EFFECTS OF SEX AND DISPOSITION ON CARDIOVASCULAR REACTIVITY AND RECOVERY

THESIS

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ABSTRACT

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This study investigated the effects of sex and optimism on cardiovascular reactivity and recovery from a psychological stressor (timed serial subtraction). Participants consisted of 35 males and 46 females with an average age of 20.4 years. A total of 26 cardiovascular measurements were taken over a 26 minute period consisting of 10 minutes baseline, 6 minutes reactivity, and 10 minutes recovery. It was hypothesized that there would be a main effect for optimism on systolic and diastolic blood pressure and a sex by disposition interaction for heart rate. Results found that optimism had no significant main effect on any cardiovascular measures (systolic, diastolic, or heart rate).

INTRODUCTION

Chronic high blood pressure (hypertension) mortality rates have been steadily rising for decades. Currently 29% of Americans suffer from hypertension (National Center for Health Statistics, 2006) and according to Cherry, Woodwell, & Rechtsteiner (2007), the mortality rate is 7.9 per 100,000 deaths, with incidence of the disease and mortality rates surely to increase in the coming decades. These figures are in large part due to the current way of life of a majority of Americans; that is, poor diet and a sedentary lifestyle. Hypertension has been linked to increased occurrences of stroke (Johansson, 2002), kidney failure (Bidani & Griffen, 2002) and increased demands on the heart, which may ultimately lead to heart attack or heart failure (Sowers et al., 2001).

Factors that might contribute to these current trends are impaired cardiovascular (CV) reactivity and recovery. CV reactivity is defined as changes in baseline CV functioning as a result of some stressor. Heightened CV reactivity has been linked to increases in basal CV blood pressure (BP) measurements both 5 years and 10 years from initial measurements (Carroll et al., 2001). Increased heart rate (HR) reactivity is further known to predict increases in future occurrences of heart disease (Treiber et al., 2003).

Cardiovascular recovery, defined as return to baseline levels of cardiovascular parameters once exposure to a stressor ceases, has gained increasing attention with its purported link to future basal blood pressure (BP) levels (Singh et al., 1999; Stewart, 2001; Steptoe & Marmot, 2005). The recovery process is an index of the ability of the body to effectively shut off the stress response from peak reactivity back to baseline or near baseline levels. Intengan & Schiffren (2001) hypothesize that slower CV recovery from stressors can lead towards future elevated baseline high blood pressure; possibly due to heightened blood pressure stimulating a proinflammatory response that produces a thickening of the arterial wall, thus leading to increased BP. Research has shown that increases in future baseline blood pressure can be accurately predicted from impaired recovery times. For example, normotensive participants with prolonged CV recovery from physical tasks, such as treadmill running (Singh et al., 1999; Steptoe & Marmot, 2005) and aerobic exercise (Tanji et al., 1989) were found to exhibit significantly higher increases in baseline BP years later compared with those who experienced a normal recovery period.

This phenomenon is experienced during psychological stressors as well. Stewart & France (2000) found that young persons between 18-20 years of age who experienced longer CV recovery times from mental stressors were found to have significantly increased baseline BP measurements 3 years after initial measurements. Borghi et al. (1986) revealed similar findings during a 5 year longitudinal study while Carroll et al. (2001) found similar results with a 10 year longitudinal study. The Stewart & France (2000) study highlighted CV recovery data as an effective predictor of future elevated baseline BP measurements, even in young healthy participants. While this is speculative, these findings do give credence to the potential of discovering future high blood pressure in young adults, years before onset. This early detection in turn might possibly allow for preventative action to be taken to eliminate or reduce future occurrences of high blood pressure and diseases related to it. The recovery process is linked to how reactive the cardiovascular system is to stress. Merritt et al. (2004) noted that heightened reactivity during a stressor is linked to a prolonged recovery period; that is, recovery is delayed. During the reactive phase of stress, the sympathetic nervous system is activated, causing an increase in the amount of both hormones cortisol and epinephrine. These, in turn, trigger the release of additional hormones which cause BP and HR to significantly increase in order to meet the perceived demands of the stressor. Once the stressor, or the perception of the event, has ceased, the CV system enters the recovery period.

How reactive the CV system becomes and the rate of physiological recovery from a stressor may be mediated by the presence and amount of certain thoughts or emotions that may persist both during and following cessation of the stressor. These thoughts and emotions may serve to impair CV reactivity and recovery (Schwartz et al., 2003). For example, repeated cognitive representation of the stressor, or rumination on negative aspects of the stressor, may negatively impact the reactive phase and recovery process (Nolen-Hoeksema, Morrow, & Fredrickson, 1993; Glynn, Christenfeld, & Gerin, 2002). Rumination of both performance and reaction to a stressor allows for the event to be replayed, and to a degree relived not only mentally but physiologically. This reliving of the event inhibits recovery from the stressor due to the fact that the body is still in the process of reacting to it.

One's disposition, having either an optimistic or pessimistic outlook, may influence what types of thoughts and emotions are present post-stressor. While recovery will ultimately occur, increased stress perception and rumination on negative thoughts, hallmarks of pessimism, may inhibit the body from effectively switching from reactivity to recovery. This effectively keeps the CV system on a prolonged stress response which increases cortisol exposure. Increased cortisol exposure in turn has many ill health effects. These ill health effects include decreased memory ability (Newcomer et al., 1999) and reduced immune system function (Cohen, Janicki-Deverts, & Miller, 2007) among other effects.

Optimistic Disposition

Dispositional optimism is defined as a "global generalized tendency to believe that one will generally experience good vs. bad outcomes in life" (Scheier & Carver, 1992, p. 203). This perception of positive outcome obtainment affects both proximal and distal expectancies in one's life; whether it is an expected grade on an upcoming test or the expectation that life as a whole will be favorable to the person. Optimists tend to believe that adversity can be drastically minimized, if not conquered completely. This disposition, in turn, affects how a person subjectively views and experiences the world. Aside from having generally positive expectancies in life, optimists experience many other benefits such as decreased hospitalization (Scheier et al., 1999) and decreased risk of CV disease (Kubzansky et al., 2001). There appear to be no significant differences in levels of optimism between sexes (Boman, Smith, & Curtis, 2003; Lai & Cheng, 2004; Huan et al., 2006). The subjective perception of stress can also be influenced by the degree to which someone has an optimistic disposition since optimists are thought to approach stressful situations in a more productive way. Ben-Zur (2003) found that people high in dispositional optimism perceived significantly less stress than did those who were high in dispositional pessimism. Due to this outlook, optimists are better able to cope with stressors and thus adjust better when confronted with stress. Once the stressor ceases, optimists are able to respond to the psychological aspects of the stress with beneficial coping strategies, thus allowing the body to switch from a reactive mode to a recovery mode. Optimists use these positive coping strategies to reduce the perception of severity of the stress. This reduction in perceived severity may ultimately decrease the need for increased blood pressure. In essence, an optimistic disposition allows for the reactive phase to be switched off more quickly. This, in turn, automatically activates the recovery phase due to reduced demands for higher blood pressure or heart rate.

Optimists utilize more beneficial coping strategies when faced with stressful situations or setbacks and are better able to cope with these potential hardships (Scheier & Carver, 1992). In one meta-analytic review, dispositional optimism was found by Nes & Segerstrom (2006) to be positively associated with "approach strategies aiming to eliminate, reduce, or manage stressors" (p. 248). Dispositional optimism was also found to be negatively correlated with avoidance coping strategies, such as ignoring, avoiding, or withdrawing from stressors or emotions (Nes & Segerstrom, 2006). It appears that optimists seek to reduce the stressor by actively dealing with it instead of failing to reduce or confront it. Nes and Segerstrom (2006) found that optimists place emphasis on the positive aspects of a stressful situation (active coping) and are less focused on the negative aspects of their experience, including both psychological (subjective) and physical (objective) manifestations of the stress response. That is, when confronted with a stressor, optimists are more likely to view it as a challenge instead of a setback and expect to have positive outcomes, regardless of how difficult the situation is. Evidence supporting the link between focusing on positive emotions and recovery was found by

Fredrickson and Levenson (1998) who reported that the presence of positive emotions sped up cardiovascular recovery rates from a stressor. This ability to view the stressor in a more positive light enables a person to endure, despite the presence of stress.

Optimists are known to experience lower levels of negative affect (NA) (Andersson, 1996; Bood, Archer, & Norlander, 2004) and perceive stress as less stressful (Huan, Yeo, & Ang, 2006). Pessimists experience not only decreased positive affect (PA), but also increased NA (Marshall et al., 1992; Chang et al., 1997). NA is highly correlated with stress perception (Fujita, Diener, & Sandvik, 1991). In other words, people high in negative affect are more likely to report more stress than those with lower NA (Watson & Clark, 1984). The way in which a stressor is perceived affects not only how a person deals with the stressor psychologically, but also how the person reacts physically. The higher the perceived level of stress, the more likely the CV system will be activated at a higher level, leading to increased CV output to meet perceived demands. For lower amounts of perceived stress, the CV system responds with a more muted response, leading to lower activation of the CV system. Thus, optimists experience not only lower levels of NA, but also lower levels of perceived stress, possibly allowing for decreased CV demands (Kennedy & Hughes, 2004). These two factors ultimately may lead to lower levels of CV reactivity, possibly allowing the CV system to enter the recovery mode more quickly.

Differences between optimists and pessimists with regard to daily CV functioning have been revealed. Raikkonen et al. (1999) monitored ambulatory blood pressure over a normal three day period of participants' lives and found that optimists had significantly lower levels of daily SBP and DBP. While this does not measure strict reactivity, it does reveal potential CV differences between dispositions. Further, it may offer a glimpse into the way disposition guides perception. Because optimists experience lower levels of NA and perceived stress, it would be expected that they should have lower activations of the CV system in response to stress.

Cardiovascular reactivity measurements in a controlled setting have revealed differences between optimists and pessimists as well. Williams, Riels, & Roper (1990) found optimists had significantly lower elevations of DBP than pessimists when exposed to a mental arithmetic (MA) task. Kennedy & Hughes (2004) similarly found optimists to have muted elevations of DBP compared to pessimists in a serial subtraction task. These lower levels of stress lead to less activation of the cardiovascular system, which allows for faster levels of recovery.

Research into reactivity and optimism so far is limited due to the relative infancy of the field of positive psychology, which "studies the strengths and virtues that enable individuals and communities to thrive" (Compton, 2005, p. 1) with optimism being one of the many variables studied in positive psychology. To the author's knowledge, the Williams, Riels, & Roper (1990) and Kennedy & Hughes (2004) studies are the only ones that were published dealing with optimism and reactivity. However neither study measured the effects of disposition and sex on BP reactivity or on HR reactivity, whose effect remains unknown.

In summary, optimists are known to utilize positive coping strategies to manage stress. During stressful situations, these coping strategies allow optimists to experience a lesser degree of perceived stress than a more pessimistic person might experience. Further, those with an optimistic disposition experience lower amounts of NA. These two factors allow for lower activations of the CV system for both ambulatory BP as well as in experimental settings. Since optimists have lower activations of CV parameters, this allows for an optimist's CV system to enter the recovery phase more quickly than a pessimist's might. With optimistic dispositions utilizing positive coping strategies compared to pessimists utilizing negative coping strategies, it is hypothesized that there will be a main effect for disposition on baseline to reactivity (the reactive phase) and on reactivity to recovery (the recovery phase), with optimists experiencing less reactivity and quicker recovery, which will allow optimists' CV measurements to return to baseline quicker than pessimists. The link between optimism and the reactivity/recovery process may help explain why optimists are known to experience lower incidence of CV disease (Giltay et al., 2007).

Gender and Stress Perception

Compared to men, women have been found to report more negative affect (Costa et al., 1987; Fujita et al., 1991; Thomsen et al., 2005). A possible explanation is that, in many cultures, it may be more acceptable for women to act more expressively, and thus, they allow themselves to report more stress at a greater degree (Weiser, Endler, & Parker, 1991). Misra, et al. (2000) reported that females self-report they are more likely to focus on negative aspects of stress and have higher levels of self-imposed stress, such as that resulting from rumination (Costa et al., 1987). Nolen-Hoeskama, Larson, & Grayson (1999) posit that ruminating may be an attempt at trying to exert some control over the environment when distressed, allowing for some alleviation of NA. However, ruminating has been shown to increase reactivity and delay recovery (Glynn, Christenfeld, & Gerin, 2002).

Differences between genders on NA may interact with disposition on experience of stressfulness. It is hypothesized that there will be a sex by disposition interaction on NA, with pessimistic females experiencing greater NA at all times compared to optimistic females. Increased NA has been linked to increased CV reactivity and prolonged recovery (Brosschot & Thayer, 2003).

While both genders should exhibit similar performance on a serial subtraction stressor (according to the gender similarities hypothesis (Hyde, 2005), females may report higher NA. However, this may be because males might be more hesitant to report NA. Pessimists are also known to experience greater NA. It is hypothesized that there will be a disposition by sex interaction on NA, with pessimistic females experiencing higher levels of NA at all times compared to optimistic females, pessimistic males, and pessimistic females.

Sex and Reactivity

At baseline, men are known to have higher resting SBP and DBP measurements than do females (Stoney et al., 1987; Sarlo et al., 2005) and females are known to have higher resting HR (Sharpley, 1994; Schmaus et al., 2008). One reason for men tending to have higher BP and women tending to have higher resting HR might be body size. There is a small positive correlation between body size and BP (Kleiber, 1947) and a negative correlation between body size and resting heart rate (Kleiber, 1947). Thus males, who are on average larger than females, have higher BP at baseline. Females, who are on average smaller than males, require a higher resting heart rate. Taking the position of the gender similarities theory, which states on mathematical ability males and females should perform equally well and experience similar amounts of stress (Hyde, 2005), both sex should experience similar amounts of stress on the task. However, according to Allen et al. (1993) and McAdoo et al. (1990), females are more likely to exhibit larger increases in cardiac output and heart rate than males during a stressor. While BP responses should be similar, HR should differ with females experiencing greater increases in HR during the stressor. Since recovery is linked to reactivity, females should experience elevated HR in the reactivity to recovery period as well. Based on McAdoo et al. (1990) and Ben-Zur (2003), it is hypothesized that there will be a significant sex by disposition interaction on HR baseline to reactivity and reactivity to recovery. It is hypothesized that optimistic females will experience similar HR reactivity/recovery compared to optimistic/pessimistic males and less HR reactivity and less HR recovery compared to pessimistic females.

Overview of the Current Study and Hypotheses

This study attempted to determine if there are any main effects or interactions between disposition and sex when predicting CV reactivity and recovery from a mental arithmetic stressor. Based on previous laboratory and natural setting observations/experiments, it is expected that SBP, DBP, and HR will significantly increase from baseline to reactivity, and decline over the reactivity to recovery period and be similar from recovery to baseline for all participants. Optimists are expected to have lower increases in SBP and DBP than pessimists in the baseline to reactivity phase. Females are expected to have higher levels of HR baseline to reactivity than males. Scores of NA are expected to increase from baseline to reactivity for all participants due to the experience of the stressor. However, optimists are expected to experience decreased amounts of NA.

Hypotheses for the current study are there will be a main effect for disposition on SBP and DBP baseline to reactivity and reactivity to recovery with optimists hypothesized to experience less reactivity and greater recovery than pessimists (hypothesis 1). It is hypothesized that there will be a sex by disposition interaction on NA, with pessimistic females experiencing greater NA at all times compared to optimistic females, optimistic males, and pessimistic males (hypothesis 2). Lastly, it is hypothesized that there will be a sex by disposition interaction on HR baseline to reactivity and reactivity to recovery with optimistic females hypothesized to experience similar HR reactivity compared to optimistic/pessimistic males and less HR reactivity and less HR recovery compared to pessimistic females (hypothesis 3).

This study sought to find a relationship between optimism and sex on reactivity and recovery, since currently there is no known relationship.

METHODS

Participants

Initial participants consisted of 81 undergraduate students from Texas State University-San Marcos. Sex break down was: n = 35 male (M age = 20.17, M BMI = 26.09) and n = 46 female (M age = 20.58, M BMI = 23.59). Breakdown of ethnicity of the sample was 52 Caucasian, 19 Hispanic, 6 African American, 2 Native American, and 2 Asian. Prospective participants were recruited through class announcements. Interested individuals were informed about the study, its procedures, the variables that were to be measured, and that participation was voluntary and could be terminated at any time without penalty. To be eligible for participation, participants were required to be at least 18 years old at time of assessment, not have consumed caffeinated products, smoked, or exercised for 3 hours prior, or taken cold medicines during the day of experiment, for these factors can affect blood pressure measurements. No consideration of prescription medication or drug use was taken. Procedures were approved by the IRB at Texas State University.

The middle 20% scores of Life Orientation Test- Revised of the sample were excluded from analysis to create two groups; optimists and pessimists. The final sample consisted of 31 male (M age = 20.3, M BMI = 25.35) and 42 female (M age = 20.5, M BMI = 23.26) participants. Breakdown of ethnicity with the middle 20% of the sample removed was; 48 Caucasian, 17 Hispanic, 5 African American, 2 Native American, and 2 Asian.

Measures

Blood Pressure and Heart Rate. Blood pressure measurements were taken via left arm cuff placement by a BP monitor (Dinamap Pro 100V2 manufactured by GE). BP measurements consisted of systolic and diastolic blood pressure and heart rate. There were a total of 26 measurements (10 baseline, 6 stress task, 10 recovery) for each component of BP (SBP and DBP) and HR (i.e. time 1 SBP, DBP, HR, time 2 SBP, DBP, HR) covering baseline, stressor task, and recovery periods. Measurements were taken every one minute. The final baseline BP measurement was the average of all baseline measurements. Final reactivity BP and HR measurement were the average of all reactivity measurements and final recovery BP and HR was the average of all recovery measurements.

Optimism/Pessimism. Participants were administered the Life Orientation Test-Revised developed by Scheier, Carver, & Bridges (1994). The LOT-R is a continuous measure of the degree someone is said to be a dispositional optimist or pessimist on a continuous scale. The scale however can be broken down into a bi-dimensional tool, allowing for separation of those who are said to be optimistic and those said to be pessimistic (Vautier, Raufaste, & Cariou, 2003). The LOT-R consists of 10 Likert-type scale statements, ranging from 0 points for “I strongly disagree” to 5 points for “I strongly agree”. The test consists of 6 core items which are evenly divided between negatively- and positively-worded items. Total scores range from 0 to 24 with higher totals suggestive of greater optimism (e.g., "In uncertain times, I usually expect the best;"

"I'm always optimistic about my future"). The remaining 4 questions are meant to function as distracters. Negatively worded items were reversed scored to obtain a final score. Previous research has reported that the tool has a Cronbach's alpha of .78 and a test-retest reliability of r = .79 over a 28 month period (Scheier, Carver, & Bridges, 1994) indicting it is a stable measure of disposition. In the current study, alpha was .70. The middle 20% of the sample was removed from the study in order to create the two groups; optimists and pessimists. For this study optimists were considered those who scored 17-24, while pessimists were those with scored 0-15. The final break down of sex and disposition was: Optimistic Females = 24, pessimistic females = 13, optimistic males = 12, pessimistic males = 19.

Affect. The Positive Affect Negative Affect Scale (PANAS) developed by Watson, Clark, and Tellegen (1988) is a Likert-type scale measuring degree to which someone is experiencing negative and positive affect. The tool includes 20 adjective words, 10 describing negative mood states and 10 describing positive mood states. The response set ranges from 1 "very slightly or not at all" to 5 "extremely". The internal consistency alphas range from .86 to .90 for positive affect and from .84 to .87 for negative affect (Watson, Clark, & Tellegen, 1988). The positive affect score was the average of participants' scores from positive affective words. Cronbach's alpha for PA at baseline was .84, at reactivity .90, and at recovery .92. The negative affect score was determined by averaging participants' scores from negative words. Cronbach's alpha for NA at baseline was .86, at reactivity .89, and at recovery .89.

Stress Task. A six minute non-gender biased task involving rapid mental serial subtraction of numbers aloud was administered. The task consisted of starting at one number and having to subtract from that number in increments of a specified number without the aid of any devices. The mental serial subtraction task has been shown to cause sharp increases in cardiovascular parameters (Williams, Riels, & Roper, 1990; Lash et al., 1991). The mental subtraction was selected due to the task exerting temporary and minimal amounts of lasting stress upon participants. The current study used a serial subtraction task adapted from Cacioppo et al. (1995). No consideration was given to participant's math ability.

Procedure

Prior to onset of serial subtraction task, participants entered the testing room, completed the LOT-R, PANAS, and demographic data and sat quietly for 10 minutes, providing an estimate of baseline CV activity. During the baseline period, blood pressure and HR measurements were taken every minute with the aid of a blood pressure monitor.

Upon completion of baseline measurements, participants were asked to complete the serial subtraction task. For minute 1 participants started at 688 counting backwards in increments of 7; for minute 2, it was 297 counting backwards in increments of 12; for minute 3, it was 593 counting backwards in increments of 14; for minute 4, it was 955 counting backwards in increments of 13; for minute 5, it was 1741 counting backwards in increments of 22; and for minute 6, it was 1200 counting backwards in increments of 45. Participants were instructed to respond in pace with a metronome set at 40 beats per minute. When participants did not respond in the allotted time, they were told to "keep pace with the metronome". When an incorrect response was given, participants were told "wrong" and were given their last correct number and to continue subtracting from the correct number. For minute 5 and minute 6, participants were told that the average numbered of correct responses was 7 correct and 5 correct respectively. A brief period followed each minute in which CV data were collected.

Promptly after the final reactivity BP measurements, participants were asked to complete the PANAS and sit quietly while recovery data was collected every 1 minute for a period of 10 minutes. After recovery data were collected, participants were asked to complete the PANAS one final time. In total, the experiment lasted approximately 40 minutes.

Data Reduction and Statistical Analysis

Blood pressure and heart rate data were averaged for the baseline, reactivity, and recovery periods. Baseline and recovery consisted of 10 individual measurements. The stressor phase consisted of six individual measurements. This created three separate measurements for each measurement type (SBP, DBP, HR). Scores on the PANAS were separated into separate scales, positive and negative affect, and summed. Each separate scale consisted of 10 individual items. This was done for all three periods, resulting in separate positive affect and negative affect scores for baseline, reactivity, and recovery.

A series of 2 (sex) x 2 (disposition) repeated measure ANOVAs were conducted to test for any main effects or interactions for SBP, DBP, and HR. Each measure received its own repeated measure ANOVA, for a total of nine repeated measures ANOVAs (baseline to reactivity, reactivity to recovery, and recovery to baseline). Adjusted means were used. Paired *t*-tests and independent *t*-tests were used to test for mean differences between psychological measures and for post hoc comparison.

RESULTS

Stress Task

The serial subtraction task was split into the first 4 tasks and into the last 2 tasks; allowing for detection of any differences in reactivity between periods of the stress task. There was no significant difference between the separate periods on any of the CV measures, indicting that both periods were most likely viewed as equally stressful.

Psychological measures

A 2 (sex) x 2 (disposition) revealed no significant difference between sex or disposition on positive affect (PA) or negative affect (NA) at any period. Paired *t*-tests revealed NA increased from baseline to reactivity, $t(77) = -4.273$, $p = .00$, and decreased from reactivity to recovery, $t(78) = 7.248$, $p = .00$, indicating the stress task was effective in increasing negative affect. Paired *t*-tests revealed PA decreased from baseline to reactivity, $t(77) = 5.479$, $p < .001$, and remained at a similar level from reactivity to recovery. Means and standard deviations for PA and NA scores for both sex and disposition are presented in table 1.

Table 1. *Total positive and negative affect scores by sex and disposition, means and standard deviations.*

Participant Sex/Disposition	Period	PA	NA
Males	Baseline	28.50(6.2)	14.50(4.9)
	Reactivity	26.00(7.0)	18.56(7.6)
	Recovery	23.79(6.6)	13.82(4.3)
Females	Baseline	29.26(7.7)	15.82(6.7)
	Reactivity	23.84(9.7)	19.20(8.1)
	Recovery	24.02(9.7)	14.11(5.9)
Optimists	Baseline	29.60(7.3)	14.35(5.7)
	Reactivity	25.85(9.7)	17.27(7.7)
	Recovery	25.37(9.8)	13.12(4.8)
Pessimists	Baseline	27.71(6.7)	16.93(6.7)
	Reactivity	23.90(7.1)	20.67(7.8)
	Recovery	22.48(6.6)	14.71(4.8)

Two separate 2(sex) x 2(disposition) repeated measures ANOVAs for baseline to reactivity, reactivity to recovery and recovery to baseline were conducted to reveal any main effects or interactions between sex and disposition on NA. The ANOVAs failed to reveal any significant interaction between sex and disposition on NA at either baseline to reactivity, $F(1,70) = 1.97$, $p = .165$, or reactivity to recovery $F(1, 70) = 1.07$, $p = .30$. Hypothesis 2, that there will be an interaction between sex and disposition on NA, was not supported. Analysis revealed no significant difference between pessimistic females' NA and any other groups' NA at any period (baseline, reactivity, recovery) (see table 2).

Table 2. *Negative affect mean scores by gender and disposition.*

Participant Sex/Disposition	Baseline NA	Reactivity NA	Recovery NA
Optimistic Males	14.36	17.33	13.33
Pessimistic Males	15.05	18.44	13.66
Optimistic Females	14.34	17.25	13.03
Pessimistic Females	19.62	23.76	16.15

Independent *t*-tests revealed optimists scored significantly higher on the LOT-R than pessimists (table 2), $t(71) = -13.77$, $p = .00$, indicating a significant difference in scores between the groups. Independent *t*-tests revealed a significant difference between sexes on scores of LOT-R, $t(74) = -2.168$, $p = .033$, with females scoring higher on the LOT-R than males (table 3).

Table 3. *LOT-R scores by sex and disposition, means and standard deviations.*

Participant Sex/Disposition	LOT-R
Males	15.23(3.7)
Females	16.91(3.2)
Optimists	19.00(1.7)
Pessimists	16.91(3.2)

Baseline CV Measures

Independent *t*-tests revealed no significant differences between the sexes when examining age (Males (M = 20.17, SD = 4.3) vs. Females (M = 20.58, SD = 2.0). Independent *t*-tests revealed a significant difference in BMI, $t(1,79) = 2.25$, $p = .027$, with males having a higher BMI than females (Males M = 26.09, SD = 4.4 vs. Females M = 23.59, SD = 5.2).

Three individual 2(sex) x 2(disposition) ANOVAs were conducted to measure differences in baseline CV measurements. As expected there were significant sex differences in baseline SBP, $F(1,70) = 59.99$, $p = .00$ with males baseline SBP being higher (M = 127.69) SBP than females (M = 110.11). Baseline sex differences in DBP were noted as well, $F(1, 70) = 4.43$, $p = .03$, with males baseline DBP (M = 69.78) being higher than females (M = 66.67). There was significant difference on baseline HR, $F(1, 70) = 3.04$, $p = .08$, with males baseline HR (M = 70.60lower than females (M = 76.82). Means and standard deviations for SBP, DBP, and HR are located on table 4.

Table 4. *Cardiovascular measurements by sex and disposition, adjusted means and standard deviations.*

Participant Sex/Disposition	Period	SBP(mmhg)	DBP	HR
Male	Baseline	127.69(8.7)	69.78(6.1)	70.60(12.7)
	Reactivity	131.92(7.9)	72.81(4.9)	70.21(12.18)
	Recovery	126.04(8.5)	69.47(7.2)	70.31(11.45)
Female	Baseline	110.11(8.5)	66.67(5.4)	76.82(12.4)
	Reactivity	118.48(9.0)	69.14(5.36)	76.39(13.88)
	Recovery	112.40(8.3)	65.76(5.45)	75.40(12.7)
Optimists	Baseline	127.69(8.7)	67.11(5.8)	74.35(11.5)
	Reactivity	123.01(10.6)	70.30(5.4)	73.96(11.7)
	Recovery	116.75(9.9)	66.23(5.1)	73.45(11.7)
Pessimists				
	Baseline	120.56(13.0)	68.52(6.4)	72.66(14.1)
	Reactivity	126.10(11.5)	71.64(5.7)	73.95(15.1)
	Recovery	120.22(11.9)	68.77(8.8)	72.72(12.8)

Reactivity CV Measures

A 2(sex) x 2(disposition) repeated measures ANOVA was next used to test for any significant main effect of disposition on baseline to reactivity SBP, DBP, and HR. Using sex and disposition as between subject variables, baseline SBP and reactivity SBP as within subject variables, and BMI as a covariate, SBP was found to significantly increase during the reactivity phase, $F(1, 63) = 5.36$ $p = .024$. A significant main effect for sex, $F(1, 70) = .06$, $p = .813$, was found for baseline SBP to stressor SBP (figure 1) with females experiencing higher levels of SBP increases compared to males (table 5). Hypothesis 1, there will be a significant main effect for disposition was not supported; optimists did not experience significantly different elevations in SBP compared to pessimists. Using sex and disposition as between subject variables, baseline DBP and reactivity DBP as within subject variables, and BMI as a covariate, DBP did not significantly increase during the reactivity phase, $F(1, 63) = 3.48$, $p = .066$. There was, however, a significant main effect for sex on DBP (figure 2), $F(1, 63) = 5.72$, $p = .020$, with males experiencing significantly higher elevations in DBP than females. Means for disposition reactivity SBP and DBP are presented in table 6.

Table 5. *Adjusted mean change scores for baseline to reactivity SBP.*

Participant Sex/Disposition	Baseline SBP	Reactivity SBP	Change
Males	126.48	131.09	4.60
Females	111.70	118.96	7.25
Optimists	120.19	126.06	5.87
Pessimists	118.03	123.98	5.95

Table 6. *Adjusted mean change scores for baseline to reactivity DBP.*

Participant Sex/Disposition	Baseline DBP	Reactivity DBP	Change
Males	69.71	73.07	3.36
Females	66.78	69.48	2.7
Optimists	66.22	71.36	3.14
Pessimists	68.27	71.19	2.91

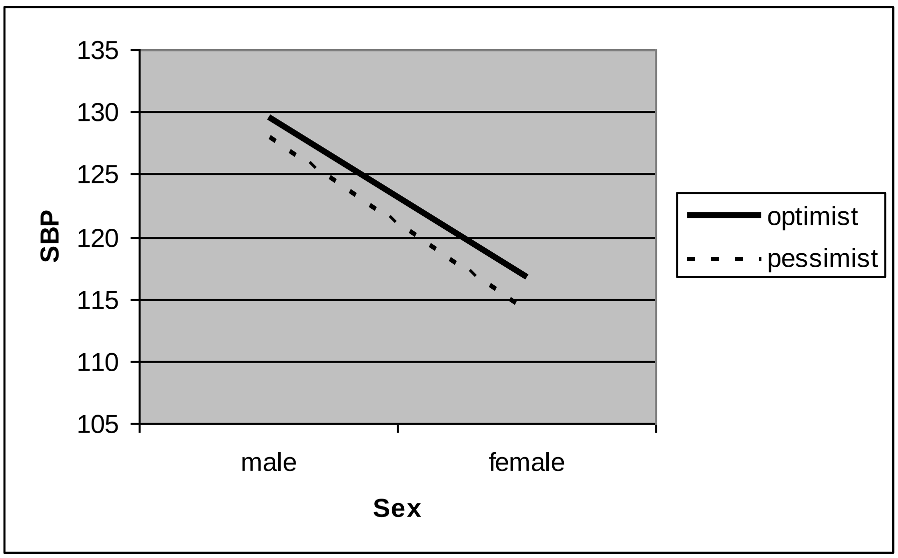

Figure 1. Significant main effect for male disposition and baseline on reactivity SBP.

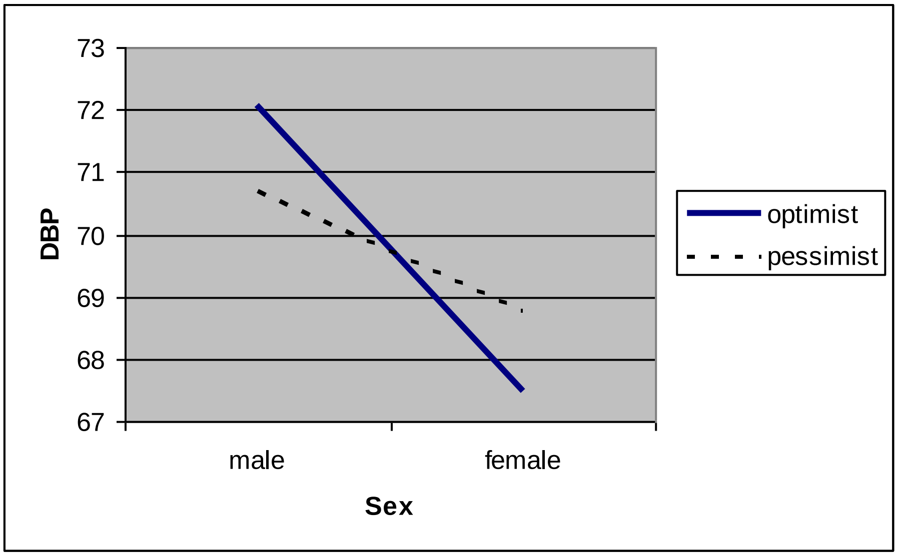

Figure 2. Significant main effect for sex on baseline to reactivity DBP.

A 2(sex) x 2(disposition) repeated measures ANOVA with sex and disposition as the between subject variable, baseline HR and reactivity HR as within subject variables, and BMI as a covariate, revealed HR did not significantly increase from baseline to stressor, $F(1, 63) < 1$ $p = .954$. There was a significant interaction of sex by disposition on reactivity HR (figure 3), $F(1, 63) = 5.412$, $p = .023$. See table 7 for means.

Table 7. *Adjusted mean change scores for baseline to reactivity HR.*

Participant Sex/Disposition	Baseline HR(BPM)	Reactivity HR	Change
Optimistic Males	70.88	70.90	.02
Pessimistic Males	70.32	69.46	.66
Optimistic Females	76.35	75.71	.64
Pessimistic Females	76.38	79.33	2.95

Groups were separated into optimistic males, optimistic females, pessimistic males, and pessimistic females to conduct post-hoc analyses. A one way ANOVA was conducted using the Tukey's post hoc analysis option. Results revealed the significant differences between optimistic females and pessimistic females in baseline to reactivity HR. Using an independent *t* test, the difference was revealed to be $t(70) = 2.81$, $p < .05$. The difference between optimistic females and pessimistic males was insignificant at $t(70) = -.41$, $p < .68$. The difference between optimistic females and optimistic males was insignificant at $t(70) = -.03$, $p < .97$. There were no other significant differences between any other group combinations.

Hypothesis 3 was confirmed. Optimistic females had comparable increases in HR reactivity compared to optimistic and pessimistic males and had significantly lower increases compared to pessimistic females.

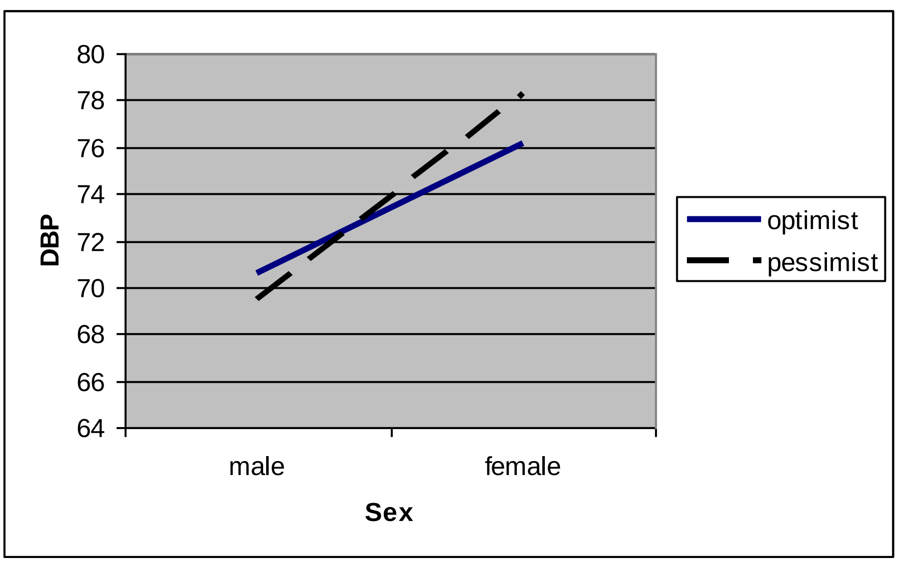

Figure 3. Significant interaction of sex by disposition on HR reactivity.

Recovery CV Measures

Separate 2(sex) x 2(disposition) repeated measures ANOVAs were next conducted to determine if there were any significant effects or interactions on reactivity to recovery period SBP, DBP, and HR. A 2(sex) x 2(disposition) repeated measures ANOVA using sex and disposition as between subject variables, reactivity SBP and recovery DBP as within subject variables, and BMI as a covariates, revealed SBP did not significantly differ from reactivity to recovery, $F(1, 63) = .027$, $p = .870$. There was a significant main effect for sex (figure 4), $F(1, 63) = 43.91$, $p = .000$, with females experiencing greater recovery than males (table 8). Hypothesis 1 was not supported; there were no significant main effect, $F(1, 63) = .940$, $p = .336$, for disposition on SBP recovery.

Table 8. *Mean change scores for reactivity to recovery SBP.*

Participant Sex/Disposition	Reactivity SBP	Recovery SBP	Change
Males	131.09	125.45	- 5.63
Females	118.96	112.66	-6.29
Optimists	70.62	70.63	-6.22
Pessimists	123.98	118.29	-5.68

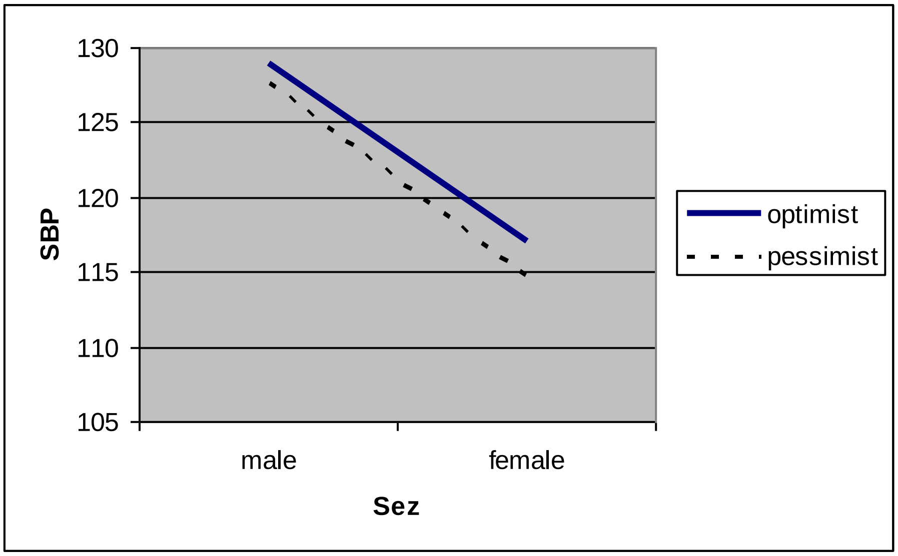

Figure 4. Significant main effect for female sex on reactivity to recovery SBP.

A 2(sex) x 2(disposition) repeated measures ANOVA using sex and disposition as between subject variables, reactivity DBP and recovery DBP as within subject variables, and BMI as a covariate, revealed DBP did not significantly decrease from reactivity to recovery, $F(1, 63) = 2.50$, $p = .119$. There was no significant main effect for disposition on DBP recovery, $F(1, 63) = .13$, $p = .718$, failing to confirm hypothesis 1. There however was a significant main effect on sex (figure 5), $F(1, 63) = 5.69$, $p = .020$, with males experiencing greater levels of reactivity to recovery DBP than females. Means for recovery DBP are presented on table 9.

Table 9. *Adjusted mean change scores for reactivity to recovery DBP.*

Participant Sex/Disposition	Reactivity DBP	Recovery DBP	Change
Males	76.07	69.29	-6.78
Females	69.48	66.00	-3.48
Optimists	71.36	67.04	-4.32
Pessimists	71.19	68.24	-2.95

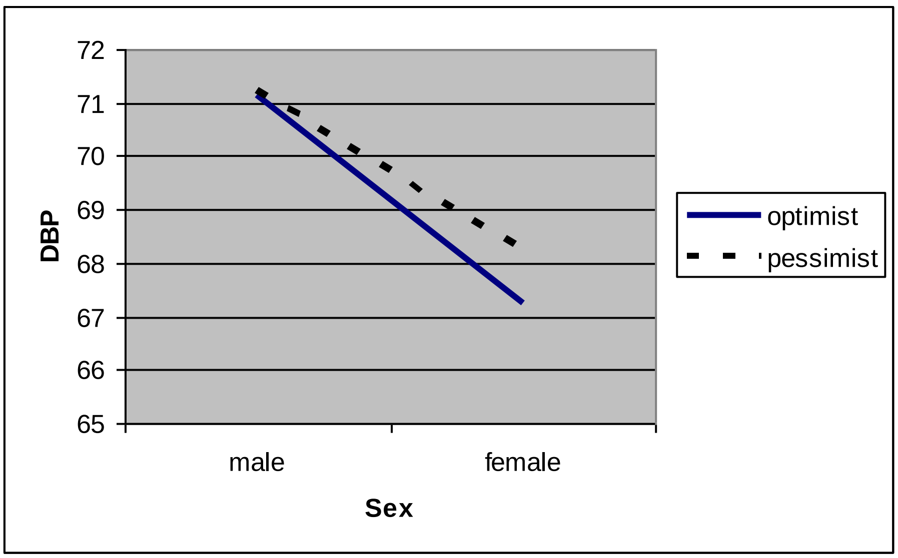

Figure 5. Significant main effect for male sex on reactivity to recovery DBP.

A 2(sex) x 2(disposition) repeated measures ANOVA using sex and disposition as between subject variables, reactivity HR and recovery HR as within subject variables, and BMI as a covariate revealed a significant interaction of sex and disposition on HR reactivity to recovery HR, $F(1, 63) = 5.83$, $p = .019$, with pessimistic females experiencing greater reactivity to recovery HR changes than optimistic females. Hypothesis 3, there will be a sex by disposition interaction HR was supported. See table 10 for means.

Table 10. *Adjusted mean change scores for reactivity to recovery HR.*

Participant Sex/Disposition	Reactivity HR	Recovery HR	Change
Optimistic Males	70.63	69.13	-1.49
Pessimistic Males	69.11	69.12	.01
Optimists Females	75.85	75.92	.06
Pessimists Females	79.74	76.54	-3.2

To see where the significant differences were, groups were separated into optimistic males, optimistic females, pessimistic males, and pessimistic females to conduct post-hoc analyses. A one way ANOVA was conducted using the Tukey's post hoc analysis option. Results revealed the significant differences between pessimistic females and optimistic females in reactivity to recovery HR. Using an independent *t* test, the difference was revealed to be $t(70) = 2.67$, $p < .05$. The difference between pessimistic females and pessimistic males was insignificant at $t(70) = -1.276$, $p < .21$. The difference between pessimistic females and optimistic males was insignificant at $t(70) = -2.50$, $p < .15$. There were no other significant differences between any other group combinations.

Hypothesis 3 was confirmed. Optimistic females had comparable increases in HR reactivity compared to optimistic and pessimistic males and had significantly lower increases compared to pessimistic females. Optimistic females experienced similar levels of HR recovery compared to optimistic/pessimistic males and less recovery than pessimistic females (figure 6). Further, optimistic females HR from reactivity to recovery did not significantly change. Both baseline to reactivity and reactivity to recovery were both significantly lower than pessimistic females.

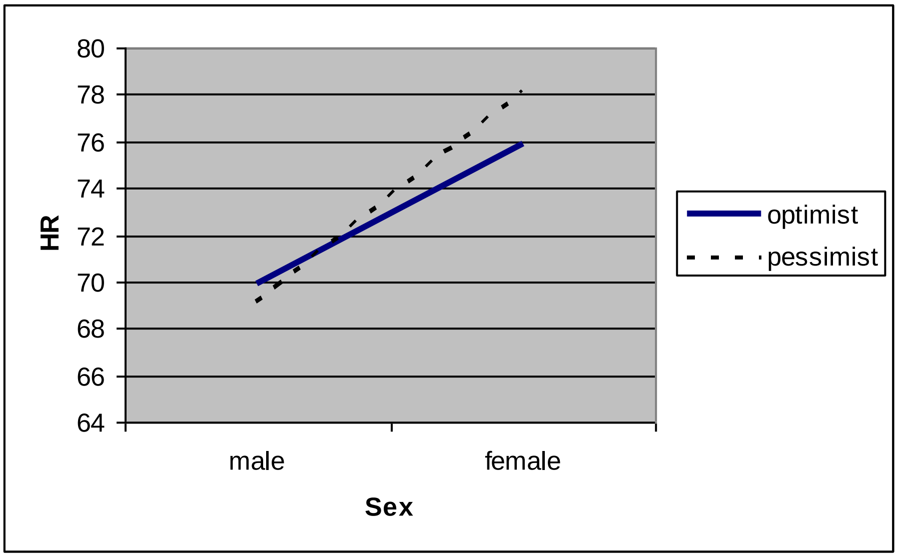

Figure 6. Significant interaction of sex by disposition on HR reactivity to recovery.

Recovery vs. Baseline

Lastly, measuring from recovery to baseline, no significant differences, main effects, or interactions appear. Recovery to baseline SBP was insignificant at $F(1, 63) = .05$, $p = .63$. Recovery to baseline was insignificant for DBP $F(1, 63) = .04$, $p = .828$. Lastly, comparison of recovery to baseline HR resulted in an insignificant difference $F(1, 63) = 1.08$, $p = .30$. This indicates that all participants successful experienced full recovery back to baseline post stressor.

Figures are presented below for an overview of average optimists' SBP (figure 7), pessimists' SBP (figure 8), optimists' DBP (figure 9), and pessimists' DBP (figure 10). Figures also are reported for an overview of average HR for optimistic females (figure 11), pessimistic females (figure 12), optimistic males (figure 13), and pessimistic males HR (figure 14).

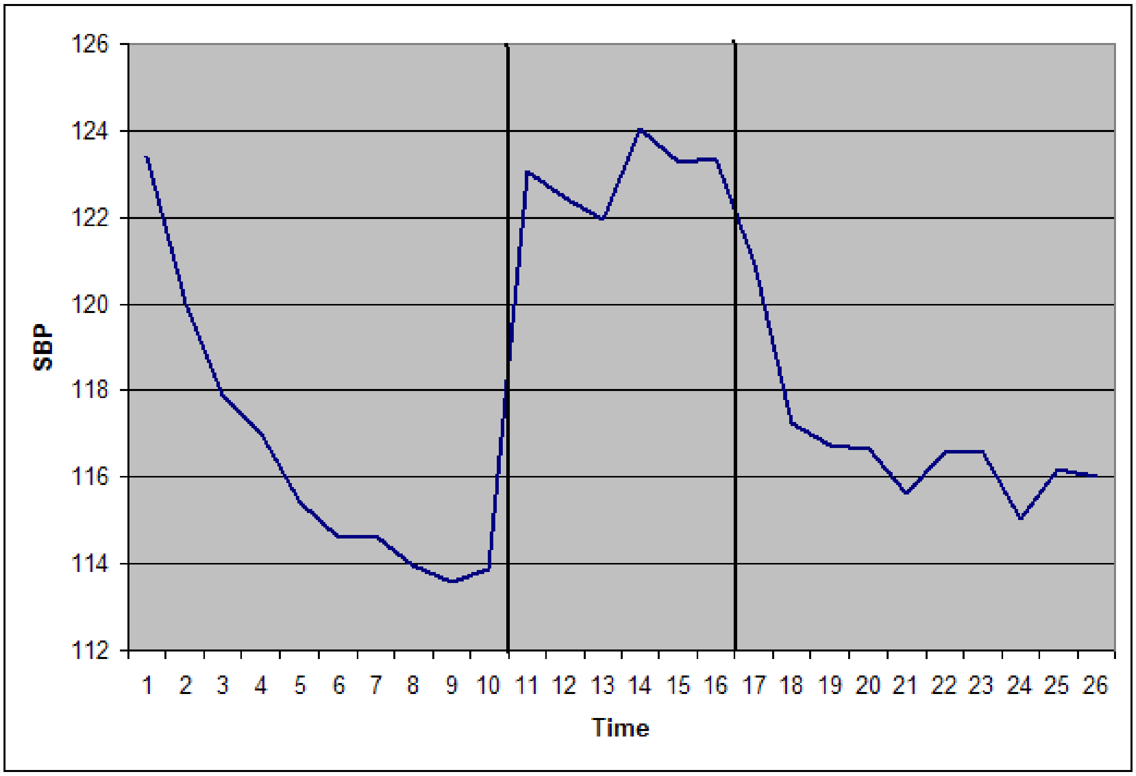

Figure 7. Optimists' SBP averages over baseline, reactivity, and recovery periods.

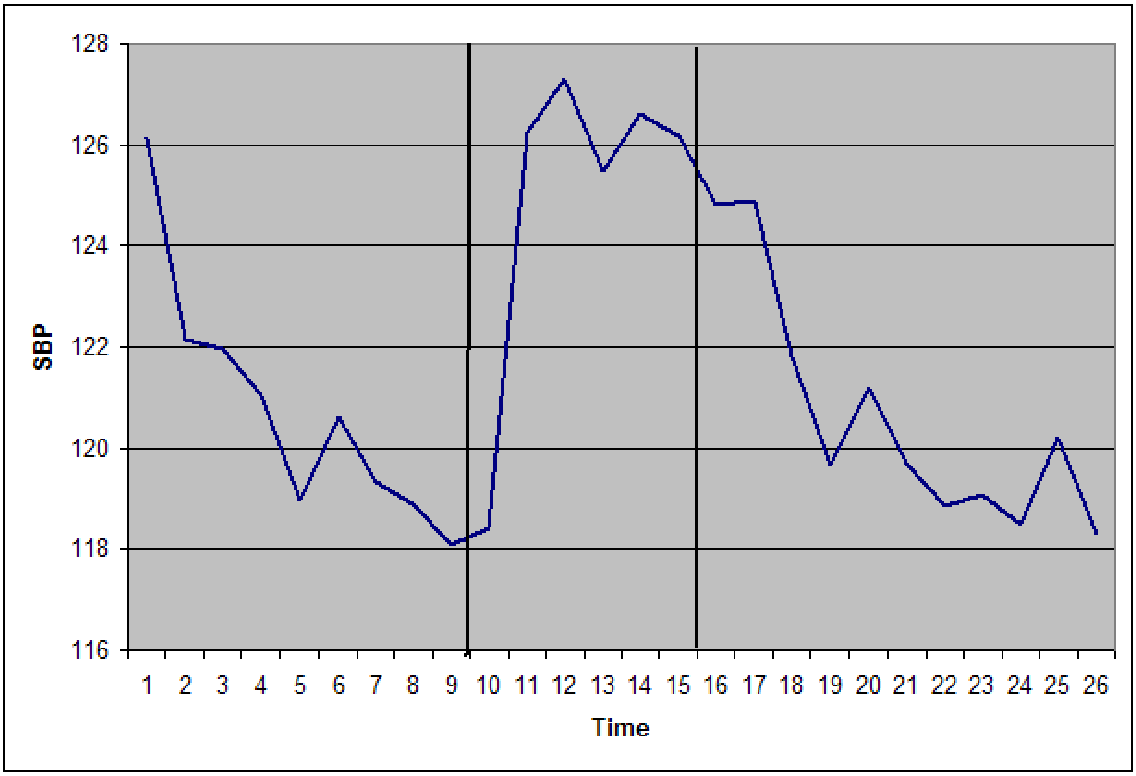

Figure 8. Pessimists' SBP averages over baseline, reactivity, and recovery periods.

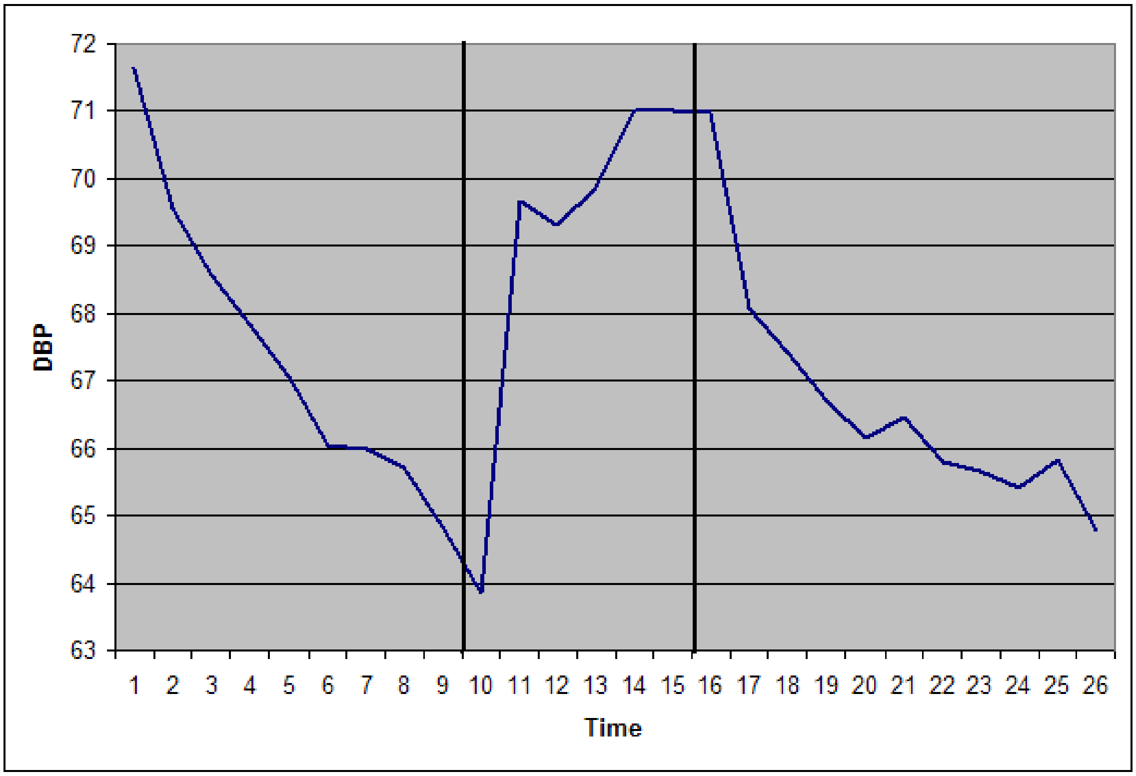

Figure 9. Optimists' overall average DBP over baseline, reactivity, and recovery periods.

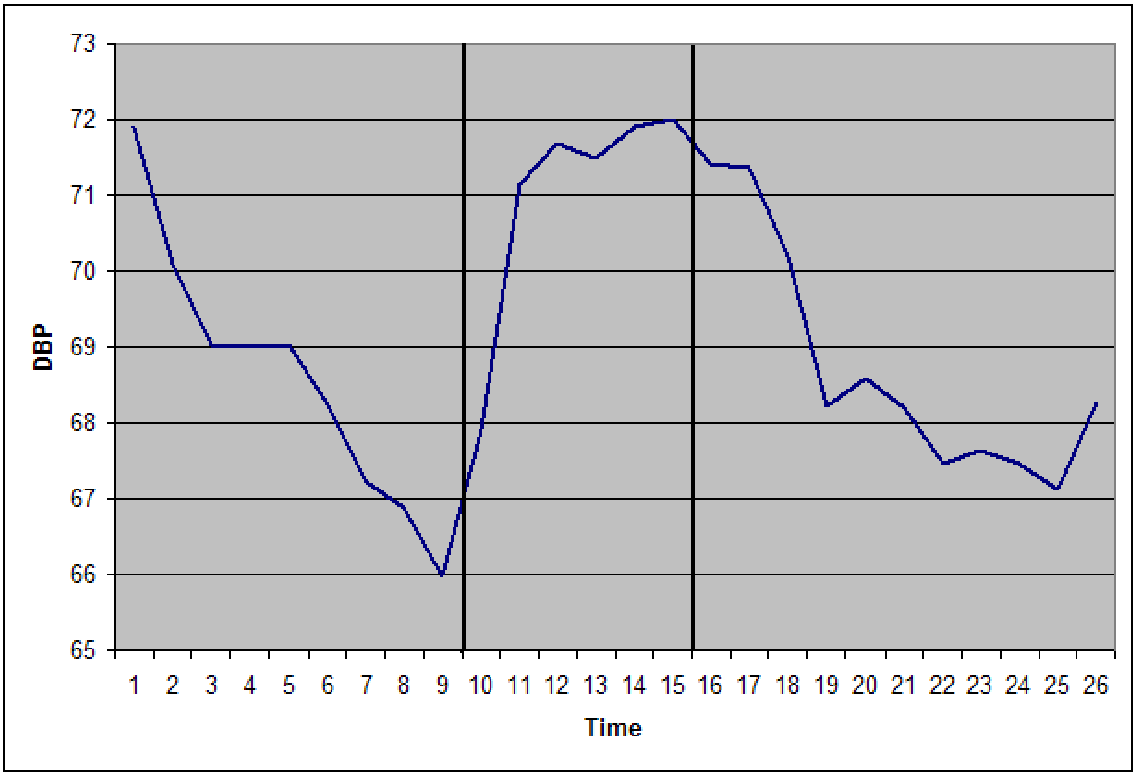

Figure 10. Pessimists’ overall averages for DBP over baseline, reactivity, and recovery periods.

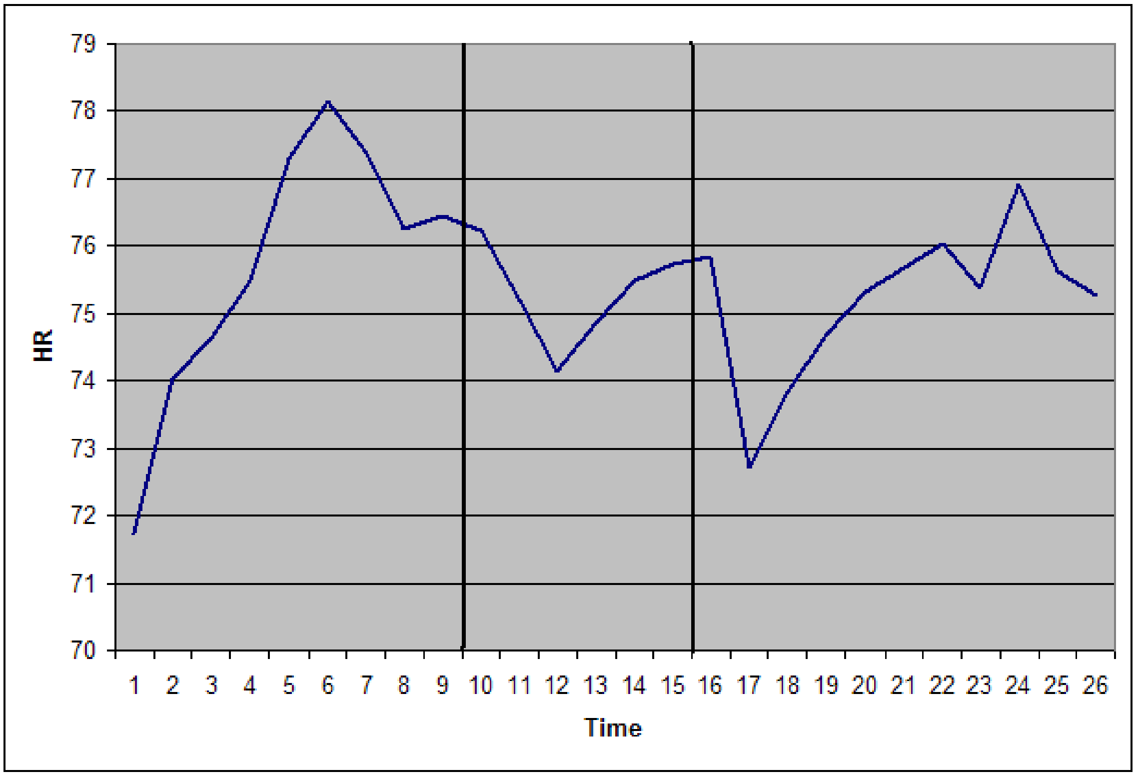

Figure 11. Optimistic females HR averages over baseline, reactivity, and recovery periods.

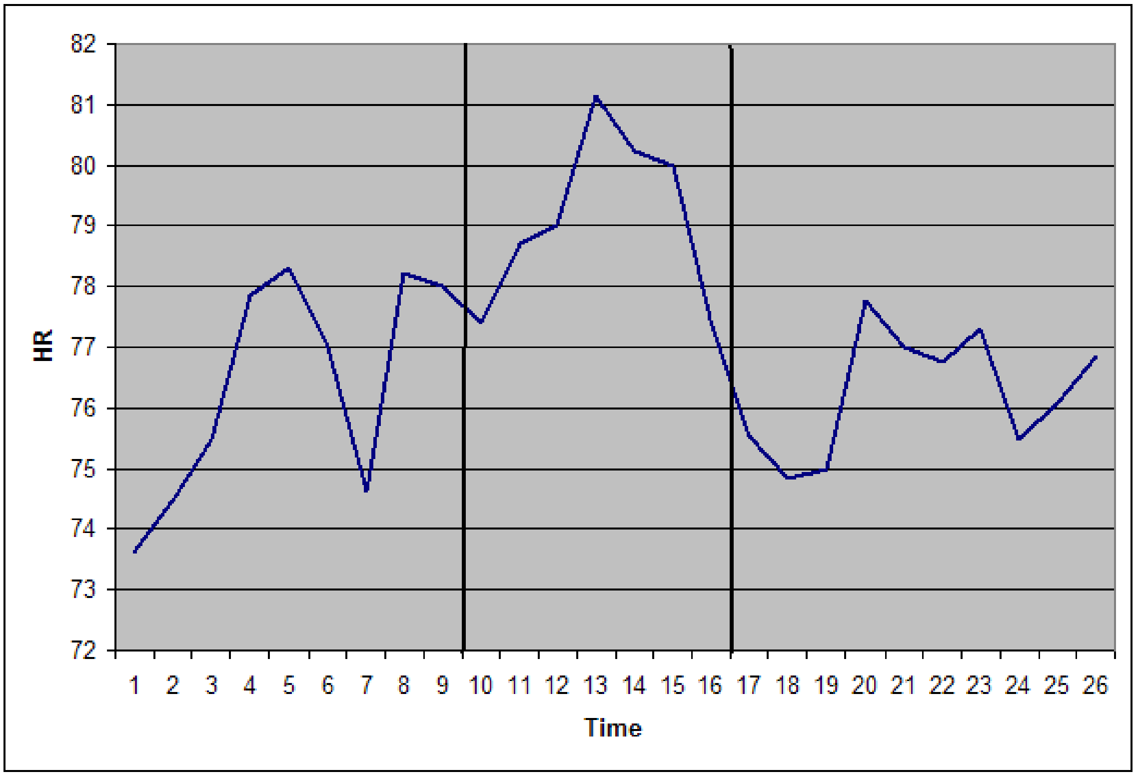

Figure 12. Pessimistic females HR averages over baseline, reactivity, and recovery periods.

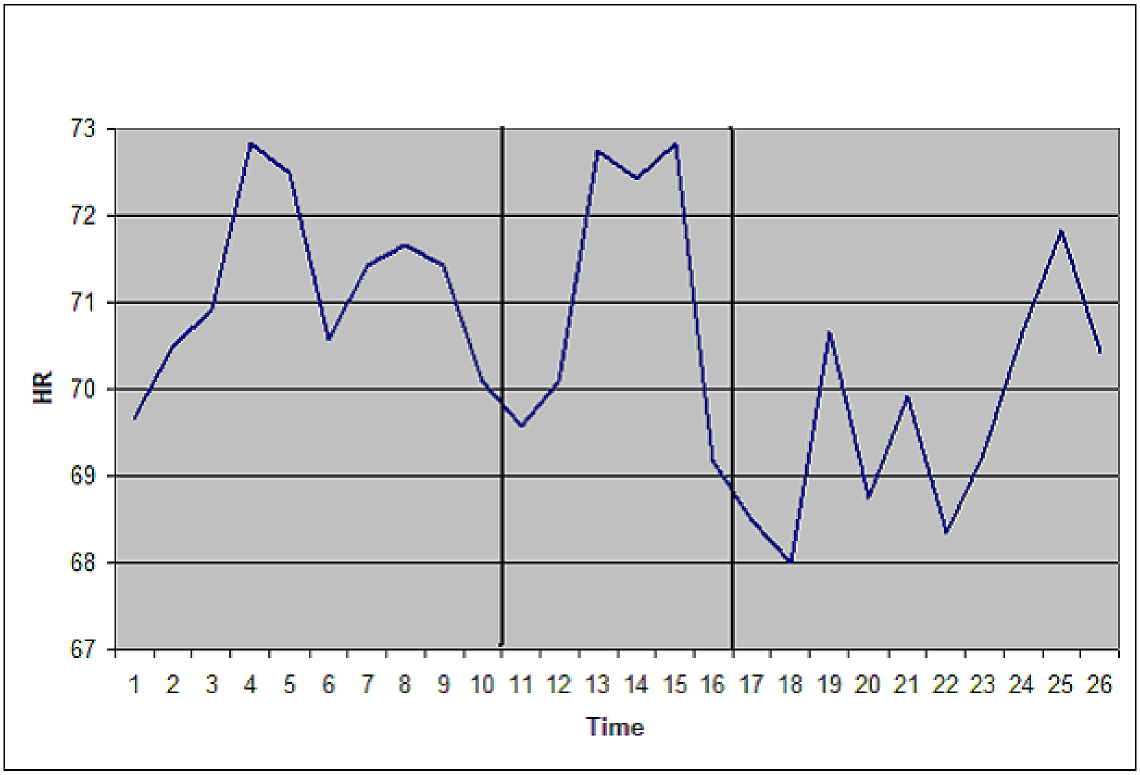

Figure 13. Optimistic males HR averages over baseline, reactivity, and recovery periods

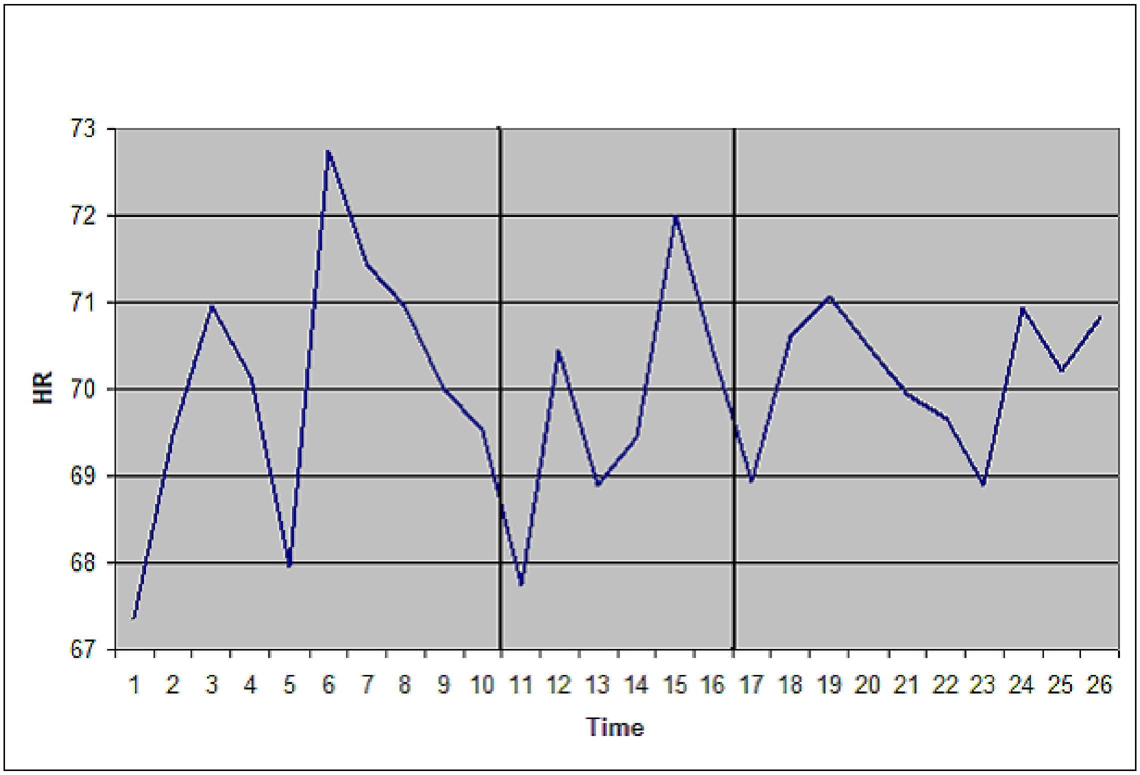

Figure 14. Pessimistic males HR averages over baseline, reactivity, and recovery periods.

Frederickson & Levenson (1998) found positive emotions sped up CV recovery. Based on this previous study, additional analysis was conducted to look at role of PA on recovery**.** Total PA at recovery was found to significantly predict recovery HR, $\beta = .675$, $t(68) = 2.04$, $p = .045$. The experience of NA is further known to have an impact on CV functioning. Using NA item 1 (distressed) as the independent variable, Linear regression analysis revealed NA1 at reactivity (distressed) significantly predicted the dependent variable, reactivity DBP scores, $\beta = -.32$, $t(69) = -2.05$, $p = .019$. Linear regression analysis further revealed that NA1 at recovery significantly predicted recovery DBP scores, $\beta = -.287$, $t(69) = -2.19$, $p = .032$. 2 (sex) by 2(disposition) ANOVAs however revealed no significant main effects or interactions for NA 1 at any period of recovery.

DISCUSSION

CV reactivity and recovery have recently gained importance in literature as predictors of future CV basal levels. This study sought to investigate the effects of optimism and sex on CV reactivity and recovery by using a mental stress task. It was hypothesized that there would be a main effect for disposition on CV reactivity and recovery (hypothesis 1), however this was not confirmed. It was hypothesized there would be an interaction for sex by disposition on NA (hypothesis 2), however this was not confirmed. Finally it was hypothesized there would be a significant sex by disposition interaction on reactivity and recovery HR (hypothesis 3). Hypothesis 3 was the only hypothesis to be confirmed in this study.

As expected, optimists scored higher on the LOT-R than pessimists. It was expected that there would be no significant difference in LOT-R scores between sex, however this study found females scored significantly higher than males on the measurement. Surprisingly, there was no significant difference in PA or NA at any period between optimists and pessimists. Levels of baseline PA were significantly positively correlated with optimism; those who experienced higher scores on the LOT-R were likely to have higher levels of PA at the beginning of the experiment.

The serial subtraction succeeded in raising SBP and but not DBP significantly from baseline to reactivity in all groups and HR in pessimistic females only. Increases in SBP and DBP may indicate the task was viewed as stressful by participants (Krantz et al., 1988; Krantz & Falconer, 1995). In line with previous research (Stoney et al., 1987; Sarlo et al., 2005), males had significantly higher measures of SBP and DBP at baseline and females higher HR at baseline (Sharpley, 1994). When examining baseline to reactivity measurements, females had higher elevations of SBP compared to males and males exhibited higher increases in DBP compared to females. Females exhibited significantly higher HR levels than males at baseline.

During the stress task, there was a significant sex by disposition interaction on baseline to reactivity HR, with optimistic females not reacting as strongly as pessimistic females. Surprisingly, there was no main effect for difference in baseline to reactivity between dispositions on SBP or DBP, opposite to Williams & Roper (1990) and Kennedy & Hughes (2004). Optimists and pessimists had no significant differences at baseline, nor did they experience any significant differences in reactivity or recovery for any measures. The only significant finding was with the sex by optimism interaction. An underlying assumption from previous research was that optimists would view the stress task as less stressful, leading towards lower reactivity levels compared to pessimists, who were assumed to view the stress task as more stressful, leading to greater levels of reactivity. This hypothesized reduction in reactivity for optimists was thought to lead towards quicker recovery. It appears that regardless of disposition, for an acute stressor, reactivity and recovery rates are similar between dispositions for SBP and DBP only. Differences in reactivity for dispositions may only become evident during more severe acute stressors or possibly longer term stressors, one that lasts for longer than six minutes. The data suggest that being optimistic affords no benefits in for acute stressor (mental serial subtraction). However, differences might have appeared had a different stress task been used (i.e. cold pressor, public speaking, or distressing films). A significant sex by disposition interaction on HR reactivity was revealed, supporting hypothesis 3. Pessimistic females experienced greater increases in HR than optimistic females during the baseline to reactivity period. This finding is interesting in that it reveals that the optimistic disposition appears to only benefit females in regards to HR. Females are known to be cardiac reactors to stress (larger increase in HR) while males are vascular reactors (larger increases in BP) (Allen et al., 1993; Schmaus et al., 2008), which may explain why males did not experience significant increases in HR. It appears that for this sample, optimism buffered the stress response, as reflected in HR reactivity, in females only. This may benefit optimistic females in the long run as well. Constant lower levels of HR reactivity levels puts less stress on the heart, allowing for a healthier heart.

A possible explanation for this finding might be NA. However hypothesis 2 was not supported, there was no significant difference in experience of NA from baseline to reactivity in females or men. Therefore the experience of NA cannot explain the increased HR reactivity in pessimistic females. Based on the data, it appears that being pessimistic or optimistic does not affect your experience of NA in the short-term. It appears that for this acute stressor, equal amounts of NA were experienced regardless of belonging to either sex or disposition or any combination of sex and disposition. It is possible that the serial subtraction was not long enough or considered stressful enough by the participants to produce such differences in NA. Differences in NA between dispositions and sexes may appear during more taxing and longer duration stressors. It was expected that differences in NA between groups would lead to differences in recovery rates. PA did not differ between optimistic females and pessimistic females, thus the experience of PA cannot explain the difference in HR either. Oldehinkel, Verhulst, & Ormel (2008) reason that lower elevations in heart rate may be a sign of resilience or possibly those with lower heart rate increases may have experienced lower levels of arousal. It may be the optimistic females are more resilient in the presence of stress or the pessimistic females' experienced greater negative arousal during the stressor. This again may benefit optimistic females' CV systems in the long run.

Compared to females, males' reactivity HR did not significantly differ from baseline to reactivity. The benefits of the optimistic disposition may not have been able to take hold due to the males being more vascular reactors (Farag et al., 2006). It is not that optimism had no effect on males, rather it is the fact that non-significant increases in HR would never allow for HR recovery to even occur in an optimistic male.

Examining the differences between reactivity to recovery, there were significant differences in rates of recovery for sex on SBP and DBP recovery. Females experienced greater recovery than males on SBP. Males appeared to recover to a greater extent than females on DBP, while optimists appeared to recover at the same rate as pessimists. Possible explanations for these findings might be due to the nature of CV reactivity of the sexes in this study (i.e. males experienced greater DBP reactivity than females while females experienced greater SBP reactivity than males). It is unknown if this has any implications for health since this may just be due to physiological differences. Had differences in SBP and DBP been found, in either the reactive or recovery phase, possible health consequences might possibly be higher chances of developing heart disease in the future (Carroll et al., 2001; Steptoe & Marmot, 2005). There was a significant sex by disposition interaction on HR reactivity to recovery with pessimistic females having lower differences of HR recovery compared to optimistic females and optimistic males when controlling for reactivity HR. The finding appears to show pessimistic females experience greater recovery than optimistic females, however this is misleading. During the reactive phase, optimistic females HR did not differ from their baseline measurements. Pessimistic females were the only group to experience a significant change in measurement. Therefore pessimistic females were the only group that theoretically would be able to experience significant change back to recovery. Pessimistic females indeed did experience recovery back to baseline. It appears that an optimistic disposition as a possible coping strategy is beneficial during the reactivity phase of a stressor for females. Using the data from this study, optimism appears to do nothing during the recovery phase of a stressor.

Lastly, possible explanations for the differences in female HR reactivity and recovery could be related to the female menstrual cycle, since it is known that the menstrual cycle can affect HR recovery in females. Carter & Lawrence (2007) found that females in the mid-luteal phase (post ovulation) had longer HR recovery from a mental arithmetic task than those in the follicular stage (receding ovulation). Since menstrual phase was not controlled for in this study, it is possible that a higher portion of optimistic females were in the mid-luteal phase and more pessimistic females were in the follicular stage. Total PA at recovery was further found to be a significant predictor of recovery HR. This finding supports Fredrickson and Levenson's (1998) study which found that the presence of positive emotions speeds up CV recovery. Had there been a significant difference between optimists and pessimists on PA at recovery, a significant difference in

SBP and DBP might have been observed in the sex by optimism interaction. Had pessimists possessed less amounts of PA than optimists, they might have experienced a significant difference between recovery phase and baseline phase of SBP and DBP.

The results from this study both affirm (sex difference in CV parameters) and contradict (optimistic disposition reducing CV reactivity) the previous research of the effects of sex on reactivity and point to an optimistic disposition affording benefits on HR reactivity to stress in optimistic females only. Females are known to experience lower levels of cardiovascular disease (Anand et al., 2008) and increased HR reactivity has been linked to increased future occurrences of heart disease (Treiber et al., 2003). The optimistic disposition's role in dampened reactivity may play a part in the reduction of risk of future incidence of heart disease for optimistic females. Relating back to the reactivity hypothesis, a reduced need for constant reactivity may dampen the effects of future incident of CV disease.

LIMITATIONS

The ability to detect any differences may have been limited by the study sample, which was made up of volunteer college students whose age is relatively young. This led to a rather homogenous sample. Participants who were not motivated to successfully complete the serial subtraction task may not have experienced necessary levels of stress, leading to minimal increases in BP. This minimal increase in reactivity may not have been enough to be significantly different from baseline, either not allowing for recovery or possibly skewing the results. Secondly, the mean score on the LOT-R for pessimists was 12.62, a value that is actually in the middle of possible scores on the LOT-R, with 0 being the lowest and 24 being the highest. As a result, only 1 point on the LOT-R separated optimists from pessimists. Any further separation would have led to a greatly reduced sample size. In essence, we did not have a true group of pessimists. This could have skewed the results. Thirdly, it may be that the stressor was too acute, lasting only six minutes in duration. Had the stressors been longer in duration there might have possibly been more significant findings. Lastly, what phase of the menstrual cycle female participants were on was not measured, had this been taken into account it might have explained the significant sex by disposition interaction on HR recovery for females. Females are more reactive CV wise to stress during the luteal phase (Sato & Miyake, 2004).

FUTURE DIRECTIONS AND APPLICATIONS

While results from this study point to no interaction of sex by disposition on SBP or DBP for an acute psychological stressor, replication of this study may produce significant findings if it is ensured that there is indeed a stark difference between optimists and pessimists. Significant findings might also be found if either a more stressful acute psychological stressor or look to stressors lasting longer than six minutes is used or if the recovery period is shorter than ten minutes. Menstrual phase should also be taken into account, doing this may neutralize any differences in heart rate. Lastly, further research should investigate the difference between optimistic and pessimistic females on HR reactivity and recovery.

Regression analysis found that total PA at recovery predicted recovery HR. This finding is in line with Fredrickson & Levenson (1998) that positive emotions speed up the recovery process. Therapists may wish to have interventions designed to allow for patients to focus on more positive aspects of current stressors or daily hassles than the negative ones. Secondly, there was a significant interaction on HR reactivity, with optimistic females having lower elevations of HR reactivity. Optimism as a coping strategy appears to be the most beneficial during the reactive phase of a stressor. Therapists again could teach patients to focus on more optimistic aspects during a stressor. Optimism has previously been documented to increase as a result of a direct intervention aimed at restructuring cognitive processes (Goldwurm et al., 2006). Such an intervention may possibly allow for a small decrease in the development of heart disease for patients with increased HR reactivity due to psychological stressors.

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