

Cardiovascular Reactivity to and Recovery from Laboratory Tasks in Low and High Worry
Women

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(ABSTRACT)

Anxiety and its cognitive component of worry have been related to exaggerated cardiovascular reactivity and delayed recovery to laboratory stressors, and to increased risk of cardiovascular disease. Previous research on the anxiety-cardiovascular system relationship, including data from Knepp and Friedman (2008), are included to support this project. Two experiments were completed during the course of this study. The first consisted of two peripheral-based body positioning tasks. The second experiment used an active versus passive sympathetic stress task paradigm (mental arithmetic, hand cold pressor). Subjects were nonsmokers free of cardiovascular and neurological disease. Trait worry was examined through the Penn State Worry Questionnaire (PSWQ). Blood pressure recordings and cardiac recordings through ECG and ICG were done in each experiment during seven epochs: an anticipatory baseline with three baselines preceding and three recovery periods following each task. Repeated measures analysis was run on all cardiovascular measures. In the first experiment, high worriers had worsened blood pressure reactivity to task. The second experiment found that high worriers had increased stroke volume across all epochs. There were mixed findings in the studies relating to subjects acclimated to the laboratory experience. Future directions of research relating anxiety, worry, and cardiovascular risk factors are discussed.

DEDICATION

This dissertation is dedicated to my wife, Kristen, who has been with me throughout the graduate school years and to my parents who get to retire the year that I start my career.

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INTRODUCTION

In the past few decades, research has examined how trait and clinical anxiety impact the cardiovascular (CV) system. While initial physiological investigations of anxiety and worry did examine autonomic nervous system (ANS) activity, these studies did not separately examine sympathetic and parasympathetic influence (e.g., Hoehn-Saric, McLeod, & Zimmerli, 1989; Roemer & Borkovec, 1993). This research then expanded into a simplified model of ANS activity, for example, as sympathetic activity increases, parasympathetic activity decreases and vice versa. Later, Berntson, Cacioppo, and Quigley (1991) depicted an ANS that is expressed in more complex patterns (nine possible combinations), including concordant and discordant activation and inhibition or one system increasing/decreasing while the other does not change. Most contemporary research has followed the Bernston model.

As the complex model of ANS activity expanded, the focus switched from the sympathetic nervous system to the parasympathetic nervous system (see Friedman, 2007; Porges, 2007 for reviews). The speculation is that the CV system has a problem with “faulty brakes” instead of a “sticky accelerator” (Friedman, 2007). One reason for this change in perspective is that the vagal component of heart rate has a quicker transmission rate on cardiac function when compared with the sympathetic system (Saul, 1990). Rather than examining changes that take time to develop, it was prudent to examine a parasympathetic system that interacts more closely with each heartbeat. Following this reasoning, some of the more recent lines of research have focused on heart rate variability (HRV) and respiratory sinus arrhythmia (Porges, 2007).

Anxiety, as a derivative of the basic emotion fear, is a multifaceted construct with cognitive, behavioral, and physiological components (Lang, Levin, & Miller, 1983; Plutchik, 1990). Fear/anxiety may be viewed on a continuum from a state to trait anxiety to clinical-level

anxiety disorders (Plutchik, 1990). From the initial study of anxiety, a specific line of research studying its cognitive component worry has been developed which has led to the study of worry and the CV system.

The previous study by Knepp and Friedman (2008) found robust heart rate (HR) differences in the absence of any HRV differences; however, this study had several limitations such as the potential for order and fatigue effects along with low power in the HF analysis was another concern. The present study set out to replicate the findings of Knepp and Friedman (2008) while correcting these limitations. Before the previous study can be discussed in detail, it is necessary to review the anxiety/worry and CV system research to this point in order to put the present study in the proper context.

Autonomic Characteristics of Anxiety

Earlier literature in the field of psychological traits and CV health examined the relationship between CV disease and the Type A personality (e.g., Friedman & Rosenman, 1971; Rosenman et al., 1975). The Type A personality is associated with traits such as impatience, time-urgency, and workaholism. Since that time, the literature in this area has been dominated by a focus on the Type A-derived traits of anger and hostility (see Everson-Rose & Lewis, 2005, for review).

Research on the link between Type A personality and CV disease has since yielded some negative findings (e.g., Ragland & Brand, 1988; Shekelle, Gale, & Norusis, 1985). Based on the idea that type A in the 1960s was confined to upper socio-economic groups, one might speculate that over time, as time urgency and competitiveness increased and spread throughout the rest of the population, type A lost its ability to predict coronary disease (Ikeda et al., 2008). These incongruent findings have led researchers to branch out and pursue components of personality

such as hostility (e.g., Carmona et al., 2009, Vella & Friedman, 2007), anger-in versus anger-out (eg., Cox & Harrison, 2008, Vella & Friedman, 2009), and anxiety (Knepp & Friedman, 2008) in order to scrutinize the relationship between psychological traits and CV disease and/or reactivity. From this broadening of the trait hypothesis, a number of earlier epidemiologic studies found anxiety to be an independent risk factor for CV disease (Haines, Imeson, & Meade, 1987; Kawachi et al., 1995; Kawachi, Sparrow, Vokonas, & Weiss, 1994) that has been confirmed in more recent research (Barger & Sydeman, 2005; Shen et al., 2008).

While the relationship between hostility and CV disease has been examined much more in depth, the connections between anxiety and CV disease along with the mechanism behind those relationships still need exploration. Panic disorder and other forms of anxiety have often been thought to relate to 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). As mentioned above, Berntson et al. (1991) depict 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, 2007). The link between anxiety and poor CV functioning relates more with autonomic inflexibility to problems with the inhibitory parasympathetic control rather than with the excitatory sympathetic nervous system.

The autonomic flexibility approach views HRV as a means of assessing cardiac vagal control. In HRV, there are three major components: (1) an HF component mediated by vagal activity and considered to be an index of vagal tone (Saul, 1990); (2) a low-frequency (LF) component that has been reported to have both sympathetic and vagal contributions, of which the

relative contributions have been debated (Malliani, Pagani, Lombardi, & Cerutti, 1991; Friedman, Thayer, & Tyrrell, 1996; Eckberg, 1997; Porges, 2007); and (3) a very low-frequency (VLF) band which has some autonomic underpinnings yet is still under investigation and has been related with thermoregulatory activity (Cohen, Matar, Kaplan, & Kotler, 1999). Knepp and Friedman (2008) approached the anxiety/worry-CV system from the autonomic flexibility perspective, but did not find significant HRV differences between high and low trait worry women. Since this replication study is discussing anxiety through the use of its component worry, it was necessary to discuss how worry can be operationalized.

What is worry?

Anxiety can be characterized by multiple variables including somatic/physiological complaints, a behavioral/oversensitivity component and cognitive/emotionality issues. Previous studies on anxiety take into account some combination of these anxiety components while the current study examined anxiety with a specific focus on its cognitive component, worry. 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 attention and memory.

Both attention and memory have consistently shown threat biases in anxiety groups (Coles & Heimberg, 2002; Mathews, 1990). For example, threat cues are processed differently by anxious and nonanxious individuals (Mathews & MacLeod, 1986), a difference potentially relying on a preattentive bias operating prior to awareness. From an implicit memory standpoint, clinically anxious subjects produced more threat word completions (Mathews, Mogg, May, & Eysenck, 1989). In explicit memory bias research, a marked bias for individuals with generalized anxiety disorder to recall threat words in a free recall test exists (Friedman, Thayer,

& Borkovec, 2000) and a bias in a S1-S2 conditioning procedure that paired colored dots with threat and nonthreat words that does not exist in the control group (Thayer et al., 2000). Hence, anxiety by means of worry has been marked by aberrations in both attention and memory (unconscious and conscious), two of the fundamental dimensions of cognition and could relate with a cognitive inflexibility to remove focus from threatening stimuli posttask.

By understanding the autonomic characteristics of anxiety and its cognitive component of worry, it was possible to understand how these traits can impact physical health. One of the aims of this paper was to show how even in healthy, nonsmoking college women, poor psychological functioning can be correlated with CV risk factors. To further explore this possibility, the literature regarding anxiety/worry and poor cardiovascular health and mortality is examined below.

Anxiety, Worry, and Cardiovascular Health

Individuals with panic disorder have been found to have comparables levels of HRV and reduced vagal tone to those found with hypertension (Langewitz, Ruddle, & Schachinger, 1994). High anxiety and defensiveness have been associated with increased blood pressure (BP) reactivity (Shapiro, Goldstein, & Jamner, 1996). Anxiety has also been linked to decreased baroreceptor control (Watkins, Grossman, Krishnan, & Blumenthal, 1999). Clients with generalized anxiety disorder have exhibited shorter cardiac interbeat intervals and lower high-frequency spectral power across all task conditions (Thayer et al., 1996). Finally, Kubzansky & Kawachi (2000) concluded that among various manifestations of negative affect, anxiety was a stronger predictor of coronary heart disease than either anger or depression in their review of the literature.

Glynn, Christenfeld, and Gerin (2002) provided evidence of slow BP recovery due to emotional stress and worry during rumination periods. In relation to generalized anxiety disorder, worrisome thinking was related to phasic reductions in vagal tone (Lyonfields, Borkovec, & Thayer, 1995). Worry has also been associated with elevated HR, reduced HRV, and cardiac vagal tone during “real-life” ambulatory recording of waking and sleep periods (Brosschot, Van Dijk, & Thayer, 2007; Pieper, Brosschot, van der Leeden, & Thayer, 2007) and during laboratory-induced worry (Hofmann et al., 2005).

One longitudinal study that evoked interest in the link between worry and CV problems found that men reporting increased levels of social worry possessed increased risks for nonfatal and fatal CV disease when compared with men who had reported lowered worry levels (Kubzansky et al., 1997). Kubzansky and colleagues suggested that worry could also be investigated through a moderated or mediated relationship with traditional factors such as smoking. As a task variable, worry has been linked to lower high-frequency spectral power, smaller mean successive differences, and shorter interbeat intervals for cardiac interbeat intervals when compared with relaxation and baseline periods (Thayer et al., 1996).

In sum, there are numerous findings that support the correlation between high trait anxiety and worry with poor CV health with autonomic inflexibility discussed as a possible mechanism. In the case of reactivity, if a high worrier has consistently high CV reactivity to task, then that person would be expected to have negative CV health outcomes later in life. While there is a small body of literature to support this idea, there has been some inconsistency in the research findings which could be from any number of factors including lower statistical power and shorter follow-ups (Treiber et al., 2003). These inconsistencies warrant the

investigation of other approaches in a CV risk model and as research moves beyond reactivity, another possible mechanism is poor CV recovery following a stressful event.

Perseverative Cognition Hypothesis

When examining CV recovery following the tasks, the primary mechanism that the present study is based on is the *perseverative cognition hypothesis*. According to this hypothesis, the tendency to suppress anger combined with hostility may delay CV recovery through the process of rumination (Brosschot & Thayer, 1998). It is possible that some hostile individuals persevere on their anger, which can result in sustained CV activation long after a provocative incident has concluded. The perseverative cognition hypothesis has since been extended to include persistent worry since both chronic anger and worry suppression share the same underlying mechanism of maintenance of negative affect thought—i.e., rumination (Brosschot, Gerin, & Thayer, 2006).

To highlight the danger in rumination, other studies have found links between CV disease risk factors and poor CV recovery such as high-risk individuals for hypertension exhibiting delayed CV recovery when compared with low-risk individuals (Hocking Schuler & O'Brien, 1997). 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 the disease history (Mezzacappa, Kelsey, Katkin, & Sloan, 2000). If one is predisposed toward poor CV recovery genetically, then poor CV recovery through rumination could compound the situation.

Conclusions: Anxiety and CV Health

Presently, the trend in anxiety-CV research is toward a strong focus on the parasympathetic branch of the ANS. The autonomic inflexibility theory is supported by findings

of high anxiety/worry individuals having poor CV recovery, following stressful events which over time could facilitate the relationship between high anxiety/worry and later CV disease. The perseverative cognition hypothesis is one explanation relating autonomic inflexibility to lessened CV recovery through which high anxiety/worry acts as a second risk factor for later disease. The present study revisited whether these ideas are valid or should be reconsidered by testing the findings of the Knepp and Friedman (2008) paper to see if they are replicated.

Summary: Knepp and Friedman (2008)

Background

The present study evolved from work by Friedman and colleagues on the autonomic characteristics of anxiety (Friedman & Thayer, 1998; Friedman et al., 1993; Knepp & Friedman, 2008; Thayer, Friedman, & Borkovec, 1996; Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000). In particular, the present study serves as a replication of Knepp and Friedman (2008) while correcting for certain potential methodological problems that arose during the previous work. Such issues that negatively impacted the previous study included power in HRV analysis and fatigue effects.

The Knepp and Friedman (2008) study consisted of an anticipatory recording period along with 18 experimental epochs consisting of six tasks along with their pre- and posttask periods. The aim of the original study was to determine what types of laboratory tasks result in the largest CV differences between high and low worriers. The body positioning tasks were chosen to introduce the notion of different task types and the second epoch set of mental arithmetic and hand cold pressor was chosen due to their history of being Obrist's active (mental arithmetic) versus passive (hand cold pressor) task paradigm. Beta-adrenergic sympathetic effects on the heart should predominate during active rather than passive coping (Obrist, 1981).

The final task pairing consisted of worry imagery and progressive relaxation to see how various cognitive structuring tasks would impact the low and high worry groups.

In Knepp and Friedman (2008), it was decided that as a control for gender, it was prudent to use an all-female sample due to an increased prevalence for generalized anxiety disorder in women when compared to men. Sex differences in CV research are also important as Stoney, Davis, and Matthews (1987) noted various psychophysiological differences in men and women to behavioral stress. Thayer et al. (1998) found that nondepressed men had higher heart period variability than depressed men, while depressed women had higher heart period variability than nondepressed women. Finally, previous work had been done on anxiety and CV disease in women which mirrors results that are found in men; e.g., women with phobic anxiety have increased risk for coronary heart disease in particular sudden cardiac death (Albert, Chae, Rexrode, Manson, & Kawachi, 2005). This link related also to other coronary heart disease risk factors correlated with phobic anxiety.

Primary findings

The primary finding of Knepp and Friedman (2008) was a robust HR difference across all epochs between high and low worriers. High worriers' HRs were on average five to ten beats per minute faster in a given epoch (see Figure 1). Conflicting with previous research, however, this study found no significant HRV findings, in particular with rMSSD and the HF component of heart rate. While not statistically significant, all HRV results were in the expected direction with low worriers displaying stronger vagal influence on the heart.

Methodological issues

The first methodological issue to address from Knepp and Friedman (2008) was the possibility of fatigue effects as the original study took place over the span of a full two hours

including 90 minutes of CV recording. By examining across the pretask periods (Figure 1), HR was found to be significantly different in the first task set, which were the orthostatic and supine epochs. Yet in the last two task sets, active/passive and imagery, there was one task with a significant HR difference in the baseline period and one without. The cold pressor pretask HR differences and the worry pretask HR differences were significantly different while the mental arithmetic and relaxation imagery pretask HR differences were only marginally significant. Fatigue effects are expected as low high worriers saw a steady decrease in HR across pretask baselines as the study continued.

Other methodological issues concern the possibility of order effects in the study and a possible lack of potency of the experimental manipulation. With regard to order effects, it was not possible in a smaller sample to fully counterbalance the study so a sequence was embedded that counterbalanced within each task set while the sets themselves for each subject remained in the following order: body positioning, active versus passive lab stressors, and imagery. This particular order might have dampened the effects of the later tasks. It is possible that in addition to fatigue and order issues, imagery was not as potent; this is supported by subject self-reports and experimenter observation. Since these tasks were not effective, they were removed from the replication.

To address these potential confounds, a series of two experiments was conducted consisting of two tasks each to shorten the overall laboratory time. This adjustment of protocols allowed for sharper comparison of task effects without a difficult counterbalancing setup. In each investigation, the amount of CV recording epochs went from nineteen (including the anticipatory baseline) to seven leading to an almost one hour decrease in the amount of time each subject participated in the CV recording.

A final methodological problem with the previous study was the potential lack of power necessary for the HRV analysis. Although the worry group mean differences for the vagal influences on heart rate were in the predicted directions, high standard errors in both the rMSSD and HF component of high rate findings reduced the chance of finding any statistical significance. A secondary benefit of the shorter study length is that it allowed for an increase in the number of subjects that could be run in each study, increasing the statistical power compared to Knepp and Friedman (2008). The aim was to assist the sensitivity in detecting smaller effect sizes than in the original study with these statistical power increases.

Replicating the study

One of the aims of this paper was to replicate the robust HR differences between high and low worriers in the absence of significant HRV differences found in Knepp and Friedman (2008). By replicating that finding (and showing that the findings were not due to low power), this study would have mirrored exercise literature findings supporting a lower intrinsic HR without autonomic adjustments (Bonaduce et al., 1998; de Geus et al., 1996; Kingwell et al., 1992; Uusitalo et al., 1996). One explanation from the exercise literature is that this lower intrinsic HR developed through changes in myocardial pacemaker tissue or cell metabolism (Katona et al., 1982). By addressing previous methodological concerns, the goal was to improve the strength of the arguments in the original study; however, a replication of the previous research would conflict with the general trend that anxiety has been marked with poor vagal control of the heart. The design of the present study was to split the tasks into two separate experiments, each with similar hypotheses and descriptions of these experiments follow.

Experiment 1

Task descriptions

Each experiment in this study included only one-third the amount of laboratory tasks in each study as only the first task set in Knepp and Friedman (2008) contained significant HR group differences at both baselines. A secondary criterion for the selection of tasks was that in the previous experiment, the tasks presented the best evidence for differentiating between high and low worriers. Worry focus and guided relaxation were the least potent at this aim. Also, self-reporting from subjects along with experimental observation led to the suspicion that the two imagery manipulations may not have been effective. The experiments were arranged to include one body position-based experiment and one investigation of a traditional stress design studying active versus passive stressor tasks.

For the first experiment, the initial task to discuss is a physical orthostatic stressor modeled after previous work done by Pagani et al. (1995) and Friedman & Santucci (2003). This body positioning consisted of the subject arising from a seated position and standing upright throughout the task period, which has been shown to elicit sympathetic activation along with vagal withdrawal (Pagani et al., 1995).

The second task in the first experiment involved the subject moving from seated to a supine position in a reclining chair. Although both body positions are mechanical tasks, supine rest has the opposite ANS effects of orthostatic stress, moving from a sitting to a supine position results in vagal activation with sympathetic withdrawal (Fox, 2008).

Hypotheses

In this experiment as well as the overall study, the methodological issues of Knepp and Friedman (2008) presented a dilemma for the hypotheses. The expected results of this experiment differ on whether or not fatigue, counterbalancing, and lower sample affected the null HRV findings. This experiment's primary hypothesis was the original study was valid and

that even when correcting these issues, the findings should be replicated. Working under this theory, the following hypotheses were formed:

- 1) It was expected that high worrying subjects would have significantly higher HRs across all epochs, including the anticipatory, when compared with low worriers.
- 2) Regarding the task and posttask periods, there would be no specific HR reactivity or recovery change score differences; however, the two groups' average HR during the task and recovery phases would differ.
- 3) Replicating the earlier paper would result in no significant group differences for HRV, which would include rMSSD and the HF component of HR.
- 4) No reactivity or recovery change score differences on the HRV variables were predicted as well.
- 5) There was expected to be no systolic (SBP) or diastolic blood pressure (DBP) differences.

Finally, stroke volume (SV) and heather index (HI) were included in the original paper. However, due to a measuring error, they were not considered valid. SV and HI were included in the present analyses as exploratory variables.

Alternative hypotheses were also considered due to the methodological issues in Knepp and Friedman (2008). In the secondary hypotheses, it was believed that by improving the methods in this study, the experimenters allowed for a better investigation of the relationship between the CV system and worry. From this line of thinking, the following alternative hypotheses were formed:

- A1) It was expected that HR and HRV tonic level differences will be seen at baselines (including the anticipatory baseline), during tasks, and during the recovery periods.

A2) The high worry group would have a higher average HR during each of the six epochs in each study as well as during the anticipatory baseline.

A3) The low worry group would have a higher average HF power (normalized and unnormalized) and rMSSD during each of the six epochs in each study as well as during the anticipatory baseline.

If the methodological issues were a problem and now corrected allow for an adequate environment for investigation, the alternate hypotheses should follow the ideas of autonomic inflexibility and the perseverative cognition hypothesis leading to these further ideas:

A4) High trait worriers were then predicted to have increased CV reactivity to task and diminished CV recovery following a task when compared to low worriers.

A5) The high worry group should have higher HR reactivity change scores than the low worry group for the orthostatic task. The opposite could be said of HF power during that task.

A6) The high worry group were anticipated to have lower HR reactivity change scores (i.e. HR does not decrease as much) than the low worry group during the supine task. HF power would increase at a greater rate in low worriers than high worriers.

A7) The low worry group were expected to remain at a decreased HR level rather than returning toward baseline as quickly. The high frequency power levels would remain increased in the high worry group as well.

Experiment 2

Task descriptions

The second experiment used the second task set from the previous study. Reasons for the selection of these tasks were to produce larger group differences in HR (when compared with the imagery tasks) and to reproduce an active versus passive stress study design. This arrangement

was felt to be more beneficial than including a parasympathetic relaxation test since it was not previously potent. The first task used was the hand cold pressor, during which, the subject remained sitting upright in a lounge chair and placed her left hand up to the wrist in a small tub of ice water. This stressor was meant to be a passive task because the subject had no cognitive or motor task to perform and is characterized by a sympathetic alpha-adrenergic activation (Saab et al., 1993).

The final task in the study was mental arithmetic. The stressor has been used in previous research because, although it lacks motor stimulation, it is not a passive task. This task was highlighted by an active cognitive component due to its mathematical difficulty and is characterized by sympathetic beta-adrenergic activation and vagal withdrawal (Gorman & Sloan, 2000).

Hypotheses

The hypotheses in the second experiment were similar to those presented in the first experiment with a few exceptions. Following the aim of a replication of Knepp and Friedman (2008), the primary hypotheses were:

- 1) A robust HR difference between worry groups in the absence of HRV findings.
- 2) These findings would be true regarding tonic level differences during all of the epochs with no expected reactivity or recovery finding.
- 3) It was anticipated that there would be no significant PEP or BP group differences.

Alternative hypotheses were created in relation to the methodological issues addressed as was done in the first experiment. Under the secondary hypotheses, it was expected that:

- A1) HR and HRV tonic level differences would be seen at baselines (including the anticipatory baseline), during tasks, and during the recovery periods.

A2) The high worry group would have a higher average HR during each of the six epochs in each study as well as during the anticipatory baseline.

A3) The low worry group would again have a higher average HF power (normalized and unnormalized) and rMSSD during each of the six epochs in each study as well as during the anticipatory baseline.

The autonomic flexibility theory and the preservative cognition hypothesis were used as guidelines for the creation of reactivity and recovery secondary hypotheses in this study as well. Based on these theories, it was predicted that:

A4) High trait worriers would also have increased CV reactivity to task and worse CV recovery following a task when compared to low worriers on both tasks.

A5) The high worry group should have higher HR reactivity change scores than the low worry group on hand cold pressor and mental arithmetic. The opposite can be said of HF power which should have decreased.

A6) The high worry group would remain at an increased HR level rather than returning toward baseline in both tasks (lower HR recovery change scores). The HF power and rMSSD levels would remain decreased in the high worry group as well.

A7) SV and HI were included as exploratory variables for both hypotheses in the second experiment as well.

METHOD

Study Design and Timeline

The current study was conducted as two separate experiments, each following similar outlines, designs, and timelines. Subtle differences between the two experiments included the tasks themselves, total subject numbers, and a difference in one of the questionnaires given at the end of the study. Each experiment consisted of two components: an online screening phase followed by a laboratory session with cardiovascular recording. Online screening was continuous throughout the semester and those fitting the criteria were invited throughout the term to participate in the laboratory portion. This study was approved by the Virginia Tech Institutional Review Board and was run in compliance with their regulations. In the materials, CV measures, and procedures sections of this paper, common elements will be listed first followed by any experiment-specific differences.

Materials

Penn State Worry Questionnaire (PSWQ)

The PSWQ was included as the measure of trait worry, and was used to produce high and low worry groups. The PSWQ is a 16-item questionnaire used to assess trait worry levels and has been used in clinical and nonclinical samples. The PSWQ includes questions such as “I worry all the time” and “I worry about projects until they are done.” Typically, control groups have a mean score around 40 or below, while individuals presenting symptoms of generalized anxiety disorder have a mean score above 60 out of 80 total (Behar, Alcaine, Zuellig, & Borkovec, 2003).

Depression Anxiety Stress Scale (DASS)

The DASS was used in both experiments as a measure of state conditions of the subjects. As in Knepp and Friedman (2008), the measure was used as a manipulation check to ensure that state anxiety in particular did not impact the results. The DASS is a 42 item self-report inventory that yields three factors: depression, anxiety, and stress. Lovibond and Lovibond (1995) proposed that physical anxiety (fear symptomatology) and mental stress (nervous tension and nervous energy) as measured by this questionnaire factor-out as two distinct domains. This screening and outcome measure instructed individuals to respond to the items with regard to the past seven days. Reliability of the three scales is considered adequate and test-retest reliability is likewise considered adequate with .71 for depression, .79 for anxiety, and .81 for stress (Lovibond & Lovibond, 1995). The DASS anxiety scale correlates .81 with the Beck Anxiety Inventory (BAI), and the DASS depression scale correlates .74 with the Beck Depression Scale (BDI) (Lovibond & Lovibond, 1995).

Godin Leisure-Time Exercise Questionnaire (GLEQ)

Exercise levels were assessed in this study utilizing an excerpt from the GLEQ (Godin & Shepard, 1997). The GLEQ was used in this study due to the positive outcomes daily exercise can have on CV health. The excerpt from the scale consisted of four self-report exercise items. The first three items focused on typical seven-day activity amounts for strenuous, moderate, and mild exercise. The final question used a three-point scale to determine regularity of sweat-inducing exercise, whether often, sometimes, or rarely/never and was used to determine high and low exercisers for any secondary analyses on exercise.

Cardiac Measures

Cardiac performance was taken from an 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). AMS application entailed prepping the skin with alcohol to reduce impedance, followed by placement of six disposable thoracic electrodes. Three electrodes for monitoring ECG were placed on the chest of the subject; while, one electrode was placed on the chest and two electrodes were placed on the back for the observation of ICG. ECG was analog filtered (high pass 17 Hz) at acquisition and subjected to online auto trigger level R-wave detection resulting in a resolution of 1 ms. A Fast Fourier transform was used to derive the spectral estimates for very low, low, and high frequencies. The IBS SD-700A automated Korotkoff BP and pulse monitor device monitored SBP and DBP (Industrial & Biomedical Sensors Corp., Waltham, MA) with the subject keeping the BP cuff at heart level during all epochs.

The ECG was used to derive HR (mean number of beats per minute), which has both vagal and sympathetic beta-adrenergic influences and the HRV variables. Interbeat interval (IBI) sequences were examined for validation as IBIs with two standard deviations outside the normal range and ones that differed more than 33% from the previous IBI to prevent any errors due to artifact. The IBI time series for each subject was analyzed with HRV Analysis Software 1.1 for Windows developed by The Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Finland. HRV analysis software calculated all the commonly used time domain and frequency domain measures of heart rate variability. From the HR data, the heart period time series was spectrally analyzed. LF (0.04–0.15 Hz) and HF (0.15–0.40 Hz) ranges were extracted from the power spectral density units. The HF 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 absolute power values and normalized units along with rMSSD (in ms) using this software. ICG data was

used to calculate PEP (in ms), which can be used as a measure of cardiac sympathetic beta-adrenergic activity (Sherwood et al., 1990). SV (in ml) or the total volume of blood pumped from one ventricle during a given beat and HI (in Ω/s^2), a heart contractility measure, were also calculated from the ICG.

Experimental Designs

Screening phase

Study recruitment was done via the Virginia Tech Psychology Department's SONA system with no further advertisement for the study. After students registered for the study, they were directed to the study website housed on survey.vt.edu where the questionnaires appeared on one page with various subsections. The opening of the survey included an online version of the informed consent form (Appendix B) to examine before beginning the questionnaires. By continuing and completing the questionnaires, each subject gave implied consent to the study. The first step in recruitment was the use of an online version of the PSWQ (Appendix C) with an additional two questions asking the subject to select a particular answer if she was paying attention. This was done to screen subjects whose answers may not have been valid. Potential low worry subjects had a cutoff score of 46 and below, and high worry was determined by a cutoff of 60 and above (out of a possible 80).

Subjects were screened further following the PSWQ through a physical and mental health background form developed by the Virginia Tech Mind-Body Lab (Appendix D). Information was collected on height and weight to calculate BMI. The physical health portion of the form contained questions about CV and neurological health histories while the mental health portion included questions about mental health diagnoses and medications taken. Individuals who reported medical conditions and/or those who reported medications which affect the CV system,

such as beta-blockers, were screened out of the laboratory phase. Only nonsmoking women were eligible for the laboratory phase as a control for tobacco use effects on cardiovascular activity.

On average, the online screening phase took approximately 20 minutes or less to complete. A total of 785 women completed the online screening with eligible subjects for the laboratory session being those who met the criteria for either the low or high worry group and were not screened out due to a health issue. All subjects who completed the online screening phase earned one point of extra credit and a raffle entry toward one of two amazon.com gift cards.

Laboratory Procedure Overview

Upon arrival to the lab, the experimenter and a female research assistant greeted the subject. First, the experimenter gave the subject a quick tour of the facilities and an explanation of the equipment used during the study. The subject was also given the informed consent form to read and sign, which was identical to the one used during the online portion of the study. Following written consent, the experimenter left the room and the research assistant applied the electrodes of the AMS necessary for ECG and ICG recording. After the equipment had been applied, the assistant marked the electrode distance for the ICG, which was used to calculate SV. The research assistant also made a subjective observer rating of worry level (high or low) for potential exploratory analysis on self versus observer reporting of worry after which she left and the experimenter returned to the room.

The first CV recording, the anticipatory baseline, was taken at this time to check equipment functioning and make any necessary recording adjustments. This period helped with familiarizing the subject with the CV recording processing in the study and served an extra

purpose to analyze how low and high worriers acclimate to the laboratory experience. It was possible with these data to examine whether coming into the lab itself was a stressor for high worriers.

After this baseline, the subject completed a short physical health form which included three exemption items about caffeine, food, and alcohol as well as a question about menstrual cycle phase (Appendix E). During this portion of the experiment, the experimenter explained this short questionnaire and the later portions of the study in full, as well as answered any questions.

Another purpose for the use of the short form and detailed explanations was to allow for acclimation to the lab. To standardize acclimation to the lab for each subject, the six main recording epochs did not begin until the subject had been in the lab for at least 15 minutes. The main recording period consisted of six experimental conditions, each three minutes in length. Between each of these epochs was a one-minute period in which preparations were made and instructions were given to the subject about the upcoming epoch. ECG and ICG were continuously recorded during each epoch. The conditions were pretask1, task1, posttask1, pretask2, task2, and posttask2 that were noted with event markers on the ambulatory monitoring system.

The first pretask period consisted of a “vanilla baseline” in which the subject sat comfortably in the lounge chair while a three-minute segment of a multicultural documentary video entitled *Powaqqatsi: Life in Transformation* (Reggio, 1988) aired as a neutral visual stimulus. This stimulus has been recommended in CV research paradigms (Jennings et al., 1992) and has been previously used in our laboratory for this purpose (Knepp & Friedman, 2008; Vella & Friedman, 2007). The second epoch was one of the two task phases that were counterbalanced

(2 possible orders in each study) across subjects to control for order effects. Following each task, there was a three-minute posttask period during which the subject sat quietly in the chair, eyes closed. The six recording epochs took approximately 30 minutes.

Upon completion of the recording epochs, the subject was asked to sit quietly for one minute of additional cardiac recording during which the CV data was backed up onto the hard drive. Following the completion of the CV recordings and saving of cardiac data, the experimenter removed the BP cuff, unplugged the AMS, and removed the electrode wires. The final portion of the study consisted of various questionnaires to help control confound completed an online format through survey.vt.edu to ease data collection. The experimenter gave the subject an ID number to increase privacy and security in the data set. For the first questionnaire, subjects completed the PSWQ again to ensure reliability as subjects whose scores changed by one standard deviation were excluded from analysis.

The second inventory that subjects completed was the GLEQ (Appendix F) to ensure that physical fitness and exercise did not confound the results. The third questionnaire was a short analysis of the study. The questionnaire included items such as, “How well were you paying attention to the video?” and “How difficult/relaxing was each task?” to ensure the tasks were providing the desired effects. The final questionnaire was the DASS as a means of assessing state anxiety levels (Appendix G) of which all subscales were recorded; however, this study was focused on in the 14-item subscale of anxiety to measure state levels.

At the completion of the questionnaires, the subject was informed about the goals of the study and given the option of seeing her cardiac measures and knowing her worry score. At this time, the investigator answered any questions about the purposes of the study as well as gave the option to have data withdrawn without penalty. Following the debriefing, the experimenter left

the room so that the subject could remove her own electrodes. The laboratory period lasted slightly less than one hour and subjects were compensated with one extra credit point toward the psychology class of their choosing as well as three additional entries into the amazon.com gift card raffle.

Experiment 1

Subjects

Of the eligible subjects from the online phase, a total of 58 undergraduate women participated in both the online and laboratory phase of this experiment; 31 were considered to have high trait worry (PSWQ $M = 66.74$, $SE = 1.00$) and 27 women were low trait worriers (PSWQ $M = 37.67$, $SE = 1.08$). Subjects were nonsmokers and asked to refrain from caffeine for 12 hours, alcohol for 24 hours, and food for one hour before the study. Five subjects (all low worriers) were considered not valid for the analyses because they did not refrain from one of these three things or because their PSWQ scores were not reliable. Time of day when the study began, BMI, and menstrual cycle phase were used as covariates for this study as these variables were previously identified as the most likely to affect the CV results (Knepp & Friedman, 2008).

Procedure

The diverging of the experiments began at the six recording epoch phase. The pretask period in both studies was the neutral video stimulus. In the first experiment, this was followed by the initial task phase. The tasks in the first experiment were both body positioning stressors. Before the body positions were done, the subject was given full instructions on what to do and was assisted into the position in the case of supine rest.

During the orthostatic task, the subject rose from the lounge chair and stood for three-minutes with eyes closed, with the experimenter helping to move the wires during the standing

portion for comfort. The task instructions were to stay as still as possible while standing upright without slouching for the full three minutes, keeping the arms at the side. Any time the subject moved, the investigator reminded her that it was important to stay still and not slouch. At the end of this task, the subject was instructed to return to the lounge chair slowly to prevent any damage to the AMS or its wires. The three minute posttask period began once the subject returned to the seated position and was still with eyes closed.

At the beginning of the supine task, the experimenter assisted with moving the lounge chair position from upright to supine with the subject's feet resting on the chair's footrest. The directions for this task were for the subject to lie still with eyes closed and not to sit up for the three-minute period and were given as the experimenter prepared the chair. If any restless 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 by the experimenter for the posttask period that began once the subject was comfortable again in the seated position with eyes closed.

During the recording period, there were two possible orders for the tasks. The orders were similar in design with only portions 2 (orthostatic) and 5 (supine) reversed between them. The following is the first possible order for experiment 1:

- (1) Pretask 1 (Pre1): Sitting quietly in a comfortable lounge chair while observing a video screen showing a neutral segment of *Powaqqatsi*.
- (2) Orthostatic (T1): Standing upright.
- (3) Posttask 1 (Post1): Sitting quietly in the lounge chair, eyes closed.
- (4) Pretask 2 (Pre2): Identical to Pre1.
- (5) Supine (T2): Lie close to horizontal in the chair.
- (6) Posttask 2 (Post2): Identical to Post 1.

Following completion of the six recording epochs, the four questionnaires were given in the order listed before: PSWQ, GLEQ, experiment analysis, and DASS. In the first experiment, the third questionnaire included questions about how strenuous it was to stand for three minutes and how relaxing the supine task was. Data from this experiment are stored online under password protection and hard copies are kept in locked cabinets in the Mind-Body Laboratory.

Experiment 2

Subjects

Of the eligible subjects from the online phase, a total of 64 undergraduate women participated in both the online and laboratory phases of this experiment; 35 were considered to have high trait worry (PSWQ $M = 67.03$, $SE = .99$) and 29 women were low trait worriers (PSWQ $M = 37.14$, $SE = 1.09$). Subjects were nonsmoking and were asked to refrain from caffeine for 12 hours, alcohol for 24 hours, and food for one hour before the study. From this sample of 64 women, 14 subjects (5 low worry, 9 high worry) were deemed ineligible because they did not refrain from one of these three things or because their PSWQ scores changed by over one standard deviation. Time of day when the study began, BMI, and menstrual cycle phase were again used as covariates for this experiment.

Experiment-specific protocol

The laboratory design of study 2 was similar to study 1 throughout with a divergence of the tasks involved and questions related to those tasks. The laboratory procedure mirrored that of study 1 during the acclimation to the lab phase up until the first task epoch. The first of the six main recording epochs following the short questionnaire was still the pretask recording using the neutral video described earlier. Following that pretask epoch, rather than using body positioning tasks, two traditional stress tasks (one active, one passive) were done.

During the hand cold pressor task epoch, 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 3–5 °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 prevented any ice from coming in contact with the subject's hand during the task. The instructions were for the subject to keep her hand in the cold water up to the wrist for the full three minutes. Although the hand could be removed from the water if discomfort was experienced, the investigator asked that the subject try to keep her hand immersed for the duration of the study. The experimenter noted whether or not each subject completed the task for the full three minutes. 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. The posttask period did not begin until the subject felt that her hand was dry and she was sitting comfortably in the chair with eyes closed.

The other task epoch in the second experiment was a mental arithmetic task challenge that incorporated serial subtraction. Subjects began counting out loud at the number 3,000 and decreased toward zero by intervals of seven as fast and accurate as possible. The experimenter reiterated that speed was the goal, but not to count recklessly as performance would be monitored with no experimenter help provided. A subjective rating of mathematical ability (low or high) was noted at the end of the task. This task was performed with the eyes closed to prevent the subject from counting on her hands. The posttask period began when the subject stated that she was ready (and told not to think about performance) and was sitting with eyes closed

During the recording period in the second experiment, there were two possible orders. The orders were similar in design with only portions 2 (hand cold pressor) and 5 (mental arithmetic) reversed between them. The following is one of the two possible orders for the second experiment:

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

(2) Hand Cold Pressor (T1): Hand placed in a container of ice water 3–5 °C.

(3) Posttask 1 (Post1): Sitting quietly in the lounge chair, eyes closed.

(4) Pretask 2 (Pre2): Identical to Pre1.

(5) Mental Arithmetic (T2): Counting backwards from 3,000 by 7.

(6) Posttask 2 (Post2): Identical to Post1.

Following the recording epochs, the two studies were similar in nature again. Subjects completed the same questionnaires that were completed by subjects in experiment 1: PSWQ, GLEQ, experiment analysis, and DASS. The third questionnaire was again related to the subject's laboratory experience, and so included questions about the cold pressor and mental arithmetic tasks. As an example, there was an item specific to whether or not the subject experienced any perceived pain during the cold pressor task. Data from the first and second experiments were later prepared into one combined study analysis file.

Ethical Considerations

To ensure the privacy of each individual, all scores were saved by subject number only in both data analysis and storage. Access to the online surveys and the cardiac recording data was available only to the experimenter and members of the research team as online questionnaire data was password protected on the Virginia Tech hosting system. The hard copies of the physical

health short form from the laboratory session were stored in a locked cabinet in the Mind-Body Lab with access granted only to the experimenter and the research team. No names were gathered from subjects, and email addresses were used for assigning extra credit, raffle winner contact, and laboratory phase eligibility notification purposes only.

The tasks involved in this study posed minimal risk to subjects. The three minute time period was short enough to prevent discomfort from standing upright during the orthostatic stress and from the cold water during the hand cold pressor. There was no experimenter harassment (as it was not necessary in this study) during the mental arithmetic task which would lower the potential risk of embarrassment. Subjects could inquire about their performance on the serial subtraction task at the end of the study.

Subjects received an explanation of the study and its goals during the debriefing and could be informed of their trait worry and state anxiety scores and could ask any questions at this point about the equipment, CV functioning, or the tasks that were performed. The experimenter reminded the subject about counseling services and the contact numbers listed in the informed consent form. At the end of the experiment the subject was again notified that if she would like her data withdrawn from the experiment for any reason, she had that option available immediately or by emailing the experimenter at a later date.

RESULTS

The data in each study were analyzed by a 2 (worry level: between-subjects) x 7 (condition: within-subjects) repeated measures MANOVA. The dependent variables were HR, rMSSD, the LF and HF spectral powers of ECG (absolute and normalized powers), PEP, SV, HI, SBP, and DBP. The results included only subjects who properly abstained from caffeine, food, and alcohol. The subjects included in the results also did not deviate by more than one standard deviation in PSWQ scores from online to in-lab assessments. PSWQ scores during the first experiment were correlated $r=.82$ ($p<.001$) and $r=.84$ ($p<.001$) during the second experiment.

Experiment 1

In the first experiment, there were no significant findings for HR (all p values $> .10$). There were also no significant group differences or worry group by epoch interaction effects for rMSSD or the LF and HF spectral powers of ECG. There were no reactivity or recovery change score based effects related to any of these ECG variables. As a manipulation check, within-subjects analysis was run for task using pairwise comparisons. The orthostatic and supine task epochs differed significantly from all other epochs in HR and HRV (using rMSSD and HF normalized units; p values $<.001$). This manipulation check was done to show that our tasks were eliciting the desired effects.

Significant findings primarily related to BP. For SBP, there was a worry group by epoch interaction ($F(6, 288) = 2.89, p < .01$). In all epochs, high worriers showed higher SBP than low worriers. Posthoc comparison testing was used to examine the interaction effects. The interaction takes place because this difference is more pronounced in the orthostatic and supine task phases. In the orthostatic task, high worriers had a recorded SBP level of

126.31 mmHg (SE = 2.40) compared with 117.88 mmHg (SE = 2.88) for low worriers ($F(1, 48) = 5.50, p < .05$). During the supine task, high worriers had a recorded SBP level of 120.29 mmHg (SE = 2.08) compared with 114.42 mmHg (SE = 2.49) for low worriers ($F(1, 48) = 3.12, p < .10$). The marginal findings for SBP can be seen in Figure 2.

Concerning DBP, there was a trend toward significance in the worry group by task epoch interaction ($F(6, 288) = 1.90, p = .081$). In the anticipatory, orthostatic, and supine pretask epochs, low trait worriers had higher DBP. Low trait worriers showed lower DBPs in both body positioning task epochs as well as the posttask periods that followed the two body positioning task epochs. Since none of the individual epochs had significant differences, the interaction was due to reactivity and recovery change differences. The findings for DBP can be seen in Figure 3.

The data from the BP findings were analyzed by comparing change scores for reactivity and recovery. Concerning reactivity, there was a trend toward significance in SBP for reactivity to the orthostatic task ($F(1, 48) = 3.91, p = .054$). While low worriers increased only .436 mmHg (SE = 1.83), high trait worriers increased 5.27 mmHg (SE = 1.53) to task. There was a significant worry group difference for DBP reactivity to the supine task ($F(1, 48) = 8.44, p < .01$). Low worriers (M = -10.68 mmHg, SE = 1.79) decreased DBP almost three-fold compared with high worriers (M = -3.71 mmHg, SE = 1.50). Low trait worriers (M = -4.57 mmHg, SE = 1.25) had improved SBP recovery change scores to first baseline (High Worry Group M = -1.12 mmHg, SE = 1.04; ($F(1, 48) = 4.29, p < .05$)). Finally, low trait worriers further decreased in DBP (M = -3.81 mmHg, SE = 1.94) during the recovery epoch following the supine task, while high worriers increased toward pretask levels (M = 2.45 mmHg, SE = 1.62; ($F(1, 48) = 5.82, p < .05$)).

There were no significant main or interaction effects for the ICG variables of PEP and SV. Although there was no group by epoch interaction effect, there was a main effect trend for tonic levels of HI ($F(1, 48) = 3.66, p = .062$). High trait worriers had higher average HI scores ($M = 10.57 \Omega/s^2, SE = .55$) across all epochs when compared with low worriers ($M = 8.89 \Omega/s^2, SE = .66$). The first experiment's HI results can be seen in Figure 4. Finally, there were no significant reactivity and recovery effects for the ICG variables of HI, PEP, and SV.

Experiment 2

In the second experiment, there was no worry group by task epoch interactions or main effects of worry group on HR (p values $> .10$). No interaction or main effects were found for the following ECG variables: rMSSD and the HF component of HR (p values $> .10$). Finally, when examining change scores for reactivity and recovery, no significant worry group differences were found for any of the ECG variables. As a manipulation check similar to experiment one, within-subjects analysis was run for task using pairwise comparisons. Both task epochs differed significantly from all other epochs in HR (with math being more potent than cold pressor; p values $< .001$). Mental arithmetic differed from all other epochs except cold pressor on HRV levels (using rMSSD and HF normalized units; p values $< .001$). Hand cold pressor did not differ however from the anticipatory phase or its baseline, although it did differ significantly from the other baseline and both posttask phases. This finding does slightly question the potency of this task in the study.

There was one significant worry group difference with the ICG variables. High worriers had increased SV levels across all epochs when compared with low trait worriers ($F(1, 45) = 6.95, p < .02$). Reactivity change score analysis yielded one significant difference. Low trait worriers ($M = 20.36, SE = 3.88$) had higher LF relative power reactivity to the mental arithmetic

task when compared with high trait ($M = 7.38$, $SE = 3.73$) worrying women ($F(1, 45) = 5.79$, $p < .05$). No significant differences existed between worry group change scores for recovering from the two tasks.

In the second experiment, there were two findings accompanying acclimation to the laboratory experience. Change score differences between the anticipatory baseline and the first baseline following the full study explanation show that low trait worriers had increased rMSSD recovery ($M = 4.11$ ms, $SE = 2.64$) to the first baseline postacclimation while high worriers decreased ($M = -3.49$ ms, $SE = 2.53$) in rMSSD ($F(1, 45) = 4.31$, $p < .05$). Figure 5 displays the rMSSD differences between the groups. High trait worriers ($M = .546$ Ω/s^2 , $SE = .130$) had marginally increased HI recovery to first baseline compared with low worriers ($M = .213$ Ω/s^2 , $SE = .135$, $F(1, 45) = 3.18$, $p = .082$).

DISCUSSION

The primary objective of this project was to replicate the study of Knepp and Friedman (2008). A secondary aim was an attempt to address certain methodological limitations that may have comprised the findings of that study. In the present study, the hypothesis that high worriers would have significantly higher levels of HR in the absence of HRV differences was not supported. Further, the hypotheses relating to the low worry group having decreased HR reactivity to the orthostatic task and increased HR recovery following the task were not supported. These findings also did not support the HR predictions specifically related to the supine task. This study, in both experiments, failed to replicate the findings of Knepp and Friedman (2008) with regard to HR. However, similar to Knepp and Friedman (2008), no HRV differences were found between high and low worriers. The primary hypothesis that there would be no significant differences in tonic levels of HRV was supported along with a lack of HRV reactivity and recovery differences.

The secondary hypothesis that this study would indicate significant HRV differences between high and low worriers is supported by the literature; however, the secondary hypotheses were also not supported when examining HR or HRV. Most secondary hypotheses regarding HR and HRV with tonic levels for all tasks including the parasympathetic supine positioning task were not supported with the exception of acclimation to baseline one. Alternative hypotheses regarding HR and HRV reactivity and recovery were also not supported by the findings. Finally, there were no significant results found for PEP in either experiment. Although the first and second predictions were not supported with HR and the second hypothesis was not supported with HRV, this study did have other significant results in each of the experiments that should be discussed.

Experiment 1

The primary finding in this experiment was a worry group by task epoch interaction effect on BP. One worry group by epoch interaction effect demonstrates an increased level of SBP for high worriers when compared with low worriers during both the orthostatic task and the supine task. This difference is further supported by the trend toward significance in SBP reactivity to the orthostatic task (which was calculated as a change score between task and baseline).

There was also a worry group by epoch interaction with DBP. The pattern in the DBP findings was much less consistent and hence less reliable than SBP, yet there were still significant findings warranting discussion. The low worry group showed a larger decrease in DBP reactivity to the supine task than the high worriers. High worriers also had less DBP recovery following the supine task. Low worriers showed improved acclimation to the laboratory experience on change scores in DBP compared with the high trait worry group.

Although it was included as an exploratory measure with no specific hypotheses, there was a significant worry group main effect for HI (a myocardial contractility measure). Throughout all epochs, low worriers had lower HI when compared with high worriers in the absence of HR and HRV differences. This increased level of myocardial contractility on its own could relate to increased activity of the heart (independent of HR) in the high worry group. Ideally, indices should be derived from the same functional dimension of the target organ, because chronotropic and inotropic influences on the heart may be subject to differential central nervous system control due to their mediation by separate efferent pathways (Bernston et al., 1991).

Experiment 2

There were two significant findings in the second experiment using the exploratory variables. There was a group main effect with high worriers having increased levels of SV across all epochs when compared with low worriers, which was independent of HR. Low worriers had significantly higher LF relative power change scores to the mental arithmetic task from baseline.

The only HRV significant finding variable in either study was related to acclimation to the laboratory experience. This acclimation to the laboratory change score was calculated by computing change scores between the study's first recording and the first recording following the time period spent filling out questionnaires and getting a full explanation of the study's tasks. During the acclimation period, low worriers increased in rMSSD, while high worriers decreased in the amount of variability.

Study Summary

In both studies, there were no group difference main effects for HR and HRV. Regarding HR, the nonsignificant HR differences conflict with previous work done in the lab and did not replicate the previous work (Knepp & Friedman, 2008). The lack of HR differences in trait worry also conflicts with findings related to GAD (Lyonfields et al., 1995; Thayer et al., 1996). Furthermore, there was no relationship found in either study between trait worry and reduced HRV. This lack of findings contrasts with previous reports of this relationship (Brosschot et al., 2007; Pieper et al., 2007; Thayer et al., 1996) but are consistent with Knepp & Friedman (2008).

The present study raises the possibility that trait worry is related to vascular function and provides evidence for the further investigation of both increased alpha- and beta-adrenergic processes and their relationship with heart health. In the first experiment, there was evidence for worry group differences on BP supporting possible sympathetic and vascular influences rather

than parasympathetic differences. Matthews et al. (2004) found that the larger increases in BP to stress tasks predicted earlier onset of hypertension. Gerin and Pickering (1995) found that parental history of hypertension related to slow BP recovery following a stressor task. Despite lacking the HR and HRV differences, these BP differences to posture changes could still be troublesome for later hypertension and CV disease.

In the second experiment, there was a main effect difference for SV. It has been found that impaired exercise tolerance during emotional disturbances achieved in the early stages by increases in SV results from exaggerated cardiac mobilization in response to symbolic stimuli (Stevenson, Duncan, & Wolff, 1949). Increased stroke volume and cardiac output along with increased left ventricular volume and wall stress are commonly found in individuals with systemic hypertension (Alpert & Hashimi, 1993; Messerli & Aepfelbacher, 1995). These differences in stroke volume could be non-autonomic, just like the HR findings in the Knepp and Friedman (2008) paper. Even though there were no HR or HRV differences, the findings support numerous cardiovascular risk factors for women with high trait worry in a young, non-hypertensive sample.

Initial laboratory exposure was found not to be an adequate stressor in either experiment as low and high worriers did not differ in HR or HRV at the anticipatory baseline. Mixed findings were discovered when examining acclimation to the laboratory experience. In the first investigation, there was no recovery effect to first baseline; however, in the second experiment there was a significant rMSSD recovery difference between worry groups. Both low and high trait worriers came into the second experiment with decreased rMSSD (perhaps due to worrying about the experiment) yet after a span of approximately 15 minutes, the low worriers recovered

with increased vagal control of the heart while the high worriers decreased in rMSSD during that period.

Why Blood Pressure and Not Heart Rate?

The looming question for this study was the change from Knepp and Friedman in the significant CV measure. Why were significant BP findings present in this study but HR differences absent? To discuss why the BP findings were significant, one must consider the components of SBP and DBP. SBP represents the force while the heart contracts and pumps blood to the body, whereas DBP represents the force while the heart relaxes between beats. Autonomic nervous system regulation of BP appears to be primarily through sympathetic alpha-adrenergic means, because BP equals cardiac output multiplied by peripheral resistance (Jones et al., 2001). There may even be some residual sympathetic influence on BP even in cases of autonomic failure (Shannon et al., 2000). SBP tends to vary with SV (beta-adrenergic influence), total peripheral resistance (alpha-adrenergic influence), and HR (beta-adrenergic and vagal influence) activity. DBP varies in a similar fashion as SBP, but to a greater degree with HR and total peripheral resistance and to a lesser extent with SV (Fox, 2008).

A potential reason behind the BP finding is the specific task set. These significant BP differences were found primarily in body positioning tasks. In the larger task design, these BP differences may have been lost; however, in a smaller task set focused on body positioning, the findings become clearer. It is interesting to note that this study separated individuals based on a cognitive difference but found differences on the mechanical task. One theory is that these differences exist due to individual differences in peripheral responses to stress. Previous research does support BP findings to body positioning tasks. These high worriers might differ from low worriers regarding alpha- or even beta-adrenergic sensitivity, which would result in a difference

in CV response. This would relate to previous work in the field finding these sensitivity differences result in differential CV response patterns despite similar central nervous system individual activation (Mills et al., 1994; Mills et al., 1990). Finally, these BP differences may be the result of altered vascular reactivity and recovery at the level of the peripheral organs (Lovallo, 2005).

Although the BP differences are supported in the research, the question of why they were found in this present work needed to be addressed. Not considered limitations in the Knepp and Friedman (2008) study, two subtle changes were made to the BP recording that may have impacted the new findings. The first change is that the recording of BP was much more standardized temporally due to increased familiarity with the equipment and recording on the experimenter's part. Since BP was recorded at only one point during the task, the time of that recording was important. In Knepp and Friedman (2008), that recording started immediately as the subject stood or was laying supine, while in this study, the experimenter waited a period of 5 seconds before starting the recording. A benefit of this method was that there was some stability in the measure rather than the large variability during the actual process of standing up and lying down.

A second change that may have improved the design was the use of a different BP cuff. In the original study, an adult cuff was used, which at first seemed to be the correct choice yet, the adult cuff appeared to be better suited for a male subject than a female one. The BP cuff during Knepp and Friedman (2008) may have lacked sensitivity due to using a cuff that did not properly work due to arm circumference size, whereas this study's increased sensitivity in recording allowed for the possibility of seeing significant group differences. The cuff was

placed with closer accuracy in this study on the brachial artery and all blood pressure recordings were standardized to be done at heart level.

While the BP differences are easily explained, it is concerning why HR differences were not found in this replication attempt. One issue that might relate to the nonsignificant HR findings is that in a college sample, the worry-HR/HRV relationship might be much more sample dependent than in older samples. In the Knepp and Friedman (2008) study, the HR differences were robust; however, the differences were only significant after controlling for BMI. Without the BMI group control, the HR differences were nonsignificant (possibly because more overweight and obese individuals in the study were low worry). While the psychological factor of worry did differentiate HR, BMI group was a much stronger indicator.

When discussing the sample-dependency of these findings, it is important to note how the groups were formed compared with other studies as this study was done on a trait condition rather than in a clinical sample. The PSWQ was the only measure used for trait worry/anxiety. For determining the groups, it was done as an online questionnaire. In a college-aged sample, this leaves the measure open to much variability from one sample to the next. During the advertisement of this study, the term “worry” was mentioned much more openly than during the advertisement of Knepp and Friedman (2008).

It might have been that when taking the PSWQ, subjects were more likely to put average answer scores during the present study (due to seeing it was a worry study) than to pay attention and answer each question properly. An example of this would be an individual who feels that she is high worry would answer mostly 4s and 5s and not pay close attention to the individual questions. This sampling issue arose because a high percentage of the online sample failed basic validity questions. Also, 10% of subjects whose worry scores changed significantly from online

to in-lab and were not included in the final analysis. Previous research found that college students' scores from time point one to two changed significantly on 16 of the 25 subscales of the MMPI-2 including the one for anxiety (Matz, Altepeter, & Perlman, 1992). While they argued that these might not be clinically significant changes, for the purpose of this study, a statistically significant change would move a subject out of their assigned worry group.

By using trait conditions rather than clinical diagnoses, there would be an expected decrease in potential effect size. Furthermore, college students could be a less reliable population to use and could be affected in much greater ways by small details such as how the study is advertised, when the study takes place, and the likelihood of reliability in their PSWQ scores. These notes make it more likely that while HR differences exist between high and low trait worriers, the findings may vary based on the sampling.

Order effects are not expected to be the result of some of the null findings in Knepp and Friedman (2008). In this study, the most pronounced group differences were again in the body positioning tasks indicating that it was the tasks themselves and not their use at the beginning of the study that resulted in the largest group differences in Knepp and Friedman (2008). Lastly, statistical power was increased in this study due to the increased sample size. Although the increase in power was calculated correctly based on effect sizes from the previous work, this study still may not have had the necessary statistical power to properly examine the HRV variables.

Limitations

A first limitation of this study was the examination of only extreme groups. While the use of extreme groups in trait worry is beneficial for examining those with near-clinical level worry, this study lost the ability to fully examine the CV-worry relationship. By examining only

extreme groups, the experiments made the assumption of a linear relationship between the measures eliminating the possibility for investigating a nonlinear relationship between worry and the CV measures. Future investigations should examine individuals that fall in the middle and less studied range of worry using a regression approach to determine whether the relationship between worry and the CV system is truly linear.

The inclusion of methods for measuring respiration would have afforded a better perspective of the contribution of the parasympathetic nervous system to the HF component (Ritz, 2009). However, based on the small mean differences between groups, it did not appear that controlling respiration would have magnified these differences to significance.

The way in which recovery was handled (as a posttask minus baseline change score) in this study was limited; it may be prudent in future research to use time course-based methods to reveal differences in CV recovery between high and low trait worriers (Linden et al., 1997). An example of a time course method would be studying the amount of time that it takes the subject to return to baseline levels following a task. It was not feasible in this study to do this as that would lead to wider variation in study length from person to person. Subjects were only requested for a one hour time period, so awaiting a long recovery period if necessary for a given subject was not possible. The inclusion of these extra measures though could make it possible to find new relationships between worry and the CV system that were not revealed in this study.

The final limitation for this study was the use of a female-only sample. While the need to further examine women is important, the findings of this study might not generalize to men. Gender differences in HRV have been reported previously (Thayer et al., 1998). The relationship between CV disease and anxiety is more inconsistent in female subjects than in male subjects (Eaker, Pinsky, & Castelli, 1992; Matthews, Owens, Kuller, Sutton-Tyrrell, & Jansen-

McWilliams, 1998). It is unknown whether this sample of healthy, college students can generalize to an older population of women as HRV does decrease in older populations.

Benefits

While the primary hypotheses were not supported in both studies, it was important to note the numerous findings relating high trait worry with negative CV risk factors. While these findings may not generalize to older ages, it is of note that CV differences appear in this sample of healthy, college-aged women without any self-report of CV health issues. Orthostatic and supine body positioning are basic tests of autonomic function, reflecting a reflexive control of BP (baroreflex). This study suggests that at some level, psychological traits relate to reflexive ANS control.

In the first experiment, the BP tonic level and reactivity differences provided insight into a risk factor for later hypertension. While there can be a debate between laboratory and real-world stress, tasks such as orthostatic and supine have plenty of real-world application as a college-aged sample consistently experiences posture changes moving from class to class on any given day. An interesting note about the findings in both studies about mechanical tasks is that it appears they are less impacted by state worry than the other task epochs. In college-aged samples that have not been impacted by chronic worry as long (compared with middle-aged/elder adults), mechanical tasks might be preferred to examine the worry/anxiety relationship with the cardiovascular system. The results may be less confounded by state condition in these cases.

There was evidence in the second experiment of the importance of acclimation to the laboratory since allowing the subject to become sufficiently comfortable in the setting might have changed her reactions to the tasks as well as how she reacted during a baseline period. Low

and high worriers may have treated the first few baselines differently (i.e., the baseline converts to worry about being in the lab in high worriers).

Conclusions and Summary

This study as a whole did replicate the nonsignificant HRV findings of Knepp and Friedman (2008) but did not replicate the robust HR differences between low and high worriers. The most pronounced finding of the first experiment was the BP group differences during the body positioning tasks. This finding was supported further by the reactivity to and recovery from these tasks. A further risk factor relating group differences in myocardial contractility was noted in the first experiment. The second experiment presented the finding of SV average differences between high and low worriers across the epochs. By looking across studies, the findings are mixed when discussing the importance of acclimation to the laboratory experience. While one study denotes no differences, the second study indicates greater recovery to first baseline in rMSSD in the low worry group.

By including electroencephalogram in later research, the central control of orthostasis could be examined further in the anxiety/worry-CV system field. The degree to which the right frontal lobe controls the orthostatic response in high and low worriers could be examined in more lateralized males and less lateralized females. A recommendation for an experiment type in this field would be the concurrent stressor method. Through an orthostatic position-guided relaxation task paradigm, it would be possible to examine voluntary and non-volitional control of the heart through the frontal lobes (as evidenced in high and low worriers).

Future work in the worry-CV system field might focus on these relationships in a more applied setting using the AMS as done by Brosschot and colleagues (2007). The interaction between trait and state worry on CV risk factors also warrants a deeper investigation. Future

investigations could expand upon any moderators or mediators in the trait worry-CV system relationship to explore what other factors might lead to poor CV health in high trait worry women.

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APPENDIX A

FIGURES

Figure A-1. Comparison of HR between high and low worriers across epochs (from Knepp & Friedman (2008))

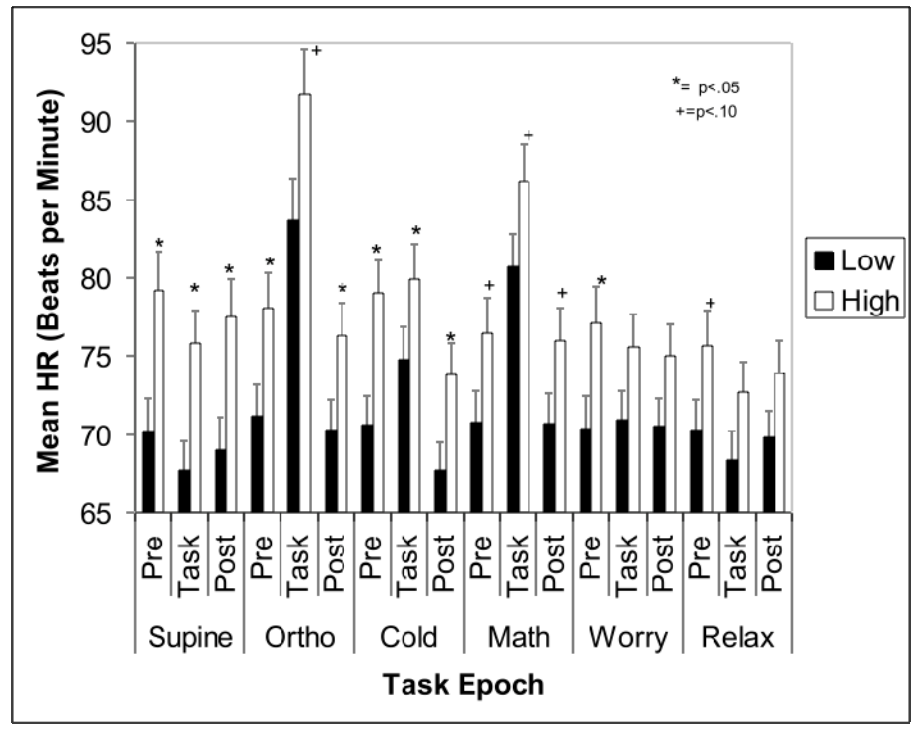


Figure A-2. Comparison of SBP between high and low worriers across epochs

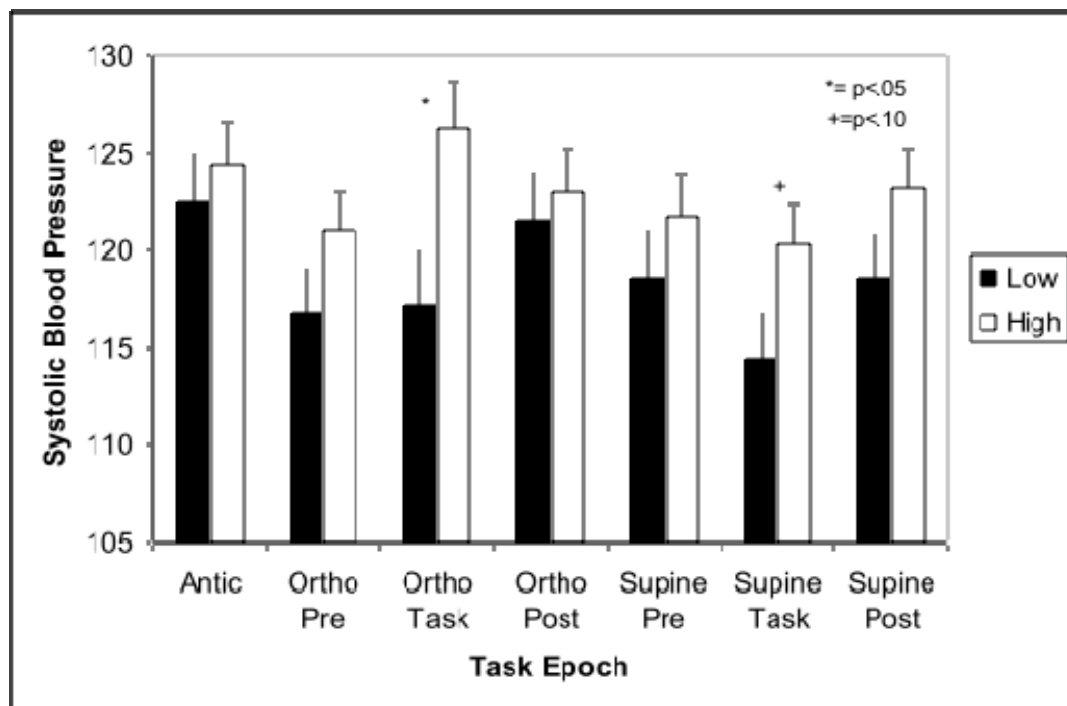


Figure A-3. Comparison of DBP between high and low worriers across epochs

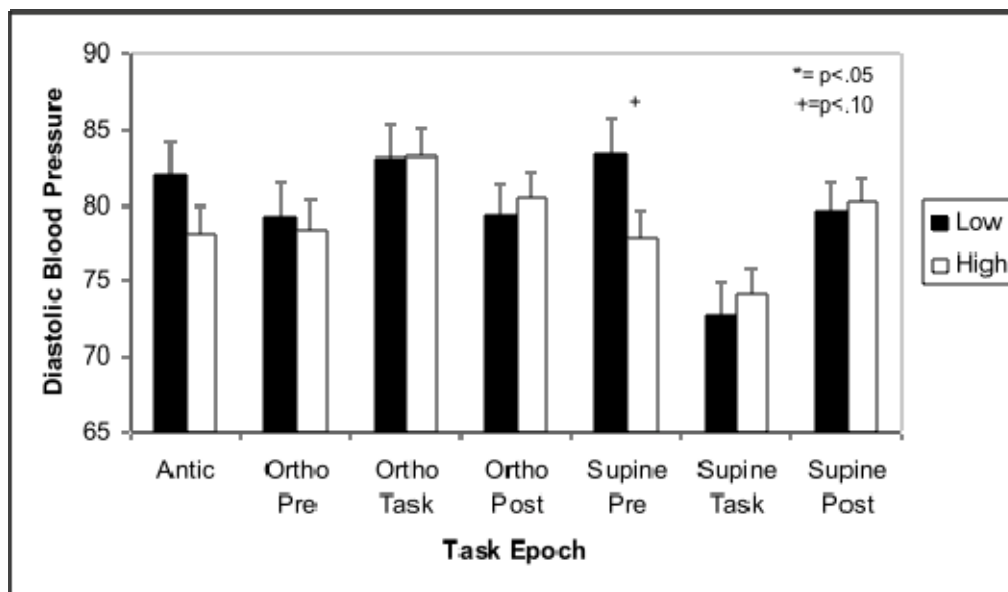


Figure A-4. Comparison of HI between high and low worriers across epochs

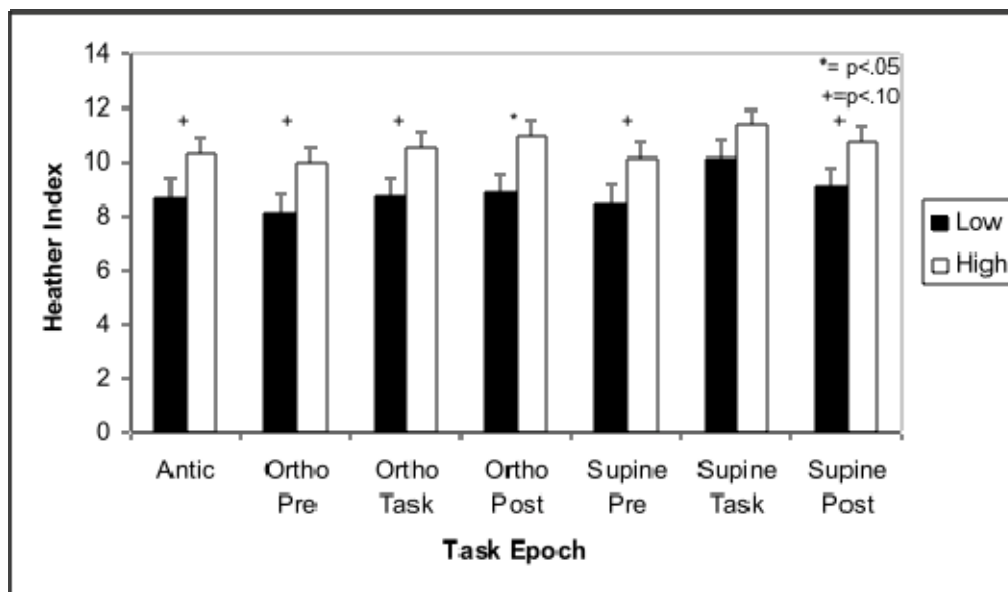
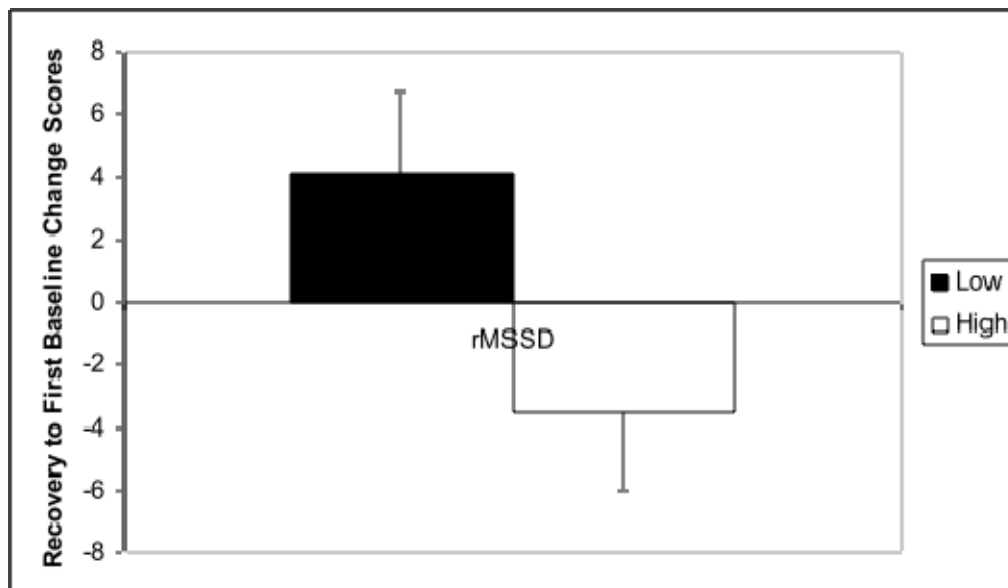


Figure A-5. Comparison of rMSSD between high and low worriers during the first baseline before and after acclimation to the lab



APPENDIX B

INFORMED CONSENT FORM (Online and Laboratory Portions)

Study Title: Cardiovascular Activity of Differences in College-aged, High and Low Worrying Women

Investigators: Bruce H. Friedman, Ph.D., Michael M. Knepp, M.S.

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, anxiety and my own physical and mental health. After completing these questionnaires, I may later be eligible for participation in a second laboratory portion of this study. Women with high 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 for physiological data recording. Before the tasks begin, 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 two 3-minute tasks: either standing upright and laying down or placing my hand in cold water and counting backwards. 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 three questionnaires to complete regarding worry, anxiety and the tasks completed. At the end of the laboratory portion, I will be allowed to remove 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 20 minutes. The laboratory portion, will likely last slightly under 1 hour. 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. 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 email 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

Undergraduates in psychology courses will receive extra credit towards the class of their choosing. 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 one extra credit point in addition to the one previously earned. Additionally, for each of the 2 laboratory studies, there will be a separate raffle for a 25 dollar Amazon.com gift card. Participation in the online phase is worth 1 entry. Participation in the laboratory phase if eligible is worth an additional 3 entries.

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 20 minutes.

During the laboratory portion, I am expected to make my best attempt at the two 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 slightly under 1 hour.

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 _____

Experimenter _____ Date _____

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

Dr. Bruce H. Friedman
Principal Investigator

phone: 231-9611
bhfriedm@vt.edu

Michael M. Knepp, M.S.
Co-Investigator

phone: 717-645-4393
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Dr. David Moore
Chair, IRB
CVM Phase II

phone: 231-4991

Dr. David W. Harrison
Chair, Psychology Human
Subjects Committee

phone: 231-4422

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
typical | | Somewhat
typical | | Very
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)?

APPENDIX E**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. 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 (beginning, middle or end)?

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

5. When was the last time you ate?

APPENDIX F

GLEQ

INSTRUCTIONS

In this excerpt from the Godin Leisure-Time Exercise Questionnaire, the individual is asked to complete a self-explanatory, brief four-item query of usual leisure-time exercise habits.

CALCULATIONS

For the first question, weekly frequencies of strenuous, moderate, and light activities are multiplied by nine, five, and three, respectively. Total weekly leisure activity is calculated in arbitrary units by summing the products of the separate components, as shown in the following formula:

$$\text{Weekly leisure activity score} = (9 \cdot \text{Strenuous}) + (5 \cdot \text{Moderate}) + (3 \cdot \text{Light})$$

The second question is used to calculate the frequency of weekly leisure-time activities pursued “long enough to work up a sweat“ (see questionnaire).

EXAMPLE

Strenuous = 3 times/wk

Moderate = 6 times/wk

Light = 14 times/wk

$$\text{Total leisure activity score} = (9 \cdot 3) + (5 \cdot 6) + (3 \cdot 14) = 27 + 30 + 42 = 99$$

Godin Leisure-Time Exercise Questionnaire

1. During a typical **7-Day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your free time (write on each line the appropriate number).

Times Per
Week

a) STRENUOUS EXERCISE

(HEART BEATS RAPIDLY)

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

b) MODERATE EXERCISE

(NOT EXHAUSTING)

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

c) MILD EXERCISE

(MINIMAL EFFORT)

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

2. During a typical **7-Day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heart beats rapidly)?

OFTEN

SOMETIMES

NEVER/RARELY

1.

2.

3.

APPENDIX G

Depression, Anxiety, Stress Scale

DASS

Name:

Date:

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

1I found myself getting upset by quite trivial things	0	1	2	3
2I was aware of dryness of my mouth	0	1	2	3
3I couldn't seem to experience any positive feeling at all	0	1	2	3
4I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5I just couldn't seem to get going	0	1	2	3
6I tended to over-react to situations	0	1	2	3
7I had a feeling of shakiness (eg, legs going to give way)	0	1	2	3
8I found it difficult to relax	0	1	2	3
9I found myself in situations that made me so anxious I was most relieved when they ended	0	1	2	3
10I felt that I had nothing to look forward to	0	1	2	3
11I found myself getting upset rather easily	0	1	2	3
12I felt that I was using a lot of nervous energy	0	1	2	3
13I felt sad and depressed	0	1	2	3
14I found myself getting impatient when I was delayed in any way (eg, elevators, traffic lights, being kept waiting)	0	1	2	3
15I had a feeling of faintness	0	1	2	3
16I felt that I had lost interest in just about everything	0	1	2	3
17I felt I wasn't worth much as a person	0	1	2	3

18I felt that I was rather touchy	0	1	2	3
19I perspired noticeably (eg, hands sweaty) in the absence of high temperatures or physical exertion	0	1	2	3
20I felt scared without any good reason	0	1	2	3
21I felt that life wasn't worthwhile	0	1	2	3

Reminder of rating scale:

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

22 I found it hard to wind down	0	1	2	3
23I had difficulty in swallowing	0	1	2	3
24I couldn't seem to get any enjoyment out of the things I did	0	1	2	3
25I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
26I felt down-hearted and blue	0	1	2	3
27I found that I was very irritable	0	1	2	3
28I felt I was close to panic	0	1	2	3
29I found it hard to calm down after something upset me	0	1	2	3
30I feared that I would be "thrown" by some trivial but unfamiliar task	0	1	2	3
31I was unable to become enthusiastic about anything	0	1	2	3
32I found it difficult to tolerate interruptions to what I was doing	0	1	2	3
33I was in a state of nervous tension	0	1	2	3
34I felt I was pretty worthless	0	1	2	3
35I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
36I felt terrified	0	1	2	3
37I could see nothing in the future to be hopeful about	0	1	2	3
38I felt that life was meaningless	0	1	2	3
39I found myself getting agitated	0	1	2	3

40I was worried about situations in which I might panic and make myself a fool of	0	1	2	3
41I experienced trembling (eg, in the hands)	0	1	2	3
42I found it difficult to work up the initiative to do things	0	1	2	3