in CV reactivity as well as delayed CV recovery related with low vagal control of the heart. Individuals high in worry should express a further reduction HR variability to stress when compared with controls. The study also examined whether there is an interaction effect with the worry imagery task (e.g., worry manifests across all tasks, yet is more pronounced in the worry imagery). A supplementary hypothesis was that high worriers would show a marked increase in



reactivity in addition to lessened and delayed recovery to the worry imagery task when compared with the other tasks.

### *Cardiovascular Measures*

CV measures in this study were derived from electrocardiogram (ECG), impedance cardiogram (ICG), and a blood pressure monitor. The ECG was used to derive HR (mean number of beats per minute), which has both vagal and sympathetic beta-adrenergic influences. The ECG was also used to derive HR variability. From the HR data, the heart period time series was spectrally analyzed. Low-frequency (0.04–0.15 Hz) and high-frequency (0.15–0.40 Hz) ranges were extracted from the power spectral density units. The high-frequency differences were observed to determine any differences in cardiac vagal activation between high and low worriers under stress. HR spectral values investigated in this study included high- and low-frequency peak values, power values, power percentages, and normalized units. ICG data was used to calculate the pre-ejection period, which can be used as a measure of cardiac sympathetic beta-adrenergic activity (Sherwood et al., 1990). Left ventricle ejection time was also measured from the ICG. Systolic and diastolic blood pressure was taken during the first 45 seconds of baseline, task, and the post-task phases for examining both reactivity and recovery at their peak amounts.

## METHOD

### *Subjects*

The subjects in this study included 41 nonsmoking women (mean age = 19.7 years) recruited through the Virginia Polytechnic and State University Psychology Department's SONA online research system. Women were used in this study due to their increased prevalence of generalized anxiety disorder compared to men (American Psychiatric Press, 1994). The first step in recruitment was the use of an online version of the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990; Appendix C). Four hundred seventy-two women completed the online portion of the study. During this selection process, subjects were screened through an online physical and mental health background form placed at the end of the PSWQ (Appendix C). One question included in the middle of the physical and mental health form asked for the subject's greatest fear or cause of worry. Information was also collected on height and weight to calculate body mass index, medications, and previous negative physical and mental health life events to control for potential confounds. Each subject had to report being in good health and report no cardiovascular, pulmonary, or other medical conditions such as hypertension, back pain, diabetes, or a neurological disease. Women who reported medical conditions were screened out and ineligible for the laboratory session. Since the study was done on nonsmokers, any women listing tobacco use were screened out as well. Of the 472 women completing the online portion of the study, 330 were deemed eligible for part two of the study. Completion of the online portion was worth one extra credit point toward the psychology class of the subject's choosing.

After this initial screening, subjects were grouped by worry level. Subjects scoring in the bottom third of the 330 eligible participants on the PSWQ were classified as low worry. Subjects

scoring in the top third of the 330 eligible participants on the PSWQ were classified as high worry. A total of 180 eligible subjects were invited to participate in the laboratory portion of the study. Before arriving for the study, subjects were asked to abstain from alcohol for 24 hours and caffeine for 12 hours before their laboratory visit. From these invited individuals, 22 women from the low worry group ( $M = 37.7$   $SD = 6.5$ ) and 19 women from the high worry group ( $M = 67.3$   $SD = 5.3$ ) chose to participate. Through the use of participant numbers, the experimenter remained blind to the worry group of the individual. Also, the individual was not told if she was a high or low worry individual until after the experiment ended. If for any reason a subject had not been in good physical or mental health upon arrival (e.g., she had alcohol before laboratory visit), a new subject would have been selected from the corresponding worry level. However, all subjects abstained the proper lengths of time from alcohol and caffeine. This confound check was made through the use of a shorter health questionnaire, which includes a question regarding what phase of the menstrual cycle the subject was in (Appendix E).

### *Materials*

This study employed the online use of the PSWQ as a means of separating women into worry level type. During the laboratory session, systolic and diastolic blood pressures were monitored using the IBS SD-700A automated Korotkoff blood pressure and pulse monitor device (Industrial & Biomedical Sensors Corp., Waltham, MA). Measures of HR, pre-ejection period, left ventricular ejection time and root mean successive differences of heart rate were taken from the ECG and ICG using the Ambulatory Monitoring System v4.4 (AMS; Vrije Universiteit, the Netherlands). The validity and reliability of the AMS has been established in previous works (Willemsen et al. 1996). This setup entails prepping the skin with alcohol to reduce skin impedance to the electrophysiological signals and the following placement of six disposable

thoracic electrodes. Three electrodes for monitoring ECG were placed on the front of the subject and three electrodes were used for impedance cardiography with one electrode on the front and two electrodes on the back of the subject. A Fast Fourier Transform was used to determine the spectral estimates for the low and high frequencies of heart rate.

### *Design*

Each laboratory session consisted of six stressor tasks lasting three minutes each. The six tasks were completed in randomized order pairings assigned to a participant when she was considered eligible for the laboratory portion. A total of eight different laboratory design orders were generated (Appendix F). Each task was preceded by a three-minute vanilla baseline period during which a three-minute segment of a multicultural documentary video entitled *Powaqqatsi: Life in Transformation* (Reggio, 1988) was shown as a neutral visual stimulus to control for perseveration confounds prior to exposure to the next task. The silent video portrays the daily life events of people in various countries. The baseline period is noted as pretask due to low and high worriers beginning at separate baselines after the first task. Following each task, there was a three-minute post-task period during which the subject was asked to sit quietly in the chair, eyes closed. ECG and ICG were continuously recorded during each epoch. The start and end time of each phase (pretask, task, and post-task) were noted with event markers on the AMS. Systolic and diastolic blood pressure recording began at the start of each phase (pretask, task, and post-task) so that the peak values were noted at the 45-second mark.

### *Procedure*

Upon arrival to the lab, the subject was greeted by the experimenter and given a quick tour of the facilities and explanation of the equipment and the study itself. The subject was then seated in the lounge chair and asked to read and sign the informed consent form (Appendix G).

After consent had been given, a female research assistant applied the electrodes necessary for the ECG and ICG, recorded the ICG electrode distance, and made a guess as to whether the individual was high or low worry. After the equipment was applied, the experimenter returned to the room and proceeded to apply the blood pressure cuff and activate the AMS. At this point, the experimenter asked the subject to sit quietly for three minutes with her eyes closed so that both machines could be examined for accuracy. This recording is regarded as the anticipatory baseline measurement. After this baseline, the experimenter administered the shorter health questionnaire (Appendix E) and gave a description of the six tasks as well as the pretask and post-task periods. Following this explanation period, the task epochs began in the following order (order for task order A; detailed descriptions are in the next section):

(1) Pretask 1 (Pre1): Sitting quietly in a comfortable lounge chair while observing a video screen showing a neutral segment of *Powaqqatsi*.

(2) Orthostatic Stressor (T1): Standing upright.

(3) Post-task 1 (Post1): Sitting quietly in the lounge chair.

(4) Pretask 2 (Pre2): Identical to Pre 1.

(5) Supine Position (T2): Lying quietly in the supine position in the lounge chair.

(6) Post-task 2 (Post2): Identical to Post 1.

(7) Pretask 3 (Pre3): Identical to Pre 1.

(8) Hand Cold Pressor (T3): Hand placed into a container of ice water.

(9) Post-task 3 (Post3): Identical to Post 1.

(10) Pretask 4 (Pre4): Identical to Pre 1.

(11) Mental Arithmetic (T4): Counting backwards from 3,000 by 7.

(12) Post-task 4 (Post4): Identical to Post 1.

(13) Pretask 5 (Pre5): Identical to Pre 1.

(14) Worry Imagery (T5): Worry about a previously discussed topic of concern for the individual.

(15) Post-task 5 (Post5): Identical to Post 1.

(16) Pretask 6 (Pre6): Identical to Pre 1.

(17) Relaxation (T6): Guided relaxation through use of a taped recording.

(18) Post-task 6 (Post6): Identical to Post 1.

There was counterbalancing within the task pairings (classical, body position, rumination/relaxation) but not between the pairings. Tasks 1 and 2 were counterbalanced with each other, as will task 3 with 4 and task 5 with task 6 for eight total combinations noted in the order definitions section (Appendix F). After the six tasks along with their pretask and post-task periods had been completed, the subjects were asked to complete the 21 item version of the DASS (Appendix H) and complete the PSWQ (Appendix C) again. With the addition of these questionnaires, this study examined how state conditions can affect trait worry. At the completion of the experiment, the subject was informed about the goals of the study and given the option of seeing her CV measures as well as learning her worry group. At this time, the investigator answered any questions that the participant had about the purposes of the study and gave her the option to have her data withdrawn. Following this, the experimenter left the room, credit was assigned on the SONA system, and the subject was allowed to remove her electrodes.

### *Task Descriptions*

The first pairing of tasks examined the effects of body position. The first task is a physical orthostatic stressor modeled after previous orthostatic stressor tasks done by Pagani et al. (1995) and Friedman and Santucci (2003). During this task, the subject was asked to arise

from the lounge chair and stand for the three-minute task with her eyes closed. The specific task instructions were to remain as still as possible while standing upright without moving, slouching, or opening the eyes for the full three minutes. At the end of this task, the three-minute recovery period began once the subject returned to the seated position and was comfortable. The orthostatic stressor has been shown by Pagani et al. (1995) to elicit sympathetic activation along with vagal withdrawal.

The second task was a supine position task. Supine position results in vagal activation with sympathetic withdrawal, which related to the opposite effects of the orthostatic stressor (Fox, 1999). At the beginning of the task, the experimenter assisted with moving the lounge chair position from upright to the supine position with the subject's feet resting on the chair's footrest. The instructions for this task were to lie still in the chair quietly with eyes closed and not to sit back up for the three minute period. If any movement was seen, the experimenter asked again that the subject stay motionless. At the end of the task, the chair was set back to the upright position for the recovery period.

The second grouping of tasks was the pairing of two standard CV stressor tasks. The first task of this pair was the hand cold pressor. During this task, the subject remained seated upright in the lounge chair and placed her left hand up to the wrist in a small tub of ice water measured between 3–6°C while keeping her eyes closed. The left hand was used because previous research has shown larger reactivity than for the right hand (Friedman, Lozier, & Vella, 2005). A small filter placed in the tub was used to prevent any ice coming in contact with the subject's hand during the task. The instructions given for this task were for the subject to keep her hand in the cold water up to the wrist for the full three minutes. While the hand could have been removed from the water if discomfort was experienced, the investigator asked that the task be completed

as long as possible. At the end of the hand cold pressor task, the investigator gave the subject a towel in order to dry off her left hand to prevent interference of a cold hand with the recovery period and other tasks. This task is characterized by a sympathetic alpha-adrenergic activation (Saab et al., 1993)

The second standard CV stressor is mental arithmetic. The stressor has been used in previous research because, although it lacks motor stimulation, it possesses an active mental component. The version of mental arithmetic that this study incorporated was subtraction. Counting began at 3,000 and decreased toward zero by intervals of seven. At the beginning of the task, the investigator informed the individual to attempt to reach the lowest number possible with the fewest or preferably no errors. This task was performed with the eyes closed to prevent the subject from counting on her hands. Mental arithmetic is characterized by sympathetic beta-adrenergic activation and vagal withdrawal (Gorman & Sloan, 2000).

The final task pairing consists of imagery tasks. The first task in this pair is a variation of an imagery task used in a study of generalized anxiety disorder (Thayer, Friedman, & Borkovec, 1996). In this task, the individuals were asked to worry about a previously discussed topic of great concern. One of the questions on the online physical and mental health questionnaire (Appendix D) asked what the subject's greatest fear, worry or point of concern was. For this task the subject remained seated in the lounge chair with her eyes closed. At the beginning of the task, the investigator reminded the subject of her greatest fear, worry, or point of concern. The instructions given for this task were to sit quietly with eyes closed and focus on the stated worry. The subject was instructed to picture this worry and its consequences, and she was instructed to focus on the details of the worry, such as what the worry embodied and how it affected her. At



the conclusion of this task, the recovery period began. The subject was instructed to clear her mind of all thoughts and to sit with eyes closed for three minutes.

The final task and second part of this pairing was relaxation. In this task, the investigator played a three-minute clip of a guided relaxation audio tape. The instructions for this task were to sit with eyes closed for the three minutes and focus on the tape, including the tones played and the voice providing the guided relaxation. The goals were to remain still and attempt to relax as much as possible while following the tape. The relaxation task was this study's use of a cognitive contrast to worry, which has been shown to increase vagal activation in relaxation versions such as paced breathing (Malliani et al., 1999).

#### *Data Analysis*

The primary hypotheses were analyzed by a 2 (worry level: between-subjects) x 18 (condition: within-subjects) MANOVA. The dependent variables in this case were systolic and diastolic blood pressure; HR; HR variability (rMSSD and high- and low-frequency powers); pre-ejection period; and left ventricle ejection time. The first comparison was a within-subjects design showing the differences among the six stressors for all subjects as well as a between-subjects comparison to see if high and low worriers differed across all tasks. The second comparison was a between-subjects comparison of CV reactivity and recovery differences between low and high worriers across the six tasks. This analysis was meant to determine if CV reactivity and recovery differences between high and low worriers existed across tasks. The third set of analyses tested for interactions between worry level and stress type. The reason for this analysis was to investigate if worriers had increased reactivity across tasks along with a larger increase for the worry task. The analysis was also conducted for CV recovery. One last set of data analyses consisted of examining the task and post-task periods in two parts. Splitting the

epochs in half allowed for comparison of immediate task and post-task changes with later reactivity and recovery. Some data points are missing due to equipment errors resulting in uneven N values across dependent variables. Post hoc testing was performed using a modified Bonferroni procedure (Simes, 1986).

### *Ethical Considerations*

To ensure the privacy of each individual, all scores were saved by subject number only in both data analysis and storage. The subject was allowed to discontinue the experiment at any time if one of the tasks caused discomfort or pain. This statement was expressed at the beginning of the experiment. This study utilized a three-minute time period to lower discomfort to the subjects during the left hand cold pressor task. While there was some discomfort, this time period was well short of a time which could have caused any damage to the left hand. Also, the three minute time period was short enough to prevent discomfort during the standing task. Even though the subject could have been shown her CV performance at her request, she was informed that the results are for research purposes only and that any concerns she had should be addressed by a medical professional. At the end of the experiment the subject was again made aware that if she would like her data withdrawn from the experiment for any reason, she had that option available at that time or by emailing the experimenter at a later date. The experimenter expressed that there was no penalty and that the subject would receive extra credit in either case.

## RESULTS

### *Primary Hypothesis Analysis*

2 X 18 repeated measures ANOVAs were run on the eight dependent cardiovascular variables. While examining the between-subjects differences, no significant differences were found for systolic blood pressure ( $F(1,35)=.441, p=.551$ ), diastolic blood pressure ( $F(1,35)=1.094, p=.303$ ), HR ( $F(1, 36)=2.649, p=.112$ ), rMSSD ( $F(1,36)=.510, p=.480$ ), the ratio of low-frequency and high-frequency power percentages ( $F(1,36)=.920, p=.344$ ), high-frequency power in normalized units ( $F(1,36)=1.095, p=.302$ ), pre-ejection period ( $F(1,34)=1.813, p=.187$ ), and left ventricular ejection time ( $F(1,34)=.634, p=.431$ ). Upon further investigation, it was noticed that BMI group might be causing the data to be slightly skewed due to more obese/overweight individuals or underweight/anorexic individuals in one group when compared with the group. More obese/overweight subjects were in the low worry group while more underweight subjects were in the high worry group. The analysis was run a second time with BMI group used as a covariate and all further analyses controlled for BMI group. Means and standard errors for the eight dependent variables are listed in tables 1 through 8. Between-subjects effects for systolic blood pressure, diastolic blood pressure, rMSSD, the ratio of low-frequency and high-frequency power percentages, high-frequency power in normalized units, pre-ejection period, and left ventricular ejection time remained nonsignificant (all p values  $>.10$ ). However, the difference in HR between groups became significant ( $F(1, 35)=4.840, p<.05$ ). As shown in Figure 1, the high worry group consistently had higher HR across pretask, task, and post-task periods.

While continuing to adjust for BMI group, the within-subjects differences across tasks were examined using a Huynh-Feldt correction for degrees of freedom. No significant findings

were found for systolic blood pressure ( $F(5, 177)=1.192, p=.315$ ), diastolic blood pressure ( $F(14, 486)=.767, p=.708$ ), rMSSD ( $F(8, 274)=1.475, p=.168$ ), left ventricular ejection time ( $F(11,357)=.642, p=.789$ ), and pre-ejection period ( $F(4,135)=.921, p=.455$ ). There were significant epoch differences among high-frequency power in normalized units ( $F(15, 518)=1.739, p<.05$ ), the ratio of low-frequency and high-frequency power percentages ( $F(4,150)=3.144, p<.02$ ), and HR ( $F(8, 275)=3.261, p<.005$ ).

The differences found in the high-frequency power spectrum were due to larger decreases during the orthostatic and mental arithmetic tasks when compared with all other epochs. The differences found in the ratio of low-frequency to high-frequency power percentages were more varied at various baselines with a noticeably higher ratio in the supine post-task period. With regard to HR, the largest epoch differences were due to increased HR during the cold pressor task and mental arithmetic. There were no interaction effects between worry group and the various epochs ( $p$  values  $>.10$ ).

#### *Anticipatory Baseline Analysis*

One-way ANOVAs were performed on worry group while controlling for BMI group on all of the dependant variables at the anticipatory baseline and at the first baseline following acclimation to the lab. At the anticipatory baseline, HR was found to be higher in the high worry group ( $F(1, 35)=7.282, p<.02$ ). HR variability measured through rMSSD was marginally different, with the low worry group presenting higher levels than the high worriers ( $F(1, 35)=2.955, p<.10$ ). At the first baseline following, acclimation to the lab, the high worry group continued to have high HR ( $F(1, 35)=6.332, p<.02$ ). The HR differences are expressed in Figure 2. No other dependent variables were significantly different. The recovery to the first baseline was not significant for all cardiovascular variables ( $p$  values  $>.10$ ).

### *Group Differences during the Laboratory Tasks*

For the orthostatic task epoch, shorter pre-ejection periods in low worriers during the second half of the task ( $F(1, 33) = 5.461, p < .05$ ) were found. Also, with regard to reactivity, there was a finding that rMSSD decreased more in the low worry group between the first and second half of the task ( $F(1, 35) = 4.493, p < .05$ ) as well as the reactivity in pre-ejection period between pretask and the second half of the task epoch ( $F(1, 33) = 4.891, p < .05$ ). However, in relation to spectral frequencies, the opposite was true. The high worry group had larger decreases in normalized high-frequency power and increases in normalized low-frequency power ( $F(1, 35) = 4.329, p < .05$ ).

In the post-task period, there was a difference in HR post-task with the high worry group having increased HR ( $F(1, 35) = 4.111, p < .05$ ). Pre-ejection period was longer for the low worry group across the post-task epoch ( $F(1, 33) = 6.090, p < .02$ ) as well as during the first ( $F(1, 33) = 4.736, p < .05$ ) and second halves of the epoch ( $F(1, 33) = 4.715, p < .05$ ). During the post-task period, left ventricular ejection time increased in larger amounts for the high worry group when compared to the low worry group between the first half of the epoch and the second half ( $F(1, 33) = 4.361, p < .05$ ). These post-task findings for pre-ejection period are expressed in Figure 3. There was also the same difference between the second half of the post-task epoch and the pretask period for left ventricular ejection time ( $F(1, 33) = 6.154, p < .02$ ). Finally, diastolic blood pressure reactivity was larger for the high worry group ( $F(1, 36) = 9.184, p < .01$ ) while diastolic blood pressure recovery was increased in the low worry group ( $F(1, 36) = 9.010, p < .01$ ).

During the supine task epoch, the significant findings related to either HR or low-frequency power. HR was significantly higher for the high worry group in both the task ( $F(1, 35) = 7.797, p < .01$ ) and post-task epochs ( $F(1, 35) = 7.267, p < .02$ ). These differences were

significant at all four time points: first half of the task ( $F(1,35)=6.248, p<.02$ ), second half of the task ( $F(1,35)=8.678, p<.01$ ), first half of the post-task period ( $F(1,35)=5.314, p<.05$ ), and second half of the post-task period ( $F(1,35)=9.190, p<.01$ ). During the post-task period, HR continued to decrease for the low worry group while it increased for high worriers between the first and second halves ( $F(1, 35) = 5.060, p<.05$ ). For low-frequency power reactivity, the low worry group had significantly larger decreases during the task than the high worry group ( $F(1, 35) = 4.537, p<.05$ ). This result is shown in Figure 4.

For the cold pressor task, various patterns emerged. First, the HR difference between high worriers and low worriers was only significant during the second half of the epoch ( $F(1, 35) = 4.642, p<.05$ ). However, HR was significantly higher in the high worry group during the post-task period as a whole ( $F(1, 35) = 4.773, p<.05$ ) as well as the first ( $F(1, 35) = 4.861, p<.05$ ) and second halves ( $F(1, 35) = 4.48, p<.05$ ) of the post-task period. Left ventricular ejection time was longer in the high worry group across the cold pressor task ( $F(1, 33) = 4.436, p<.05$ ) but more specifically during the second half of the epoch ( $F(1, 33) = 6.412, p<.02$ ). The comparison of left ventricular ejection time during the pretask and task periods is shown in Figure 5. Pre-ejection period was only significantly longer in the low worry group during the second half of the post-task period ( $F(1, 33) = 4.234, p<.05$ ).

With regard to reactivity, left ventricular ejection time increased during the cold pressor task in the high worry group ( $F(1, 33) = 5.205, p<.05$ ). The pattern in particular was an increase in time between the second and first halves of the epoch ( $F(1,33)=9.545, p<.005$ ) as well as an increased time difference in the high worry group when comparing the second half of the task with the pretask period ( $F(1,33)=8.694, p<.01$ ). For recovery, the pre-ejection period was found

to increase in the second half of the post-task period when compared to the first half in low worriers ( $F(1,33)=6.104, p<.02$ ).

The mental arithmetic task epoch presented a lack of group differences. There was only one finding which was for the high-frequency power percentage. During the task, the high-frequency power percentage increased more in the high worry group ( $F(1, 35) =4.302 p<.05$ ). There were no findings for reactivity or recovery differences.

For the worry task epoch, there were no significant differences between the high and low worry groups with regard to cardiovascular function during the task itself or with regard to reactivity. However, the two groups did differ on recovery. The high worry group had increased HR recovery during the worry task as a whole ( $F(1, 35) =4.711, p<.05$ ), yet the low worry group exhibited increased recovery during the second half of the post-task epoch ( $F(1, 35) =4.547, p<.05$ ). Utilizing the ICG findings, left ventricular ejection time increased significantly more in the high worry group in the second half of the post-task time in relation to the pretask period ( $F(1,33)=4.368, p<.05$ ). Pre-ejection time increased in the low worry group and decreased in the high worry group between the first and second half of the post-task period ( $F(1,33)=5.193, p<.05$ ). This pre-ejection period recovery is shown in Figure 6. The last result was that post-task, diastolic blood pressure in low worriers was marginally lower than the high worry group in the post-task period ( $F(1,36)=2.968, p<.10$ ).

Finally, the relaxation imagery task yielded results that were the opposite of the other tasks. During the task itself, pre-ejection period decreased in the low worry group and increased in the high worry group ( $F(1, 33) =4.88, p<.05$ ). In the post-task period, HR increased in the low worry group between the second half and first half of the epoch ( $F(1, 35) =8.531, p<.01$ ). Also, the high worry group had increased recovery between the second half of the post-task period

when compared to the pretask epoch ( $F(1, 35) = 4.750, p < .05$ ). Finally, low-frequency power was higher during the task in the low worry group when compared with the high group ( $F(1, 35) = 6.087, p < .02$ ). The task low-frequency power differences are noted in Figure 7.

The last results to discuss are the effects of the length of the study on the group differences in HR. For the first two task sets, pretask HR was significant in the orthostatic set ( $F(1, 35) = 4.828, p < .05$ ) and the supine task set ( $F(1, 35) = 7.154, p < .02$ ). However, in the last two groups, there was one task with a significant difference and one without. The cold pressor pretask HR differences ( $F(1, 35) = 7.662, p < .01$ ) and the worry pretask HR differences ( $F(1, 35) = 4.717, p < .05$ ) while the mental arithmetic ( $F(1, 35) = 3.942, p < .10$ ) and relaxation imagery ( $F(1, 35) = 3.005, p < .10$ ) pretask HR differences were only marginally significant.

#### *Manipulation Checks*

To eliminate the possibility of state conditions affecting the study, the worry groups were compared on the three scales of the DASS 21 item and a second administration of the PSWQ. In relation to state conditions, the high worry group scored higher for state anxiety ( $F(1, 38) = 11.339, p < .005$ ), stress ( $F(1, 38) = 20.959, p < .001$ ), and depression ( $F(1, 38) = 6.730, p < .02$ ). To examine the validity of the manipulation, the high worry group scored higher on the second administration of the PSWQ as well ( $F(1, 38) = 60.03, p < .001$ ). Finally, to examine the validity of the worry task paradigm, there was no difference between the two groups on the subjects' self-reported worry to the task ( $F(1, 37) = .342, p = .562$ ).



## DISCUSSION

The purpose of this experiment was to examine the cognitive trait of anxiety, worry, and whether or not high trait worry could impact the cardiovascular system beyond the influence of other factors. In this regard, the major finding of this study was the persistently higher HR in the high worry group when compared with the low worry group. Also, when cardiovascular reactivity differences were discovered in HR, they were in the direction of a greater increase in the high worry group. In cardiovascular recovery, the discoveries in HR differences were related to increased recovery for the low worry group. Reverting to the primary hypothesis, this study predicted increased cardiovascular reactivity across all tasks with decreased cardiovascular recovery for the high worry group. This primary hypothesis was supported by the HR group differences but was not supported by the study's other cardiovascular variables. The hypothesis that HR variability would be consistently higher across tasks for the low worry group was not supported, however, upon visual investigation; differences appear and yet are hindered by large amounts of error variance.

The second aim of this study was to examine the effects of worry as a task variable. There were no significant findings relating to cardiovascular differences during the task itself or to cardiovascular reactivity. This was probably due to the lack of manipulation as high worriers did not express their thoughts as more worrisome than the low group. However, there were significant findings in the post-task period. Even with a weaker manipulation, the longer-term effects of rumination are seen in the second half of the post-task epoch. In the cognitive tasks, both groups initially take time returning to baseline; however, the low worry group has further recovered in the second half of the epoch while the high worry group has not.

Another debate relating to the task comes from the type of anxiety used in the task. Previous research has debated that anxiety studies struggle to show differences in the brain and cardiovascular system because the studies themselves use two different anxiety manipulations. The authors state that the individuals possess anxious apprehension or worry, but the manipulated variable in the task is anxious arousal or panic (Heller, Nitschke, Etienne, & Miller 1997). Taking into account the lack of manipulation in this study, one future implication will be developing a task that relates to anxious apprehension in a nonclinical sample.

The analysis of the anticipatory baseline and the first baseline after acclimation to the lab further provide evidence supporting the group differences. HR was significantly higher for the high worry group in both the anticipatory period and the first baseline. The recovery to the first baseline for HR was not significantly different for the groups. Both groups decreased in HR with acclimation to the laboratory setting; however, the patterns were the same, and the high worry group continued to have an increased HR. HR variability as measured in rMSSD also was marginally significant despite high standard error. The low worry group responded to the novel setting with higher levels of rMSSD than the high worry group. Beyond further supporting this study's primary aim, these findings also provide evidence that coming to the lab is itself a stressor. With elevated levels toward the beginning of the study, acclimation to the laboratory setting must be taken into account when comparing early tasks to later ones especially, in other studies where tasks begin upon arrival to the study.

The final item for discussion was the different responses of the high and low worry groups to the different tasks. The findings for the orthostatic task relate to decreased vascular sympathetic activity during the second half of the task for high worriers. Yet, this finding is in discordance with the high worry group's decrease in normalized high-frequency power and

increased diastolic blood pressure reactivity. In the post-task period of the orthostatic task set, the low worry group showed decrease cardiac sympathetic activity as evidenced by increases in the pre-ejection period. In the post-task period, HR was higher for the high worry group relating with an increase in sympathetic arousal and parasympathetic withdrawal.

During the supine body position task, low-frequency power decreased significantly more in the low worry group than in the high worry group. While the autonomic underpinnings of the low-frequency spectrum have been debated, there is some evidence for a relationship to the sympathetic nervous system. Also, HR was significantly lower across all task and post-task periods for the low worry group. The lower HR can be related to increased vagal control during the body position, which elicits parasympathetic arousal.

For the cold pressor task, HR was only significant during the second portion of the epoch. This may relate to acclimation to the cold water. The cardiovascular systems of high and low worriers initially saw marked increases in HR, yet as the task wore on and the low worriers acclimated to the task, the group differences reemerged. During the post-task period, the HR differences were significant across the epoch and both of its halves. Left ventricular ejection time was significantly longer during the cold pressor task in the high worriers across the task but not during the first half of the epoch. Finally, the pre-ejection period showed a decrease in sympathetic cardiac activity in the second half of the post-task period for the low worry group. The confound of a cold hand causing discomfort in the first part may have prevented the earlier parasympathetic arousal post-task.

There was a lack of significant findings in the mental arithmetic task paradigm. This lack of findings includes the marginally significant difference in HR at the pretask period. The high-frequency power percentage finding opposes the primary hypothesis of increased vagal control in

the low worry group. One possibility for the lack of findings relates to the difficulty of the task. By using a difficult serial subtraction task (starting at 3000 and subtracting 7), there may have been a ceiling effect for the high worry group. The mental arithmetic task should relate increased sympathetic arousal and parasympathetic withdrawal; however, the ceiling effect would prevent noticeable group differences in high and low worriers.

The group differences were not apparent during the worry task epoch but were perceptible in the post-task period. Cardiac sympathetic activation was confirmed by decreased pre-ejection periods in high worriers during the post-task epoch. As stated before, it is difficult to discuss the findings relating to the worry paradigm due to the lack of manipulation and differences in anxiety type. However, the main findings of this section present substantiation for delayed rumination in the high worry group as evidenced by the sympathetic activation and parasympathetic withdrawal in the post-task period.

The results in the relaxation imagery section indicate increased parasympathetic activation in the high worry group. These discordant findings appear in both the task and post-task periods. One potential reason could be rumination on the relaxation imagery during the post-task period. If during the post-task worry period high worriers continued to ruminate on their worry, it is possible that during the post-task relaxation period, they continued to focus on the guided relaxation. One potential theory related to this idea comes from investigations in emotionality and brain laterality. Papousek and Schulter (2002) hypothesized that a possible confound during mood induction is susceptibility. Individuals who are high on an emotion trait may be predisposed to respond greater to mood induction. In this case, high worriers would be susceptible to marked responses during the worry and relaxation tasks.

One limitation of this study is the lack of continuous blood pressure recordings. Systolic blood pressure recordings were nonsignificant and a select few significant and marginally significant diastolic blood pressure findings existed. As discussed earlier regarding the patterns of cardiac response, being unable to compare the first half of an epoch with the second half, may have resulted in significant findings being overlooked. Group differences in blood pressure may have been present only in the second half of a task. They would have been missed by a single recording. Also, there exist more possibilities for error in only taking one recording per epoch in that movement can dramatically impact results. The other limitation in the study was the failure to manipulate worry during the task portion. While the method used in this study had previously been successful (Thayer, Friedman, & Borkovec 1996), there is no modified version for use in a nonclinical college sample. It remains important to consider the points made by Heller et al. regarding the differences between anxious apprehension and anxious arousal (Heller, Nitschke, Etienne, & Miller 1997).

The last point of discussion returns to the debate of the “gold standard” of cardiovascular recovery. The group differences found in this study were discovered using a post-task to pretask comparison. This method has been previously used in other rumination studies as well as in studies run by this laboratory (Glynn, Christenfeld, & Gerin 2002; Vella & Friedman in press). An example of a different method of cardiovascular recovery studies the system as a temporal measure. In this method, recovery is recorded as the time it takes for a subject to return to the pretask levels within a certain time period (Linden, Gerin, & Christenfeld 1997). While there is still debate over the means to record recovery, this study does present significant findings related to rumination as well as the purpose for studying the post-task period. These post-task

differences between high and low worriers present a possible mechanism for examining the relationship between worry and CV disease.

### *Conclusions*

This study supports the idea that the cardiovascular functionality of high and low worriers differs in some regard. The overall group differences for HR regardless of pretask, task, or post-task epoch provide the most support for this hypothesis. The findings on HR variability are mixed. Although they were almost entirely nonsignificant, they were visibly noticeable, yet the standard errors prevented further analysis. Whether an increased sample size would alleviate this problem is debatable in this case. Finally, the worry task paradigm did not result in increased reactivity for the high worry group. In this study, the worry task paradigm was borrowed from one used in a clinical sample. The lack of a difference in cardiovascular function might be due to worry manipulation not being effective and the need to develop a paradigm for use in nonclinical samples.

This study also provides support for the use of different laboratory tasks and the need to examine multiple time points across an epoch. The need for different laboratory tasks was shown by cardiovascular variables exhibiting group differences during some tasks and not others. An example of this need can be seen in the lack of findings during the mental arithmetic task, the opposing findings in the relaxation imagery, and the positive findings in the worry, cold pressor, and both body position tasks. Without the examination of the two epoch halves during the task and post-task periods, the patterns of reactivity and recovery would have been lost. With the inclusion of this analysis, this study was able to examine how the high and low worry groups differ initially and during task and recovery.

In conclusion, the differences in HR and pre-ejection period during the post-task period present evidence for sympathetic nervous system dysfunction in high worriers. The results of this study provide support for the hypothesis that individuals with high worry differ from low worriers in that they lack adequate sympathetic withdrawal in the post-task period. As evidence by the worry task, one possibility for these sympathetic differences is rumination during the post-task period. However, body position tasks provide further evidence for differences in autonomic system control of the heart between high and low worriers.

## REFERENCES

- Algra, A., Tijessen, J. G. P., Roelandt, J. R. T. C., Pool, J., & Lubsen, J. (1993). Heart rate variability from 24-hour electrocardiography and the 2-year risk for sudden death. *Circulation, 88*, 180–185.
- American Psychiatric Press. *Diagnostic and statistical manual of mental disorders (DSM-IV)*, 4th ed. Washington, DC: APA, 1994.
- Behar, E., Alcaine, O., Zuellig, A. R., & Borkovec, T. D. (2003). Screening for generalized anxiety disorder using the Penn State Worry Questionnaire: A receiver operating characteristics analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 34*, 25–43.
- Berntson, G. G., Cacioppo, J. T. & Quigley, K. S. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review, 98*, 459–487.
- Borghi, C., Costa, F., Boschi, S., Mussi, A., & Ambrosioni, E. (1986). Predictors of stable hypertension in young borderline subjects: a five-year follow-up study. *Journal of Cardiovascular Pharmacology, 8*, 138–41.
- Borkovec, T. D., Ray, W. J., & Stober, J. (1998). Worry: A cognitive phenomenon intimately linked to affective, physiological, and interpersonal behavioral processes. *Cognitive Therapy and Research, 22*, 561–576.
- Brosschot, J. F. (2006). Daily worry is related to low heart rate variability during waking and the subsequent nocturnal sleep period. Manuscript submitted for publication.



- Brosschot, J. F., Gerin, W., & Thayer, J. F. (2006). The perseverative cognition hypothesis: A review of worry, prolonged stress-related physiological activation, and health. *Journal of Psychosomatic Research, 60*, 113–124.
- Brosschot, J. F. & Thayer, J. F. (1998). Anger inhibition, cardiovascular recovery, and vagal function: a model of the link between hostility and cardiovascular disease. *Annals of Behavioral Medicine, 4*, 326–332.
- Carroll, D., Smith, G. D., Sheffield, D., Willemsen, G., Sweetnam, P. M., Gallacher, J. E., & Elwood, P. C. (1996). Blood pressure reactions to the cold pressor test and the prediction of future blood pressure status: Data from the Caerphilly study. *Journal of Human Hypertension, 10*, 777–780.
- Cohen, H., Matar, M. A., Kaplan, Z., & Kotler, M. (1999). Power spectral analysis of heart rate variability in psychiatry. *Psychotherapy & Psychosomatics, 68*, 59-66.
- Coles, M. E. & Heimberg, R. G. (2002). Memory biases in the anxiety disorders: current status. *Clinical Psychological Review, 22*, 587–627.
- Corse, C. D., Manuck, S. B., Cantwell, J. D., Gordani, B., & Matthew, K. A. (1982). Coronary prone behavior pattern and cardiovascular response in persons with and without coronary heart disease. *Psychosomatic Medicine, 44*, 449–459.
- Coryell, W., Noyes, R., & Clancy, J. (1982). Excess mortality in panic disorder: a comparison with primary unipolar depression. *Archives of General Psychiatry, 39*, 701–703.
- Dekker, J. M., Crow, R. S., Folsom, A. R., Hannan, P. J., Liao, D., Swenne, C. A., Schouten, E. G. (2000). Low heart rate variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes. *Circulation, 102*, 1239–1244.

- Dembroski, T. M., MacDougall, J. M., & Luschene, R. (1979). Interpersonal interaction and cardiovascular response in Type A subjects and coronary patients. *Journal of Human Stress, 5*, 28–36.
- Eckberg, D. L. (1997). Sympathovagal balance: A critical appraisal. *Circulation, 96*, 3224–3232.
- Fox, S. I. (1999). *Human Physiology* (6<sup>th</sup> ed). Dubuque, IA: WC Brown Publishers.
- Frasure-Smith, N. & Lesperance, F. (2003). Depression and other psychological risks following myocardial infarction. *Archives of General Psychiatry, 60*, 627–636.
- Friedman, B. H. (2007). An autonomic flexibility-neurovisceral integration model of anxiety and cardiac vagal tone. *Biological Psychology, 74*, 185–199.
- Friedman, B. H., Lozier, L. M., & Vella, E. J. (2005). Gender differences in cardiovascular responses to lateralized hand cold pressor. *Psychophysiology, 41* (Suppl. 1), S56.
- Friedman, B. H., & Santucci, A. K. (2003). Idiodynamic profiles of cardiovascular activity: A p-technique approach. *Integrative Physiological and Behavioral Science, 38*, 295–315.
- Friedman, B. H., & Thayer, J. F. (1998a). Autonomic balance revisited: Panic anxiety and heart rate variability. *Journal of Psychosomatic Research, 44*, 133–151.
- Friedman, B. H. & Thayer, J. F. (1998b). Anxiety and autonomic flexibility: a cardiovascular approach. *Biological Psychology, 47*, 243–263.
- Friedman, B. H., Thayer, J. F., & Borkovec, T. D. (2000). Explicit memory bias for threat words in generalized anxiety disorder. *Behavior Therapy, 31*, 45–756.
- Friedman, B. H., Thayer, J. F., Borkovec, T. D., Tyrrell, R. A., Johnsen, B. H., & Colombo, R. (1993). Autonomic characteristics of nonclinical panic and blood phobia. *Biological Psychiatry, 34*, 298–310.

- Friedman, B. H., Thayer, J. F., & Tyrrell, R. A. (1996). Spectral characteristics of heart period variability in shock avoidance and cold face stress in normal subjects. *Clinical Autonomic Research, 6*, 147–152.
- Friedman, M. & Rosenman, R.H. (1971). Type A behavior: its association with coronary heart disease. *Annals of Clinical Research, 3*, 300–312.
- Glynn, L. M., Christenfeld, N., & Gerin, W. (2002). The role of rumination in recovery from reactivity: Cardiovascular consequences of emotional states. *Psychosomatic Medicine, 64*, 714–726.
- Gorman J. M. & Sloan R. P. (2000). Heart rate variability in depressive and anxiety disorders. *American Heart Journal, 140 (4 suppl)*, 77–83.
- Harbin, T. J. (1989). The relationship between type A behavior pattern and physiological reactivity: A quantitative review. *Psychophysiology, 26*, 110–119.
- Heller, W., Nitschke, J. B., Etienne, M. A., & Miller, G. A. (1997). Patterns of regional brain activity differentiate types of anxiety. *Journal of Abnormal Psychology, 106*, 376–385.
- Hoehn-Saric, R., McLeod, D. R., & Zimmerli, W. D. (1989). Somatic manifestations in women with generalized anxiety disorder. *Archives of General Psychiatry, 46*, 1113–1119.
- Houston, B. K. (1992). Personality characteristics, reactivity, and cardiovascular disease. In J. R. Turner, A. Sherwood, & K. C. Light (Eds.), *Individual differences in cardiovascular responses to stress* (pp. 103–124). New York: Plenum.
- Kamarck, T., Manuck, S., & Jennings, J. R. (1990) Social support reduces cardiovascular reactivity to psychological challenge: a laboratory model. *Psychosomatic Medicine, 52*, 42–58.

- Kasagi, F., Akahoshi, M., & Shimaoka, K. (1995). Relationship between cold pressor test and development of hypertension on 28 year follow-up. *Hypertension, 25*, 71–76.
- Kawachi, I., Sparrow, D., Vokonas, P. S., & Weiss, S. T. (1995). Decreased heart rate variability in men with phobic anxiety (Data from the Normative Aging Study). *American Journal of Cardiology, 75*, 882–885.
- Keys, A., Taylor, H. L., Blackburn, J., Anderson, J. T., & Somonson, E. (1971). Mortality and coronary heart disease among men studied for 23 years. *Archives of Internal Medicine, 128*, 201–214.
- Krantz, D. S., Helmers, K. F., Bairey, C. N., Nebel, L. E., Hedges, S. M., & Rosanski, A. (1991). Cardiovascular reactivity and mental stress-induced myocardial ischemia in patients with coronary artery disease. *Psychosomatic Medicine, 53*, 1–12.
- Krantz, D. S. & Manuck, S. B. (1984). Acute psychophysiological reactivity and risk of cardiovascular disease: A review and methodological critique. *Psychological Bulletin, 96*, 435–464.
- Kubzansky, L. D., Kawachi, I., Spiro, A., Weiss, S. T., Vokonas, P. S., & Sparrow, D. (1997). Is worrying bad for your heart? A prospective study of worry and coronary heart disease in the Normative Aging Study. *Circulation, 5*, 818–824.
- Kuo, T. B. J., Lin, T., Yang, C. C. H., Li, C., Chen, C., & Chou, P. (1999). Effect of aging on gender differences in neural control of heart rate. *American Journal of Physiology-Heart and Circulatory Physiology, 277*, 2223–2239.
- Linden, T. L. W., Gerin, E. W., & Christenfeld, N. (1997). Physiological stress reactivity and recovery: Conceptual siblings separated at birth? *Journal of Psychosomatic Research, 42*, 117–135.

- Langewitz, W., Ruddle, H., & Schachinger, H. (1994). Reduced parasympathetic control in patients with hypertension at rest and under mental stress. *American Heart Journal*, *127*, 122–128.
- Lyonfields, J., Borkovec, T. D. & Thayer, J. F. (1995). Vagal tone in generalized anxiety disorder and the effects of aversive imagery and worrisome thinking. *Behavioral Therapy*, *26*, 457–466.
- Malliani, A., Pagani, M., Lombardi, F., & Cerutti S. (1991). Cardiovascular neural regulation explored in the frequency domain. *Circulation*, *84*, 482–492.
- Manuck, S. B. (1994). Cardiovascular reactivity cardiovascular disease: “Once more unto the breach”. *International Journal of Behavioral Medicine*, *1*, 4–31.
- Manuck, S. B., Kasprovicz, A. L., Monroe S. B., Larkin, K. T., & Kaplan, J. R. (1989). Psychophysiologic reactivity as a dimension of individual differences. In N. Schneiderman, S. B. Weiss, & P. Kaufmann (Eds.) *Handbook of methods and measurements in cardiovascular behavioral medicine* (pp. 365–382). New York: Plenum.
- Markovitz, J. H., Raczynski, J. M., Wallace, D., Chettur, V., & Chesney, M. A. (1998). Cardiovascular reactivity to video game predicts subsequent blood pressure increases in young men: The CARDIA study. *Psychosomatic Medicine*, *60*, 186–191.
- Matthews, A. (1990). Why worry? The cognitive function of anxiety. *Behaviour Research and Therapy*, *28*, 455–68.
- Matthews, K. A., Woodall, K. L., & Allen, M. T. (1993). Cardiovascular reactivity to stress predicts future blood pressure status. *Hypertension*, *22*, 479–85.

- Menkes, M. S., Matthews, K. A., Krantz, D. S., Lundberg, U., Mead, L. A., Qaquish, B., Liang, K., Thomas, C. B., & Pearson, T. A. (1989) Cardiovascular reactivity to the cold pressor test as predictor of hypertension. *Hypertension*, *14*, 524–530.
- Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour, Research and Theory*, *28*, 487–495.
- Mezzacappa, E. S., Kelsey, R. M., Katkin, E. S., & Sloan, R. P. (2001). Vagal rebound and recovery from psychological stress. *Psychosomatic Medicine*, *63*, 650–657.
- Mitchell, J. H. & Shapiro, A. P. The confusing syndromes of cardiovascular autonomic imbalance: cardiovascular dysautonomias. In: Shapiro A. P., Baum A., eds. Behavioral aspects of cardiovascular disease. Hillsdale, New Jersey: Lawrence Erlbaum 1991: 75–102.
- Murphy, J. K., Alpert, B. S., & Walker, S. S. (1992). Ethnicity, pressor reactivity, and children's blood pressure: five years of observation. *Hypertension*, *20*, 327–32.
- Pagani, M., Lucini, D., Rimoldi, O., Furlan, R., Piazza, S., & Biancardi, L. (1995). Effects of physical and mental exercise on heart rate variability. In M. Malik & A. J. Camm (Eds.), *Heart rate variability* (pp. 245–266). Armonk, NY: Futura Publishing Co.
- Papousek, I. & Schulte, G. (2002). Brain asymmetry and stress: New perspectives in psychophysiological oriented psychosomatic research. *Psychologische Beitrage*, *44*, 535–544.
- Porges, S. W. (2007). The Polyvagal Perspective. *Biological Psychology*, *74*, 116-43.
- Ragland, D. R., & Brand, R. J. (1988). Type A behavior and mortality from coronary heart disease. *New England Journal of Medicine*, *318*, 65–69.

- Reggio, G. (Director). (1988). *Powaqqatsi: Life in transformation*. [Motion Picture]. United States: MGM/United Artists.
- Rosenman, R. H., Brand, R. J., Jenkins, C. D., Friedman, M., Straus, R., & Wurm, M. (1975). Coronary heart disease in the Western Collaborative Group Study: final follow-up experience of 8 1/2 years. *Journal of American Health Association, 233*, 872–877.
- Rosenzweig, S. (1984). Idiodynamics. In R.J. Corsini (Ed.), *Encyclopedia of psychology* (2<sup>nd</sup> ed.) (pp. 205–208). New York: Wiley & Sons.
- Rostrup, M., Westheim, A., Kjeldsen, S. E., & Eide, I. (1993). Cardiovascular reactivity, coronary risk factors, and sympathetic activity in young men. *Hypertension, 22*, 891–899.
- Ryan, S. M., Goldberger, A. L., Pincus, S. M., Mietus, J., & Lipsitz, L. A. (1994). Gender-and-age-related differences in heart rate dynamics: are women more complex than men? *Journal of the American College of Cardiology, 24*, 1700–1707.
- Saab, P. G., Llabre, M. M., Hurwitz, B. E., Schneiderman, N., Wohlgenuth, W., Durel, L., Massie, C. & Nagel, J. (1993). The cold pressor test: vascular and myocardial response patterns and their stability. *Psychophysiology, 30*, 366–373.
- Saul, J. P. (1990). Beat-to-beat variations of heart rate reflect modulation of cardiac autonomic outflow. *News in Physiological Science, 5*, 32–37.
- Schuler, J. L. & O'Brian, W. H. (1997). Cardiovascular recovery from stress and hypertension risk factors: a meta-analytic review. *Psychophysiology, 34*, 649–659.
- Schwartz, A. R., Gerin, W., Davidson, K., Pickering, T. G., Brosschot, J. F., Thayer, J. F., Christenfeld, N., & Linden, W. (2003). Toward a causal model of cardiovascular responses to stress and the development of cardiovascular disease. *Psychosomatic Medicine, 65*, 22–35.

- Shapiro, D., Goldstein, I. B., & Jamner, L. D. (1996). Effects of cynical hostility, anger out, anxiety, and defensiveness on ambulatory blood pressure in black and white college students. *Psychosomatic Medicine*, *58*, 54–364.
- Shekelle, R. B., Gale, M., & Norusis, M. (1985). Type A score (Jenkins Activity Survey) and risk of recurrent coronary heart disease in the Aspirin Myocardial Infarction Study. *American Journal of Cardiology*, *56*, 221–25.
- Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W.R., & van Doornen, L. J. P. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology*, *27*, 1–23.
- Simes, R. J. (1986). An improved Bonferroni procedure for multiple tests. *Biometrika*, *73*, 751–754.
- Steptoe, A., Feldman, P.J., Kunz, S., Owen, N., Willemsen, G. & Marmot, M. (2002). Stress responsivity and socioeconomic status. A mechanism for increased cardiovascular disease risk? *European Heart Journal*, *23*, 1757–1763.
- Stewart, J. C. & France, C. R. (2001). Cardiovascular recovery from stress predicts longitudinal changes in blood pressure. *Biological Psychology*, *58*, 105–120.
- Thayer, J. F., Friedman, B. H., & Borkovec, T. D. (1996). Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry*, *39*, 255–66.
- Thayer, J. F., Friedman, B. H., Borkovec, T. D., Johnsen, B. H., & Molina, S. (2000). Phasic heart period reactions to cued threat and nonthreat stimuli in generalized anxiety disorder. *Journal of Psychophysiology*, *37*, 361–368.
- Treiber, F. A., Musante, L., Kapuku, G., Davis, C., Litaker, M., & Davis, H. (2001) Cardiovascular (CV) responsivity and recovery to acute stress and future CV functioning



- in youth with family histories of CV disease: a 4-year longitudinal study. *International Journal of Psychophysiology*, *41*, 65–74.
- Tsuji, H., Larson, M. G., Venditti, F. J., Manders, E. S., Evans, J. C., Feldman, C. L., & Levy, D. (1996). Impact of reduced heart rate variability on risk for cardiac events. *Circulation*, *94*, 2850–2855.
- Vella, E. J., & Friedman, B. H. (in press). Autonomic characteristics of defensive hostility: Reactivity and recovery to active and passive stressors. *International Journal of Psychophysiology*.
- Vitaliano, P. P., Russo, J., Paulsen, V. M., Bailey, S. L. (1995). Cardiovascular recovery from laboratory stress: biopsychosocial concomitants in older adults. *Journal of Psychosomatic Research*, *39*, 361–77.
- Watkins, L. L., Grossman, P., Krishnan, R., & Blumenthal, J. A. (1999). Anxiety reduces baroreflex cardiac control in older adults with major depression. *Psychosomatic Medicine* *61*, 334–340.
- Willemsen, G. H. M., De Geus, E. J. C., Klaver, C. H. A. M., Van Doornen, L. J. P., & Carroll, D. (1996). Ambulatory monitoring of the impedance cardiogram. *Psychophysiology*, *33*, 184–193.

## APPENDIX A

## FIGURES

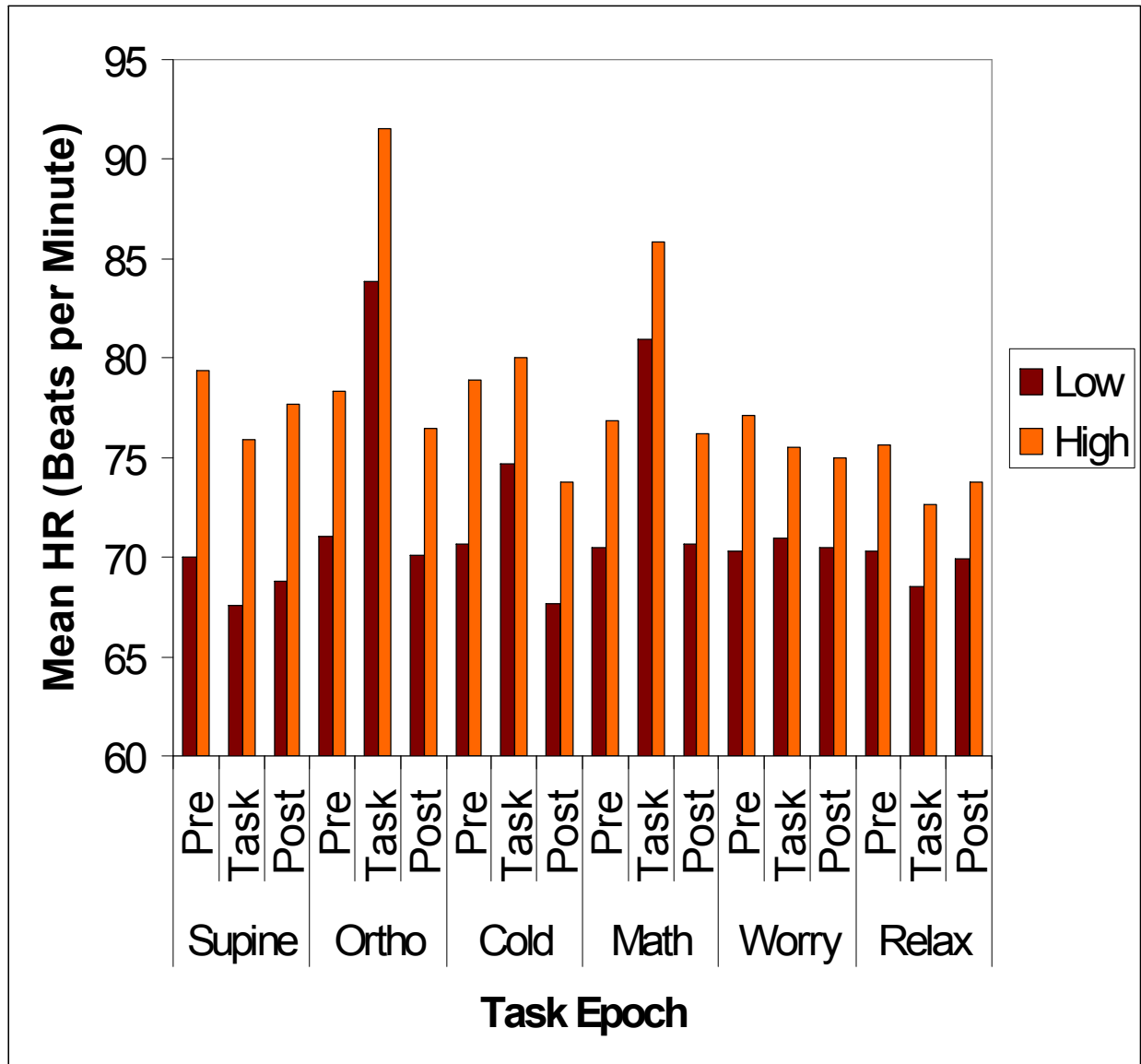
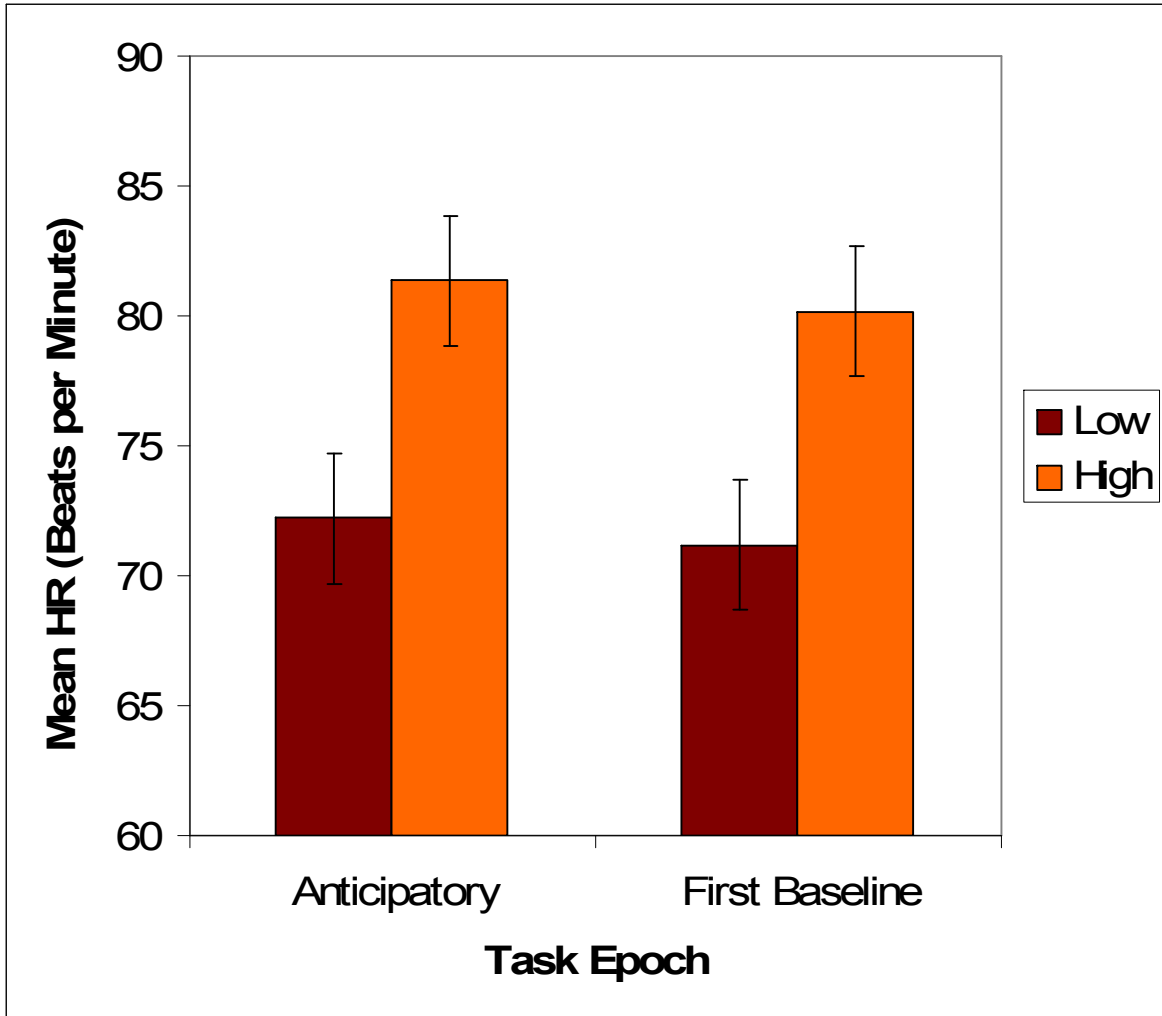


Figure A-1. Heart Rate Differences Across Epochs by Group



*Figure A-2. Anticipatory and First Acclimated Baseline HR Differences by Group*

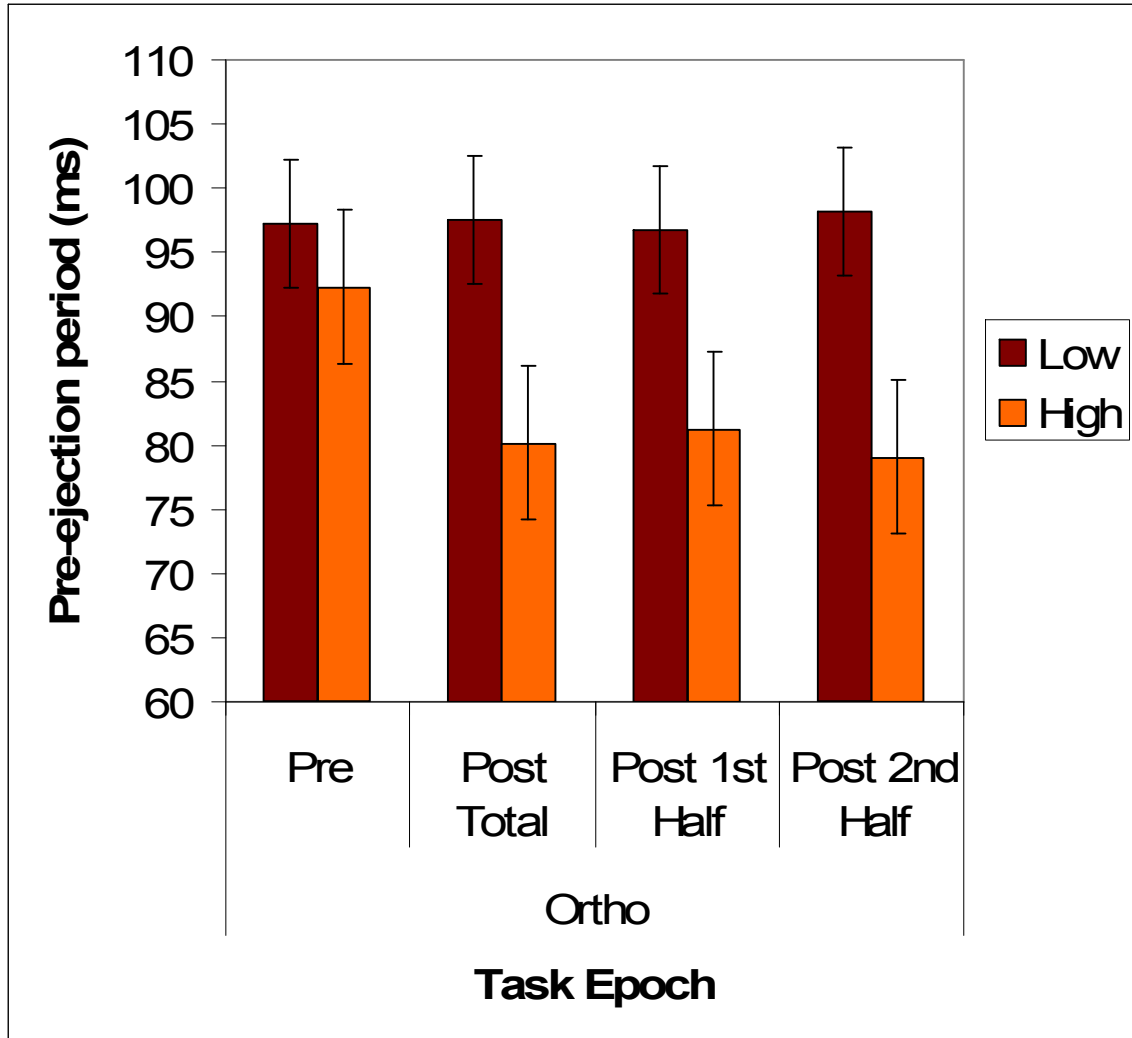


Figure A-3. Pre-ejection Period Differences During Orthostatic Post-task by Group

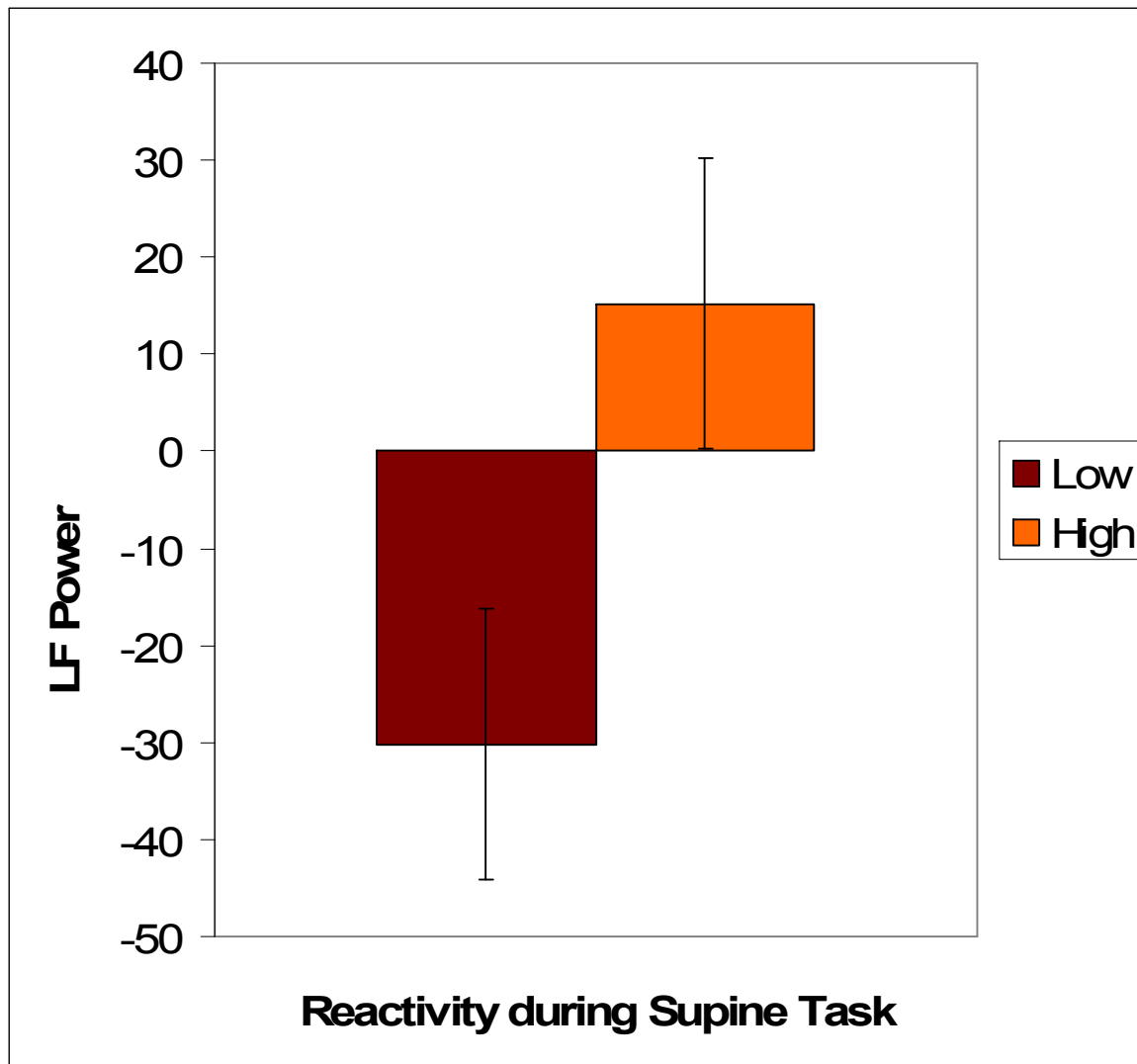


Figure A-4. Low-frequency Power Reactivity During the Supine Task by Group

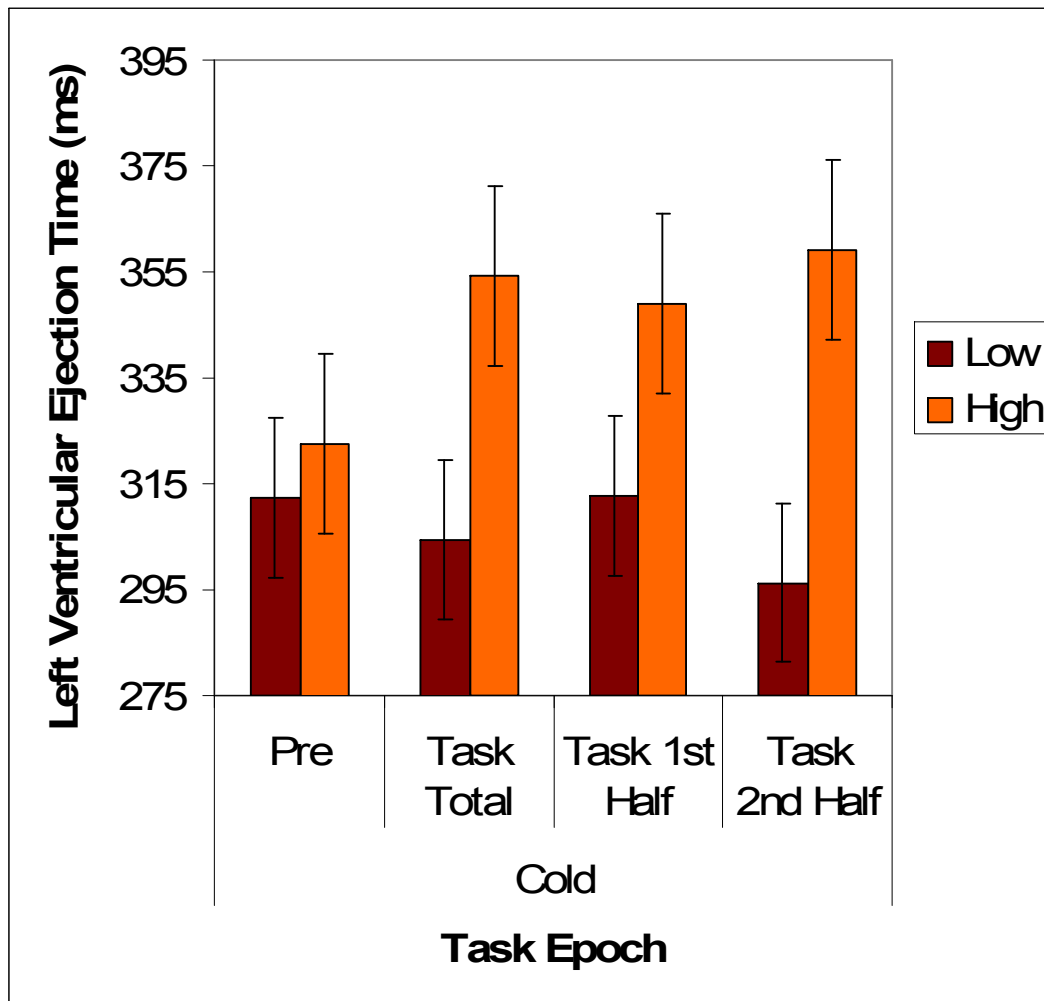
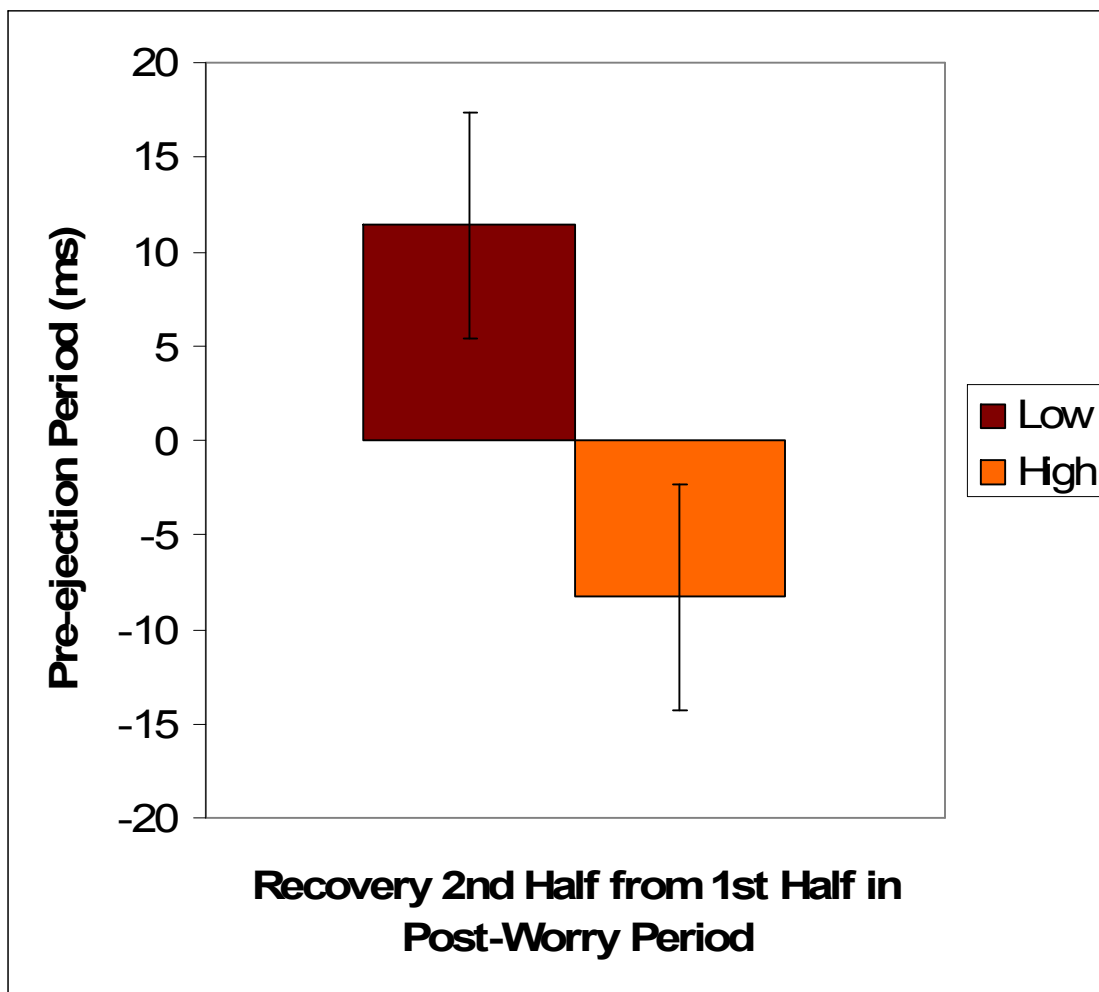


Figure A-5. Left Ventricular Ejection Time Differences During Cold Pressor Task by Group



*Figure A-6.* Pre-ejection Period Differences After Worry Task between Second Half Post-task and First Half Post-task by Group

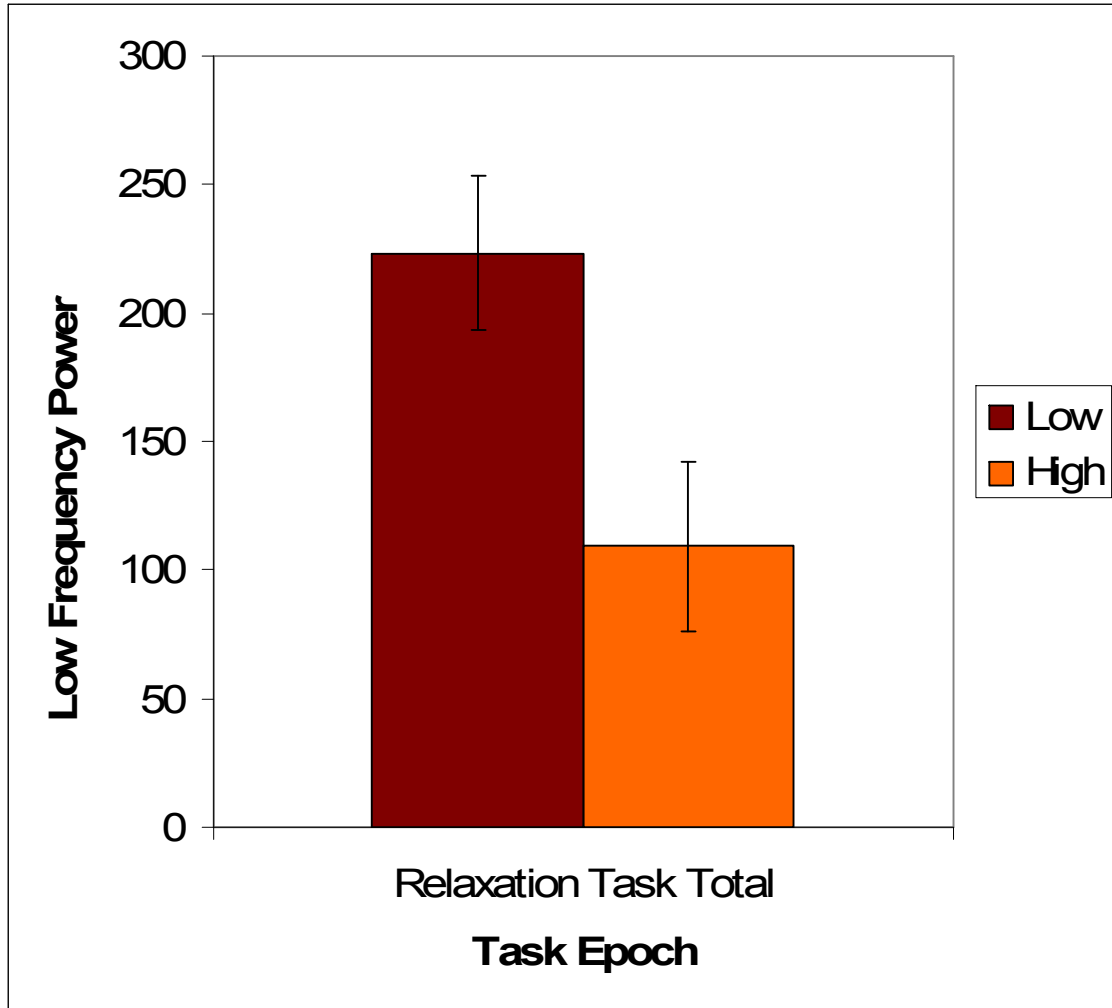


Figure A-7. Low-frequency Power Totals During the Relaxation Task by Group



## APPENDIX B

## TABLES

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	122.12	1.76	-	-	-	-
Anticipatory	High	122.09	1.92	-	-	-	-
First Baseline	Low	120.49	1.57	-	-	-	-
First Baseline	High	119.30	1.71	-	-	-	-
Orthostatic	Low	118.98	1.71	122.94	2.56	116.10	4.37
Orthostatic	High	116.78	1.86	118.66	2.79	119.65	4.76
Supine	Low	118.36	1.96	119.48	1.86	118.85	1.89
Supine	High	119.11	2.14	119.56	2.02	118.65	2.05
Cold Pressor	Low	116.87	2.10	126.15	1.84	123.71	2.05
Cold Pressor	High	115.85	2.29	122.42	2.01	120.92	2.23
Mental Arithmetic	Low	117.54	2.11	128.56	2.17	121.06	2.21
Mental Arithmetic	High	115.30	2.30	126.04	2.36	118.28	2.40
Worry Imagery	Low	118.7	1.83	120.95	1.60	117.71	1.69
Worry Imagery	High	118.06	1.99	118.06	1.74	118.29	1.84
Relaxation Imagery	Low	119.97	1.74	117.35	2.00	118.40	2.00
Relaxation Imagery	High	117.15	1.89	115.41	2.18	115.88	2.17

Table B-1. Systolic Blood Pressure Means and Standard Errors

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	77.01	2.14	-	-	-	-
Anticipatory	High	80.76	2.33	-	-	-	-
First Baseline	Low	78.61	2.43	-	-	-	-
First Baseline	High	81.16	2.64	-	-	-	-
Orthostatic	Low	79.16	2.21	78.82	2.37	74.87	2.18
Orthostatic	High	77.17	2.41	84.50	2.58	79.92	2.37
Supine	Low	74.26	2.38	74.18	2.73	76.74	2.28
Supine	High	80.05	2.59	77.44	2.97	79.49	2.48
Cold Pressor	Low	77.24	2.40	88.81	2.13	79.58	2.11
Cold Pressor	High	79.25	2.61	90.17	2.31	80.73	2.29
Mental Arithmetic	Low	75.22	2.35	86.30	2.61	78.65	2.21
Mental Arithmetic	High	79.45	2.56	87.29	2.84	80.88	2.40
Worry Imagery	Low	77.32	2.15	81.07	1.86	77.90	2.20
Worry Imagery	High	82.28	2.34	83.92	2.02	83.59	2.39
Relaxation Imagery	Low	76.03	2.56	78.12	1.89	76.74	2.19
Relaxation Imagery	High	78.44	2.79	79.68	2.06	82.31	2.38

*Table B-2.* Diastolic Blood Pressure Means and Standard Errors

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	72.16	2.34	-	-	-	-
Anticipatory	High	81.10	2.55	-	-	-	-
First Baseline	Low	71.13	2.46	-	-	-	-
First Baseline	High	79.88	2.68	-	-	-	-
Orthostatic	Low	71.19	2.26	84.32	2.90	70.31	2.14
Orthostatic	High	78.36	2.46	91.53	3.16	76.5	2.33
Supine	Low	70.37	2.37	67.56	2.02	69.08	2.23
Supine	High	79.40	2.58	75.93	2.20	77.65	2.43
Cold Pressor	Low	70.89	2.03	75.02	2.10	67.81	1.91
Cold Pressor	High	78.95	2.21	79.99	2.28	73.81	2.08
Mental Arithmetic	Low	70.69	2.18	81.13	2.29	70.92	2.00
Mental Arithmetic	High	76.88	2.38	85.88	2.49	76.15	2.18
Worry Imagery	Low	70.52	2.15	71.25	2.02	70.84	1.87
Worry Imagery	High	77.19	2.35	75.53	2.20	74.92	2.04
Relaxation Imagery	Low	70.59	2.07	68.62	1.83	70.12	1.97
Relaxation Imagery	High	75.61	2.25	72.67	1.99	73.76	2.15

*Table B-3. Heart Rate Means and Standard Errors*

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	57.69	7.10	-	-	-	-
Anticipatory	High	41.47	7.73	-	-	-	-
First Baseline	Low	55.35	6.70	-	-	-	-
First Baseline	High	42.55	7.29	-	-	-	-
Orthostatic	Low	56.65	6.81	34.06	4.27	64.37	7.37
Orthostatic	High	45.12	7.41	26.23	4.65	52.76	8.02
Supine	Low	55.58	6.10	67.14	7.62	60.02	7.45
Supine	High	40.25	6.65	52.24	8.30	47.63	8.11
Cold Pressor	Low	58.29	7.33	55.94	8.25	63.80	8.29
Cold Pressor	High	44.70	8.00	47.39	8.99	55.38	9.02
Mental Arithmetic	Low	56.42	6.88	46.89	5.63	56.08	7.12
Mental Arithmetic	High	50.01	7.49	40.38	6.14	51.28	7.76
Worry Imagery	Low	60.13	7.97	59.68	8.44	58.44	7.70
Worry Imagery	High	48.19	8.68	48.91	9.19	54.14	8.38
Relaxation Imagery	Low	59.37	7.85	62.46	7.09	58.00	7.55
Relaxation Imagery	High	49.97	8.55	56.85	7.72	53.94	8.22

Table B-4. rMSSD Means and Standard Errors

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	1.52	.38	-	-	-	-
Anticipatory	High	1.28	.42	-	-	-	-
First Baseline	Low	1.21	.28	-	-	-	-
First Baseline	High	1.12	.30	-	-	-	-
Orthostatic	Low	1.09	.17	3.41	.81	1.75	.60
Orthostatic	High	.81	.19	3.23	.89	1.3	.66
Supine	Low	1.22	.28	.76	.20	1.10	.36
Supine	High	1.30	.31	.80	.22	1.55	.40
Cold Pressor	Low	1.75	.67	1.98	.80	1.22	.27
Cold Pressor	High	1.71	.73	1.97	.87	1.47	.30
Mental Arithmetic	Low	1.29	.23	2.73	.38	1.50	.35
Mental Arithmetic	High	1.30	.25	2.25	.41	1.41	.38
Worry Imagery	Low	1.30	.31	1.35	.26	1.34	.24
Worry Imagery	High	1.73	.34	1.61	.28	1.38	.26
Relaxation Imagery	Low	1.48	.22	2.18	.38	1.05	.16
Relaxation Imagery	High	1.26	.24	1.47	.42	.824	.17

*Table B-5. Low Frequency:High Frequency Ratio Means and Standard Errors*

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	51.04	4.32	-	-	-	-
Anticipatory	High	55.03	4.71	-	-	-	-
First Baseline	Low	52.15	4.30	-	-	-	-
First Baseline	High	58.58	4.69	-	-	-	-
Orthostatic	Low	53.13	3.89	35.21	4.79	49.37	4.24
Orthostatic	High	61.44	4.23	34.31	5.21	57.67	4.61
Supine	Low	54.40	4.76	64.37	4.12	58.62	4.87
Supine	High	53.54	5.18	62.46	4.49	51.89	5.31
Cold Pressor	Low	49.67	4.41	49.25	4.53	53.75	4.74
Cold Pressor	High	52.51	4.80	47.38	4.93	51.04	5.16
Mental Arithmetic	Low	50.52	4.02	30.02	3.17	52.10	4.46
Mental Arithmetic	High	52.23	4.38	40.46	3.45	54.74	4.98
Worry Imagery	Low	50.82	4.51	47.74	4.42	48.58	4.06
Worry Imagery	High	47.32	4.91	47.69	4.81	50.71	4.42
Relaxation Imagery	Low	46.41	3.99	41.18	4.42	52.34	4.08
Relaxation Imagery	High	50.40	4.34	47.44	4.81	57.86	4.44

Table B-6. High-frequency Power (Normalized Units) Means and Standard Errors

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	108.92	9.34	-	-	-	-
Anticipatory	High	86.95	10.49	-	-	-	-
First Baseline	Low	109.52	11.68	-	-	-	-
First Baseline	High	84.89	13.12	-	-	-	-
Orthostatic	Low	97.27	5.88	91.98	3.92	97.48	4.57
Orthostatic	High	92.31	6.60	98.73	4.40	80.14	5.14
Supine	Low	111.45	11.25	96.00	4.70	93.59	5.18
Supine	High	80.53	12.64	87.31	5.28	91.05	5.82
Cold Pressor	Low	112.33	10.78	110.31	11.08	115.77	10.45
Cold Pressor	High	91.56	12.11	87.52	12.45	88.98	11.74
Mental Arithmetic	Low	103.61	5.81	91.98	4.26	101.81	7.33
Mental Arithmetic	High	88.32	6.53	89.52	4.79	85.87	8.24
Worry Imagery	Low	104.18	9.03	112.11	9.08	107.91	9.75
Worry Imagery	High	92.28	10.15	98.75	10.21	94.79	10.96
Relaxation Imagery	Low	111.54	9.93	97.31	7.46	98.78	7.05
Relaxation Imagery	High	92.38	11.16	93.99	8.38	90.37	7.92

*Table B-7.* Pre-ejection Periods Means and Standard Errors

	Worry Group	Pre-Task Mean	Pre-Task SE	Task Mean	Task SE	Post-Task Mean	Post-Task SE
Anticipatory	Low	312.00	14.50	-	-	-	-
Anticipatory	High	326.90	16.29	-	-	-	-
First Baseline	Low	313.28	15.52	-	-	-	-
First Baseline	High	322.91	17.44	-	-	-	-
Orthostatic	Low	309.99	14.76	305.03	12.31	309.20	14.26
Orthostatic	High	314.20	16.59	292.8	13.83	340.02	16.03
Supine	Low	310.75	14.12	332.26	13.48	312.86	14.56
Supine	High	327.21	15.86	324.53	15.15	329.11	16.36
Cold Pressor	Low	312.35	14.66	304.49	15.33	309.71	15.99
Cold Pressor	High	322.71	16.47	354.15	17.23	334.38	17.97
Mental Arithmetic	Low	315.89	13.93	321.81	13.07	315.57	15.40
Mental Arithmetic	High	321.45	15.65	328.24	14.68	232.08	17.31
Worry Imagery	Low	318.25	14.19	308.32	14.60	312.83	13.89
Worry Imagery	High	331.21	15.95	329.32	16.40	342.29	15.61
Relaxation Imagery	Low	313.91	14.32	328.60	13.35	324.49	14.01
Relaxation Imagery	High	330.62	16.09	333.77	15.00	343.49	15.74

Table B-8. Left Ventricular Ejection Time Means and Standard Errors



## APPENDIX C

### Penn State Worry Questionnaire

Enter the number that best describes how typical or characteristic each item is of you, putting the number next to the item.

- | 1                     | 2   | 3   | 4 | 5               |
|-----------------------|-----|---|---|-----------------|
| Not at all<br>typical |     | Somewhat<br>typical   |   | Very<br>typical |
| ___                   | 1.  | If I don't have enough time to do everything I don't worry about it.                  |   |                 |
| ___                   | 2.  | My worries overwhelm me.  |   |                 |
| ___                   | 3.  | I don't tend to worry about things.   |   |                 |
| ___                   | 4.  | Many situations make me worry.  |   |                 |
| ___                   | 5.  | I know I shouldn't worry about things, but I just can't help it.                      |   |                 |
| ___                   | 6.  | When I am under pressure I worry a lot.   |   |                 |
| ___                   | 7.  | I am always worrying about something.   |   |                 |
| ___                   | 8.  | I find it easy to dismiss worrisome thoughts.   |   |                 |
| ___                   | 9.  | As soon as I finish one task, I start to worry about everything else I have to do.    |   |                 |
| ___                   | 10. | I never worry about anything.   |   |                 |
| ___                   | 11. | When there is nothing more I can do about a concern, I don't worry about it any more. |   |                 |
| ___                   | 12. | I've been a worrier all my life.  |   |                 |
| ___                   | 13. | I notice that I have been worrying about things.                                      |   |                 |
| ___                   | 14. | Once I start worrying, I can't stop.  |   |                 |
| ___                   | 15. | I worry all the time.   |   |                 |
| ___                   | 16. | I worry about projects until they are all done.                                       |   |                 |

(Reverse-score items 1, 3, 8, 10, and 11, and then sum over 16 items.)

**APPENDIX D****Mind-Body Laboratory Health History Questionnaire**

A very brief medical history must be obtained as part of the experimental protocol. It is very important that you be completely honest. This information will be kept strictly confidential.

1. What is your age, height, weight, and gender?

Age: \_\_\_\_\_ years

Height: \_\_\_\_\_ feet, \_\_\_\_\_ inches

Weight: \_\_\_\_\_ pounds

Sex: \_\_\_\_\_M \_\_\_\_\_F

2. Since birth, have you ever been hospitalized or had any major medical problems?

\_\_\_\_ Yes \_\_\_\_ No

If yes, briefly explain:

3. Have you ever experienced a concussion or lost consciousness due to a blow to the head?

\_\_\_\_ Yes \_\_\_\_ No

If yes, briefly explain:

4. Have you ever had problems that required you to see a counselor, psychologist, or psychiatrist?

\_\_\_\_ Yes \_\_\_\_ No

If yes, briefly explain:

5. Do you use tobacco products of any kind?

\_\_\_\_ Yes \_\_\_\_ No

If yes, describe what kind how often/much:

6. Have you ever been diagnosed with a psychological disorder?

\_\_\_\_ Yes \_\_\_\_ No

If yes, briefly explain:

7. Do you currently have or have you ever had any of the following?

\_\_\_\_ Yes \_\_\_\_ No      Strong reaction to cold weather

- Yes  No      Circulatory problems  
 Yes  No      Tissue disease  
 Yes  No      Skin disorders (other than facial acne)  
 Yes  No      Arthritis  
 Yes  No      Asthma  
 Yes  No      Lung problems  
 Yes  No      Cardiovascular disorder/disease  
 Yes  No      Diabetes  
 Yes  No      Hypoglycemia  
 Yes  No      Hypertension (high blood pressure)  
 Yes  No      Hypotension (low blood pressure)  
 Yes  No      Hepatitis  
 Yes  No      Neurological problems  
 Yes  No      Epilepsy or seizures  
 Yes  No      Brain disorder  
 Yes  No      Stroke

If you responded yes to any of the above conditions, briefly explain:

8. Have you ever been diagnosed as having:

- Yes  No      Learning deficiency or disorder  
 Yes  No      Reading deficiency or disorder  
 Yes  No      Attention deficit disorder  
 Yes  No      Attention deficit hyperactivity disorder;

9. Do you have:

- Yes  No      Claustrophobia (extreme fear of small closed spaces)  
 Yes  No      Blood phobia (extreme fear of needles or blood)  
 Yes  No      Phobia of any type (if yes, briefly explain:)  
 Yes  No      Generalized anxiety disorder  
 Yes  No      Anxiety disorder of any type (if yes, briefly explain:)

If you responded yes, briefly explain here:

10. List any over-the-counter or prescription medications you are currently taking:

11. List the symptoms that these drugs are treating

12. List any other medical conditions that you have or have had in the past:

13. What is your average daily caffeine consumption (approximate number of cups/glasses of coffee, tea, or caffeinated soda)?

14. What is your average weekly alcohol consumption (approximate number of alcoholic beverages)?

15. What is your greatest point of concern, fear, or worry?

**APPENDIX E****Mind-Body Laboratory Short Health History Questionnaire**

A very brief medical history must be obtained as part of the experimental protocol. It is very important that you be completely honest. This information will be kept strictly confidential.

1. What is your age, height, weight, and gender?

Age: \_\_\_\_\_ years

Height: \_\_\_\_\_ feet, \_\_\_\_\_ inches

Weight: \_\_\_\_\_ pounds

Sex: \_\_\_M \_\_\_F

2. When was the last time you have had any alcohol before the study began?

3. What phase of the menstrual cycle are you currently in?

4. When was the last time you have had a caffeinated beverage before the study began?

**APPENDIX F****ORDER DEFINITIONS****A**

Orthostatic, Supine, Cold Pressor, Mental Arithmetic, Worry Imagery, Relaxation

**B**

Orthostatic, Supine, Cold Pressor, Mental Arithmetic, Relaxation, Worry Imagery

**C**

Orthostatic, Supine, Mental Arithmetic, Cold Pressor, Worry Imagery, Relaxation

**D**

Orthostatic, Supine, Mental Arithmetic, Cold Pressor, Relaxation, Worry Imagery

**E**

Supine, Orthostatic, Cold Pressor, Mental Arithmetic, Worry Imagery, Relaxation

**F**

Supine, Orthostatic, Cold Pressor, Mental Arithmetic, Relaxation, Worry Imagery

**G**

Supine, Orthostatic, Mental Arithmetic, Cold Pressor, Worry Imagery, Relaxation

**H**

Supine, Orthostatic, Mental Arithmetic, Cold Pressor, Relaxation, Worry Imagery

## APPENDIX G

### INFORMED CONSENT FORM (Online and Laboratory Portions)

**Study Title:** Cardiovascular Activity During Laboratory Tasks in Individuals with High and Low Worry

**Investigators:** Bruce Friedman, Ph.D., Michael Knepp

#### I. Purpose of this Project:

The purpose of this project is to examine the effects of worry on the cardiovascular system.

#### II. Procedures

I am being asked to help the above researchers in a project. In the online portion of this study, my part of this project will be to fill out a series of questionnaires about worry and my own physical and mental health. After completing these questionnaires, I may be contacted again, by the researchers for participation in a second laboratory portion of this study. Both women with high levels of worry and low levels of worry are needed for this project and will be contacted for the laboratory portion. At the beginning of the laboratory session, a gender matched assistant will equip electrodes and a blood pressure cuff for physiological data recording. Before the experiment begins, I will be asked to complete one short physical health form. During the laboratory period, the researchers also will collect some physiological data, like my heart rate, blood pressure and skin conductance levels. During this recording, I will be asked to complete 6 three minute tasks: standing upright, lying in a supine position, placing my hand in cold water, counting backwards, thinking about a specified topic, and listening to a guided relaxation tape. Before each task, there will be a three minute period where I watch a silent film and after each task I will sit quietly in a chair for three minutes. After the tasks have been completed, there will be one more mental health form to complete. At the end of the laboratory portion, the gender-matched assistant will help with the removal of the recording equipment and I will be given the opportunity to see my cardiovascular activity at the end of the study.

If I decide to participate, the online portion of this study will last approximately 30 minutes. If contacted by the researchers after the first session, the second part of my participation, the laboratory portion, will likely last between 1 ½ to 2 hours. Participation in the second portion of the study is optional for increased extra credit amounts and will in no way impact the extra credit received during the online portion

#### III. Risks

There may be physical and emotional discomfort for me as a participant. During the hand cold pressor task, the cold water may present some discomfort. I may remove their hand from the water if I feel the discomfort is too high. During the worry imagery task, if I feel emotional discomfort, I may ask the research to stop this portion of the study. If I feel that my worry levels are too high, the researchers can assist in providing help for me. **In this case, I will be encouraged to contact with the researchers either the Cook Counseling Center (231-6557) or the Psychological Services Center (231-6914).**

#### **IV. Benefits of this Project**

There is a societal benefit of increasing the understanding of how worry affects the cardiovascular system under stress. Also, there is the benefit of determining if the differences between high and low worriers appear during the stress or afterwards. Additionally, I will be asked by the researcher if I would like to see my cardiovascular data from the study. This information is for research purposes only but I may gain extra knowledge about my own physiological functioning and the cardiovascular system in general.

#### **V. Confidentiality**

All of my responses will be completely confidential. I will provide my e-mail address only for the purpose of getting academic course credit, but not in relation to my particular set of questionnaires. A code number will be assigned to my answers and only this number will be associated with the data. My e-mail contact info will only be used for the research team to contact me for the laboratory portion of the study. Please note that although the responses to the questionnaire require a password for entry and completion of the questionnaire, this does not guarantee complete confidentiality should the responses be intercepted inappropriately from the Internet.

At no time will the researchers release identifying information from this study to anyone other than the individuals working on the project without my written consent.

#### **VI. Compensation**

Introductory Psychology undergraduates will receive extra credit points averaged into their final grade, with one credit for every hour or hour portion of participation. Undergraduates in other courses may receive extra credit, as determined by their course instructor. Completion of the online portion of this study is worth one extra credit point. The completion of the laboratory portion of this study is worth two extra credit points in addition to the one previously earned.

#### **VII. Freedom to Withdraw**

This project has been explained to me and I have been allowed to ask questions about it. I understand that I do not have to fill out the questionnaires or participate in any way if I do not want to and that there exist no negative consequences for withdrawal. I can stop part way through or withdraw at any time, if I choose. If I decide to withdraw, I understand that extra credit will be prorated based on my length of participation in the study, where one credit is awarded for each hour of participation. I also understand that as per university policy and Psychology Department policy, my course instructor can provide me with other opportunities for extra credit.

#### **VIII. Approval of Research**

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects of Virginia Polytechnic Institute and State University, and by the Department of Psychology.

#### **IX. Participant's Responsibility**

I am responsible for filling out several questionnaires on worry and my physical and mental health, as well as providing my contact information if I would be willing to participate in the second portion of this study. I expect the online portion to last approximately 30 minutes.



During the laboratory portion, I am expected to make my best attempt at the 6 tasks I will be asked to complete. I will try to complete the tasks as directed to during the instructions to the best of my abilities. I expect that the laboratory portion to last between 1 ½ hours to 2 hours.

### **X. Participant's Permission**

I have read and understood the Informed Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

Participant \_\_\_\_\_ Date \_\_\_\_\_

Should I have any questions about this research or its conduct, I may contact:

Dr. Bruce Friedman  
Principal Investigator

phone: 231-9611  
[bhfriedm@vt.edu](mailto:bhfriedm@vt.edu)

Michael Knepp  
Co-Investigator

phone: 717-645-4393  
[kneppy@vt.edu](mailto:kneppy@vt.edu)

Dr. David Moore  
Chair, IRB  
CVM Phase II

phone: 231-4991

Dr. David Harrison  
Chair, Psychology Human  
Subjects Committee

phone: 231-4422

**APPENDIX H**  
**DASS 21 Item Scale**

Please read each statement and circle a number 0, 1, 2, or 3 that indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

0 Did not apply to me at all

1 Applied to me to some degree or some of the time

2 Applied to me to a considerable degree or a good part of time

3 Applied to me very much or most of the time

1. I found it hard to wind down
2. I was aware of dryness of my mouth
3. I couldn't seem to experience any positive feeling at all
4. I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)
5. I found it difficult to work up the initiative to do things
6. I tended to over-react to situations
7. I experienced trembling (eg, in the hands)
8. I felt that I was using a lot of nervous energy
9. I was worried about situations in which I might panic and make a fool of myself
10. I felt that I had nothing to look forward to
11. I found myself getting agitated
12. I found it difficult to relax
13. I felt down-hearted and blue
14. I was intolerant of anything that kept me from getting on with what I was doing
15. I felt I was close to panic
16. I was unable to become enthusiastic about anything
17. I felt I wasn't worth much as a person
18. I felt that I was rather touchy
19. I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)

20. I felt scared without any good reason

21. I felt that life was meaningless

**VITA****Michael M. Knepp**

504 Hunt Club Road Apt 204

Blacksburg, VA 24060

717-645-4393

kneppy@vt.edu

**Present Appointments**

Jan 2007-present                      Assistant Graduate Coordinator                      Department of Psychology  
 Introduction to Psychology  
 Virginia Polytechnic Institute and State University  
 Blacksburg, VA 24061-0436

Aug 2006-present                      Research System Coordinator                      Department of Psychology  
 SONA Online Research System  
 Virginia Polytechnic Institute and State University  
 Blacksburg, VA 24061-0436

Aug 2005-present                      Graduate Research Assistant                      Department of Psychology  
 Mind-Body Laboratory  
 Dr. Bruce Friedman, director  
 Virginia Polytechnic Institute and State University  
 Blacksburg VA 24061-0436

**Professional Employment**

May 2004-April 2005 Undergraduate Research Assistant                      Department of Psychology  
 LRDC Research Assistant  
 Spatial Reasoning Laboratory  
 Dr. Christian Schunn, director  
 University of Pittsburgh  
 Pittsburgh, PA 15213

Aug 2003-May 2004 Undergraduate Research Assistant                      Department of Neuroscience  
 Vestibular Laboratory  
 Dr. Bill Yates, director  
 University of Pittsburgh  
 Pittsburgh, PA 15213

**Teaching**

Aug 2005-Dec 2006                      Graduate Teaching Assistant                      Department of Psychology  
 Introduction to Psychology Recitation  
 Virginia Polytechnic Institute and State University  
 Blacksburg, VA 24061-0436

August 2003-Dec 2004 Undergraduate Teaching Assistant College of Arts and Sciences  
 Introduction to the Arts and Sciences  
 University of Pittsburgh  
 Pittsburgh, PA 15213

### **Education**

2005-present Virginia Polytechnic Institute and State University  
 Developmental and Biological Psychology PhD program  
 Current QPA: 3.96

2001-2005 University of Pittsburgh  
 Major in Neuroscience Minor in Chemistry  
 QPA: 3.47

### **Funding**

Association for Psychological Science Travel Fund (April 2007, unfunded )  
 GSA Travel Fund Program (\$375)  
 GSA Graduate Research and Development Program Master's Thesis Grant (Dec 2006, \$280)  
 American Heart Association Pre-doctoral Fellowship (June 2006, unfunded)  
 Association for Psychological Science Travel Fund (April 2006, unfunded)

### **Awards & Honors**

College of Science Roundtable Make-A-Difference Scholarship Award, 2007 (\$1000)  
 Departmental Honors, University of Pittsburgh Department of Neuroscience, 2005  
 Cum Laude, University of Pittsburgh, Department of Neuroscience, 2005  
 Undergraduate Teaching Fellowship, University of Pittsburgh, Fall 2003, 2004  
 Dean's List, University of Pittsburgh, 2001 and 2002

### **Professional Memberships**

National Society for Collegiate Scholars  
 Alpha Epsilon Delta  
     Historian/Public Relations Officer, Pittsburgh Chapter, 2002-2003  
     Vice President, Pittsburgh Chapter, 2003-2004  
 Association for Psychological Science  
 Phi Kappa Phi

### **Research Interests**

The effects of anxiety and stress on various cardiovascular functions  
 Differences in cardiovascular functions of worriers and non-worriers  
 The relationship between heart rate variability and heart disease  
 Neurological differences between high and low anxious individuals

The correlation between anxiety and heart disease

### **Publications**

**Knepp, M.** (2006). Sensation and Perception. In P.K. Lehman, E. Tison, & J. Finney (Eds.), *Readings in Psychology*. Boston: McGraw Hill.

### **Presentations**

**Knepp, M.M.**, Immel, C.S., Moore, R.M., Jones, R.T., & Ollendick, T.H. (Nov 2007). *Earlier Anticipated Future Coping Efficacy Predicts Present Coping Efficacy at a 1-Year Follow-up*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

**Knepp, M.M.**, Hadder, J.M., Immel, C.S., Jones, R.T., & Ollendick, T.H. (Nov 2007). *Children's Everyday Life Fear as a Predictor of Future Manifest Anxiety in Fire Trauma Victims*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

Immel, C.S., **Knepp, M.M.**, Hadder, J.M., Jones, R.T., & Ollendick, T.H. (Nov 2007). *Reporter reliability of Somatization and Effects of Parental Symptoms on Reporting of Child Symptoms*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

Moore, R.M., **Knepp, M.M.**, Immel, C.S., Jones, R.T., & Ollendick, T.H. (Nov 2007). *The Use of Religious Coping Strategies for African Americans Following Residential Fires*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

Immel, C.S., Moore, R.M., **Knepp, M.M.**, Jones, R.T., & Ollendick, T.H. (Nov 2007). *Examining Symptom Intensity Longitudinally and the Moderational Role of Life Threat*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

Hadder, J.M., Immel, C.S., **Knepp, M.M.**, Jones, R.T., & Ollendick, T.H. (Nov 2007). *Longitudinal Analysis of Children's Avoidant Coping Behavior Following Residential Fire*. Poster submitted to the 23<sup>rd</sup> annual meeting of the International Society for Traumatic Stress Studies, Baltimore, MD.

**Knepp, M.M.**, Stephens, C.L., & Friedman, B.H. (May 2007). *Daily habits, physical wellbeing, and mental health, and relationships with trait worry*. Poster to be presented at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

Patriquin, M.A., **Knepp, M.M.**, Wells, A.O., Scarpa, A., & Friedman, B.H. (May 2007). *The effect of internet use on autonomic responses in undergraduates*. Poster to be presented

at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

Stephens, C.L., **Knepp, M.M.**, & Perez-Rivera, M.B. (May 2007). *Influences of affective states: Relationships between effortful control and emotion regulation*. Poster to be presented at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

Stephens, C.L., **Knepp, M.M.** & Friedman, B.H. (May 2007). *Empirical validation of music excerpts for investigations of emotion and emotion elicitation*. Poster to be presented at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

Hadder, J.M., Immel, C.S., **Knepp, M.M.**, Jones, R.T., & Ollendick, T.H. (May 2007). *Longitudinal analysis of children's coping behavior following residential fire*. Poster to be presented at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

Immel, C.S., Hadder, J.M., **Knepp, M.M.**, Jones, R.T., & Ollendick, T.H. (May 2007). *Examining the clinical utility of predictors in somatic symptomatology*. Poster to be presented at the 19<sup>th</sup> annual meeting of the Association for Psychological Science, Washington, D.C.

**Knepp, M.M.** & Friedman, B.H. (March 2007). *Trait worry on the PSWQ and its relationship with daily habits, previous negative physical and mental health events*. Poster presented at the annual Virginia Tech Graduate Student Association Research Symposium, Blacksburg, VA.

Stephens, C.L., **Knepp, M.M.** & Friedman, B.H. (March 2007). *Creation of a standardized set of emotion elicitation music excerpts for investigations of emotion and emotion elicitation*. Poster presented at the annual Virginia Tech Graduate Student Association Research Symposium, Blacksburg, VA.

Patriquin, M.A., **Knepp, M.M.**, Wells, A.O., Scarpa, A., & Friedman, B.H. (March 2007). *The Effects of Frustration and Novelty during Internet Use on Heart Rate and Heart Rate Variability*. Poster presented at the annual Virginia Tech Graduate Student Association Research Symposium, Blacksburg, VA.

Friedman, B.H., Lozier, L.M., Stephens, C.L., **Knepp, M.M.**, Pardikes, T.J., & Vella, E.J. (2006, May). *Gender and hemispheric differences in cardiovascular responses to lateralized hand cold pressor*. Poster presented at the annual meeting of the Association for Psychological Science, New York, NY.

**Knepp, M. M.** (2005). *The Use of Spatial Gesturing for the Resolving of Uncertainty*. Poster presented at the 2005 University of Pittsburgh Undergraduate Research Fair. Pittsburgh, PA. (April 2005).

**Thesis Work**

**Knepp, M. M.** (2005). *The use of spatial gesturing for the reconciliation of uncertainty*.  
Unpublished honors thesis, University of Pittsburgh, Pittsburgh, Pennsylvania.

**Review Work**

Graduate Reviewer, Association for Psychological Science, Rise-Up Competition  
Graduate Reviewer, Association for Psychological Science, Student Grant Competition