The Association between Resting Cardiac Vagal Tone and Facets of Perseveration: Sex as a Moderating Factor

THESIS

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Abstract

Perseverative cognition, defined as repeated activation of cognitive representations of a stressor, is connected with poor outcomes in physical and psychological health. Relatively high resting heart rate variability (HRV) is frequently linked to adaptive use of emotion regulation abilities and behavioral inhibition, and individuals with higher HRV show greater activity of executive regions of the brain. Emotion regulation is defined as the adaptation of emotional experiences, expressions, and physiological responses to an organism’s environment. As lower HRV is related to lower inhibitory control and difficulties in emotion regulation, the Perseverative Cognition Hypothesis theorizes that lower HRV may predict whether an individual may be susceptible to perseveration and experience subsequent negative outcomes (e.g., anxiety). Importantly, sex differences in resting HRV have been documented, and a recent study indicated that sex moderates the aforementioned association between resting HRV and emotion regulation abilities. Additionally, another study showed resting HRV to predict self-reported maladaptive, but not potentially neutral, forms of perseveration; however, sex was not considered as a moderating factor. The present study therefore builds upon this prior research by investigating whether sex differences play a role in the established relationship between HRV and emotion regulation strategies such as...
perseveration. In particular, my study assesses a potential moderating effect of sex on the relationship between HRV and three different facets of rumination. To assess this relationship, participants (n = 298) in the study first completed a 5-minute resting-baseline period where resting HRV was recorded via electrocardiogram (ECG); and was quantified as the root mean square of successive differences. Participants then completed the Ruminative Responses Scale, designed to assess total ruminative tendencies, in addition to three subscales: depressive rumination (sadness and despair), brooding rumination (wallowing and sulking), and reflective rumination (problem solving and analyzing). Controlling for important covariates, sex did not significantly moderate the relationship between HRV and total rumination, depressive rumination, or brooding rumination. However, sex significantly moderated the association between HRV and reflective rumination. Conditional analyses showed a significant negative association between HRV and reflective rumination in women, but not men. In a subsample of participants, results also showed that reflective rumination mediated the relationship between resting HRV and trait anxiety in women only. This pattern of data is similar to aforementioned sex differences in the association between resting HRV and emotion regulation abilities, and extends them to the domain of emotion regulation strategies (i.e., rumination) as well as related maladaptive psychological outcomes (i.e., anxiety). Overall, the current results suggest that women and men differ in which forms of perseveration may be characterized as non-harmful or maladaptive – I propose that research should consider sex as an important demographic in better understanding the link between stress vulnerability, perseveration, and disease.
Dedication

This thesis is dedicated to my mother and father, Drs. Patria and Ernesto Gerardo.

I love and thank you both.
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Table of Contents

Abstract ........................................................................................................................................... ii

Dedication ...................................................................................................................................... iv

Acknowledgments ........................................................................................................................... v

Vita .................................................................................................................................................. vi

Table of Contents ........................................................................................................................... vii

List of Tables .................................................................................................................................. ix

List of Figures ................................................................................................................................. x

Chapter 1: Introduction .................................................................................................................... 1

Reflective Perseverative Cognition .................................................................................................. 2

The Perseverative Cognition Hypothesis ......................................................................................... 3

Heart Rate Variability ...................................................................................................................... 5

Evidence of Sex Differences in HRV and Perseverative Cognition ............................................... 7

Present Study .................................................................................................................................. 8

Chapter 2: Methods ......................................................................................................................... 10

Vagally Mediated Heart Rate Variability ....................................................................................... 11
Self-Report Measures ........................................................................................................ 12

Index of Rumination: Ruminative Response Scale ................................................. 12

Index of Anxiety: Spielberg State-Trait Anxiety Inventory ................................ 13

Statistical Analyses ........................................................................................................ 13

Chapter 3: Results ........................................................................................................ 16

Descriptive Statistics ..................................................................................................... 16

Correlations ..................................................................................................................... 16

Moderation Analyses and Conditional Effects .......................................................... 17

Chapter 4: Discussion ................................................................................................... 20

Implications: Compensation in Perseveration ......................................................... 21

Limitations and Future Directions .............................................................................. 22

Conclusion ...................................................................................................................... 23

References ...................................................................................................................... 24

Appendix A ..................................................................................................................... 33

Appendix B ..................................................................................................................... 41

Appendix C ..................................................................................................................... 48
List of Tables

Table 1: HRV Group Comparisons for Variables of Interest ........................................... 33
Table 2: Sex Group Comparisons for Variables of Interest ........................................... 35
Table 3: Zero-order and Partial r Correlation Matrices .................................................... 37
Table 4: Zero-order Matrices Split by Sex ........................................................................ 38
Table 5: Partial r Correlation Matrices Split by Sex ......................................................... 39
Table 6: Partial r Correlation Matrices Split by Sex & Controlling for Other Facets of
Rumination ....................................................................................................................... 40
List of Figures

Figure 1. Conceptual Moderation Model (Model 1) .................................................. 41
Figure 2. Statistical Moderation Model (Model 1) ....................................................... 42
Figure 3. Graphical representation of the Moderating Effect of Sex .......................... 43
Figure 4. Conceptual Moderated Mediation Model (Model 58) ............................... 44
Figure 5. Statistical Moderated Mediation Model (Model 58) ................................. 45
Figure 6. Conceptual Moderated Mediation Model (Model 7) ................................. 46
Figure 7. Statistical Moderated Mediation Model (Model 7) ..................................... 47
Perseverative cognition, often characterized as maladaptive or detrimental to wellbeing, is the repetitive or persistent activation of cognitive representations of a real or imagined stressor (Brosschot, Gerin, & Thayer, 2006). Heart rate variability (HRV) is defined as the beat-to-beat variability in the time in between consecutive heartbeats (Task Force, 1996). Higher resting state HRV is typically associated with better outcomes such as flexible and context appropriate control of cognitions and behaviors, mediated by activity of frontal brain regions (Thayer et al., 2012). This may be because lower HRV is associated with lower inhibitory control and difficulties in emotion regulation (Thayer & Brosschot, 2005; Williams et al., 2015). Emotion regulation is the process by which individuals adapt their emotional experiences, expressions, and physiological responses to environmental demands (Aldao, 2013). The Perseverative Cognition Hypothesis therefore theorizes that lower HRV may indicate a predisposition to engage in perseverative cognition (Brosschot et al., 2006; Brosschot et al., 2010; Verkuil et al., 2010; Thayer & Lane, 2002). There is a bounty of evidence in the literature to substantiate sex differences in both resting-state vagally mediated HRV (see Koenig, J., & Thayer, J. F., 2016 for view) and emotion regulation (Domes et al., 2010; Stevens & Hamann, 2012). However, the findings of such studies regarding emotion regulation are
mixed (e.g., Amelang & Steinmayer, 2006; Craig et al., 2009; Extremera et al., 2007; Mak et al., 2009; Mikolajczak et al., 2007). Interestingly, research suggests that sex moderates the aforementioned association between HRV and emotion regulation abilities (Williams et al., under review). Following this line of investigation, the current study examines the extent to which there may be sex differences in the established relationship between HRV and an emotion regulation strategy, perseverative cognition. Specifically, the study evaluates a potential moderating effect of sex on the association between HRV and facets of rumination, and whether this potential moderating effect may impact negative outcomes such as anxiety.

Reflective Perseverative Cognition

Two fundamental elements driving perseverative cognition are worry and rumination (see Brosschot, Gerin, & Thayer, 2006, for review). While worry is defined as repetitive thinking of possible future events or outcomes, rumination is repetitive thinking of past events or outcomes (Nolen-Hoeksema, Wisco, Lyubomirsky, 2008). The ruminative subtype of perseverative cognition has previously been discussed as multidimensional and as such, three facets have been identified: depressive rumination (sadness and despair), brooding rumination (wallowing and sulking), and reflective rumination (problem solving and analyzing; Treynor, Gonzalez, Nolen-Hoeksema, 2003). While the depressive and brooding subtypes of rumination have commonly been linked to symptoms and the development of depressive disorders (Verstraeten et al., 2010; Treynor et al., 2003; Kwon & Olson, 2007; Raes & Hermans, 2008; Joireman et al., 2002; Rude, Maestes, & Neff, 2007; Takano & Tanno, 2009; Trapnell & Campbell, 1999), the impact
of reflective rumination is unclear. In summary, there are studies indicating positive (Roelofs et al., 2008; Rude et al., 2007; Verhaeghen, Joormann, & Khan, 2005), negative (Treynor et al., 2003; Crane, Barnhofer, & Williams, 2007; Arditte & Joormann, 2011), and zero (Burwell & Shirk, 2007; O’Connor & Noyce, 2008; Cox, Funasaki, Smith, & Mezulis, 2012) correlations between reflection and depressive symptoms.

The Perseverative Cognition Hypothesis

The Perseverative Cognition Hypothesis (Brosschot et al., 2006) proposes that excessive perseveration is particularly common among individuals with difficulties in recognizing safety signals. For such individuals, the fight-or-flight response is sustained for longer periods of time and this prolonged physiological activation can negatively impact psychological and physiological health (Brosschot et al., 2006; 2010). For example, perseverative cognition has been established as a key mechanism in the connection between stress vulnerability and poor psychological outcomes including the development of Generalized Anxiety Disorder (GAD) and Major Depressive Disorder (MDD; Verkuil, Brosschot, Gebhardt, & Thayer, 2010).

There is research suggesting anatomical and functional pathways from orbitofrontal, and medial prefrontal cortices (PFC) to the amygdala (Barbas, Saha, Rempel-Clower, & Ghashghaei, 2003). For example, projections from the prefrontal cortex which are mediated by gamma-Aminobutyric acid (GABA) have been shown to inhibit autonomic excitatory output from the amygdala to the cortex (Thayer, 2006; Davidson, 2000). The Perseverative Cognition Hypothesis posits that the neural concomitants of perseveration include brain regions in the cortex which are associated
with appraisal and coping, such as the PFC and anterior cingulate cortex (ACC; Poldrack, Russell, Ochsner, & Gross, 2008), as well as subcortical structures linked to threat, namely the amygdala (Anderson et al., 2004; Brosschot, et al., 2006; Verkuil et al., 2010; Thayer & Lane, 2002). Fittingly, stress vulnerability, which may lead to perseverative cognition, is marked by hypoactivity of the PFC and hyperactivity of the amygdala while at rest, when objectively there is no threat present. It is proposed that engaging in perseveration creates a cognitive representation of a stressor which facilitates maintenance of a vigilant state that is thought to be the product of both heightened attention to negative stimuli (indicated by hyperactivity of the amygdala) and deficits in safety recognition (indicated by hypoactivity of the PFC and ACC; see Verkuil et al., 2010 for review). This idea is not unique to the Perseverative Cognition Hypothesis, as converging evidence via imaging studies have also supported this framework. For example, both decreased activity of the PFC and ACC and increased activity of the amygdala are associated with perseverative tendencies such as task induced ruminative self-focus (Cooney, Joormann, Eugène, Dennis, & Gotlib, 2010). In contrast to this maladaptive pattern of neural activity, it appears that individuals without such tendencies and associated stress vulnerability show greater inhibitory control via the PFC.

This bi-directional communication between executive regions of the brain and subcortical autonomic structures may be reflected in autonomic nervous system (ANS) activity (Thayer & Lane, 2009; Thayer et al., 2012). Broadly speaking within the ANS, studies have shown that activity of the PFC is associated with activity of the parasympathetic nervous system (PNS) and activity of the amygdala is associated with
the heightened threat response of the sympathetic nervous system (SNS)—when the organism is at rest (Thayer & Lane, 2000). Successful inhibition of the influence of the SNS is vital to maintaining autonomic balance in which clear threat stimuli, rather than irrelevant neutral stimuli, trigger the “brake pedal” of the PNS to let up and the “acceleration” of the SNS to take over. Therefore those without stress vulnerability, marked by high PFC activity in a non-threatening state, exhibit adaptive cortical modulation of the ANS. Specifically, brain regions (e.g., PFC, ACC) associated with the PNS successfully inhibit the fight-or-flight response of the SNS while at rest. This distinction between the typical or adaptive pattern of ANS activity and that described in the Perseverative Cognition Hypothesis suggests that perseveration may lead to not only poor mental health outcomes, but also changes to physiological function and health (Brosschot et al., 2009; Thayer & Lane, 2009).

Heart Rate Variability

The heart (as well as many other important organs) is under tonic inhibitory control of the PNS (Yamamoto & Brosschot, 2009). The PNS is vital to adaptive regulation of physiological functions, such as inflammatory and cardiovascular processes. Resting HRV has been identified as an index of activity of the PNS—also referred to as activity of the vagus nerve, the primary nerve of the PNS—and has been linked with activity of brain areas associated with emotion regulation. For instance, one meta-analysis showed that resting HRV was positively correlated with regional cerebral blood flow in both the PFC and ACC across multiple fMRI investigations (Thayer et al., 2012).
This study, along with multiple behavioral studies, supports the idea that activity of the vagus is associated with that of executive brain regions, and therefore indexes an individual’s ability or readiness to regulate emotions and engage in other self-regulatory processes. For example, resting HRV is predictive of self-reported emotion regulation (Williams, Cash, Rankin, Bernardi, Koenig, & Thayer, 2015) and cognitive control (Anderson et al., 2004; Williams, Thayer & Koenig, 2016). Also, previous research has linked greater cardiac flexibility to the ability to engage in adaptive emotion regulation strategies (Aldao & Mennin 2012).

In line with this notion, lower HRV reflects greater stress vulnerability for engaging in perseverative cognition (Brosschot et al., 2006; Brosschot et al., 2010; Verkuil et al., 2010; Thayer & Lane, 2002). As HRV may reflect activity of the PFC, this activity is disinhibited during perseverative cognition (Brosschot et al., 2006, 2010; Thayer & Friedman, 2002). As such, resting HRV may predict whether an individual is more likely to participate in perseverative cognition and therefore at an elevated risk for negative psychological and physiological consequences. For example, a recent study evaluated the relationship between resting HRV and the depressive, brooding, and reflective facets of rumination. It found that HRV was associated with maladaptive (depressive and brooding facets) but not potentially neutral (reflective facet) rumination. Moreover, this study found maladaptive, but not neutral, facets of rumination carried the relationship between resting HRV and trait anxiety. These results provide additional evidence of resting HRV as a marker for stress vulnerability, which can lead to greater perseveration and negative outcomes such as anxiety. However, recent research suggests
that men and women may differ in the activity of the very brain areas responsible for the regulation of both HRV and perseverative cognition.

**Evidence of Sex Differences in HRV and Perseverative Cognition**

There are documented sex differences in resting-state HRV such that women demonstrate relatively higher resting HRV on average compared to men (Koenig & Thayer, 2016). Of note, HRV is positively associated with activity of the PFC (see Thayer, Ahs, Fredrickson, Sollers, & Wager, 2012, for review), negatively associated with difficulties in emotion regulation (see Thayer & Lane, 2000, for review; Williams, Cash, Rankin, & Bernardi), and negatively associated with poor health outcomes (Thayer & Lane, 2007; Thayer & Sternberg, 2006; Thayer & Sternberg; 2011; Thayer, Yamamoto, & Broschott, 2010). Women and men also differ in the structure and function of brain areas associated with emotion regulation and perseverative cognition such that women show greater amygdala reactivity to negative stimuli (Domes et al., 2010; Ruigrok et al., 2014; Stevens & Hamann, 2011). Importantly, neurophysiological and psychological studies suggest differential processing of emotions between the sexes via variance in activation of areas of the PFC and self-report of emotion regulation strategies, respectively (Domes et al., 2010; Koenig & Thayer, 2016; Stevens & Hamann, 2012; Thayer et al., 1998). In fact, some propose that these differences represent a compensatory mechanism in women whereby females exhibit greater frontal brain activation compared to men in response to increased amygdala activity (Drevets, 1999; Koenig & Thayer, 2016; Thayer, Rossy, Ruiz Padial, Johnsen, 2003; Thayer, Smith, Rossy, Sollers, & Friedman, 1998). Moreover, researchers propose that this
compensatory mechanism may be mediated by symptoms of depression and anxiety (Nolen-Hoeksema, 2001; Piccinelli & Wilkinson, 2000; Lewinsohn, Gotlib, Lewinsohn, Seeley, & Allen, 1998; Bruce et al., 2005). These findings provide a neurophysiological basis for sex differences in emotion regulation.

A recent study found that sex moderated the link between resting HRV and self-reported difficulties in everyday emotion regulation such that women showed a significantly stronger negative association between resting HRV and emotion regulation difficulties than men (Williams et al., under review). This finding contributes to the body of research demonstrating a compensatory mechanism in women but not men. Overall, sex appears to be an important factor in the relationship between stress vulnerability, as indexed by lower resting HRV, and overall emotional regulation. However, research has not yet examined how the relationship between stress vulnerability and perseverative cognition may change as a function of sex.

Present Study

As mentioned above, a recent study showed a negative association between resting HRV and varying facets of self-reported rumination. Results suggested that not all perseverative cognition, specifically reflective rumination, contribute to the relationship between stress vulnerability and the development of psychological problems such as anxiety (Williams et al., under review). However, that investigation did not examine the potential moderating effect of sex on the link between resting HRV and rumination.

Analysis of the potential sex difference in the direction and magnitude of the association between HRV and perseverative cognition is necessary to contribute to the
limited understanding of the link between HRV and different facets of rumination.
Investigation of processes that may influence rumination is important because there is
evidence that rumination may function as a mechanism through which the activity of the
PNS impacts psychological outcomes such as trait anxiety.

If higher resting HRV acts as a compensatory mechanism for the heightened
processing of negative emotions in women compared to men (Koenig & Thayer, 2016;
Thayer et al., 1998; Thayer et al., 2003), and sex differences exist in the relationship
between HRV and difficulties in emotion regulation, then it is plausible that men and
women may differ in the association between resting HRV and perseverative cognition. It
is hypothesized that resting HRV will be negatively correlated with self-reports of
rumination in both men and women. However, the association between HRV and
reflective rumination (given previous differential findings among the three facets of
rumination) will be stronger in women than in men.
Chapter 2: Methods

Subjects were recruited from the Research Experience Program (REP) pool at The Ohio State University, allowing students to participate in research for partial class credit in an introductory level psychology course. Data were pooled across six studies conducted within the same lab. Each study was approved by the institutional review board, and all participants signed written informed consent. Funding from the Ohio State University College of Social and Behavioral Science and College of Arts and Sciences also allowed for recruitment and compensation of participants outside of the REP pool, resulting in a diverse sample across the university (i.e., students from various majors and cohorts). No individual participated in more than one of the six studies.

A total of 289 participants’ (168 females, 106 ethnic minorities, mean age = 19.37, standard deviation = 1.93) data were available for analysis. All participants were asked not to smoke, undergo vigorous physical activity, or drink caffeine 6 hours prior to the experiment. A portion of these data has been published elsewhere; however, the current investigation expands on the previous project with the use of the data of additional participants in a much larger collection (Williams et al., under review).

In all studies, participants were placed in a soundproof experimental room, equipped with a camera and microphone for safety and instructional reasons and high definition TV for stimuli presentation. Participants were given a detailed explanation of
the study procedures without information about the specific hypotheses or manipulations applied. ECG leads were attached to the subjects. Meanwhile in a separate control room, the experimenter led the subjects through the initial phases of the experiment. Participants first completed a 5-minute baseline period during which they sat in a resting position with the television displaying a blank, grey screen. During this baseline period, participants were instructed not to move or fall asleep (spontaneous breathing). The total duration for each data collection was approximately 60 minutes.

_Vagally Mediated Heart Rate Variability_

Heart rate was recorded continuously throughout each experiment via a 3-lead ECG at a 1000 Hz sampling rate using Mindware™ 2000D (MW2000D) Impedance Cardiograph package. Heart rate was measured in beats per minute. Electrodes were placed (1) below the right clavicle, (2) on the left side of the abdomen (below the heart, and (3) on the right side of the abdomen. Participants’ successive inter beat intervals (IBIs)—also known as the time between R-spikes—, in milliseconds, were extracted using HRV 3.25 Analysis software. IBIs were written in a text file and analyzed using Kubios HRV analysis package 2.0 (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014; [http://kubios.uku.fi/](http://kubios.uku.fi/)), allowing for the calculation of time and frequency domain indices of resting HRV. Artifacts within the R-to-R series were visually detected and an artifact correction level was applied. This tool differentiated and removed artifacts (IBIs that differed significantly from the mean IBI) using piecewise cubic spline interpolation method. All analyses were conducted in accordance with the Task Force (1996) guidelines. The primary time-domain measure of HRV was the root
mean square of the successive differences (RMSSD). RMSSD primarily reflects PNS influence over the heart (Task Force of the European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996; Thayer, Hansen, & Johnsen, 2010) and is considered a stable (Li et al., 2009) and valid (Thayer et al., 2010) time domain measure of HRV. RMSSD values were log transformed (ln) to better approximate a normal distribution in order to meet the assumptions of linear analyses (Thayer, Hansen, & Johnsen, 2010). High frequency values of HRV were highly correlated with RMSSD ($r = .91$) and were therefore excluded from this report to avoid redundancy (Williams et al., 2015). Lastly, high frequency peak (HFpeak) values were obtained from the spectral analysis as a measure of respiratory frequency to control for the potential influence of respiration on HRV (for review see Thayer, Loerbroks, & Sternberg, 2011; Thayer, Sollers, Ruiz-padial, & Vila, 2002).

**Self-Report Measures**

**Index of Rumination: Ruminative Response Scale**

Trait level rumination was assessed using the 22-item Ruminative Responses Scale (RRS; Treynor, Gonzalez, Nolen-Hoeksema, 2003). Participants endorsed ruminative responses (sample item: *How often do you think about how alone you feel?*) on a scale from 1 (*almost never*) to 4 (*almost always*), with higher values representing higher trait rumination (Cronbach’s $\alpha = .922$). The RRS contains three subscales used to assess the aforementioned forms of rumination, including (i) brooding (wallowing and sulking; 5-items; $\alpha = .759$), (ii) depressive (sadness and despair; 12-items, $\alpha = .886$), and
reflective (analytical thinking; 5-items; $\alpha = .773$) rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

*Index of Anxiety: Spielberg State-Trait Anxiety Inventory*

The 20-item trait portion of the Spielberg State-Trait Anxiety Inventory (STAI-T) was utilized to assess trait feelings of anxiety (Spielberger, Gorsuch, & Luchene, 1970). Participants rated how they generally feel about statements regarding anxiety (sample item: *I take disappointments so keenly that I can’t put them out of my mind*) on a scale from 1 (almost never) to 4 (almost always) where higher scores reflect greater trait anxiety. The STAI-T shows high internal consistency ($\alpha = .898$). Because this project combined participants from multiple data collections with separate primary aims, the number of individuals within the sample for whom there is trait anxiety data ($n = 209$, 55% women and 38% minority with 105 individuals within the high HRV group) is less than the total sample.

*Statistical Analyses*

All statistical tests were conducted using SPSS (ver. 23, IBM Chicago, IL, USA). The use of median split has been commonly been performed throughout the literature regarding HRV, therefore the same practice was utilized on lnRMSSD (median value = 3.782) in the current study to stratify participants into high and low resting HRV groups for ease of comparison to prior studies. Independent samples t-tests were conducted to examine between-group differences as well as sex differences among all included variables. Zero-order correlation (Pearson’s r) tests were performed in order to test the
association between lnRMSSD, heart rate, RRS scores (including subscales), and STAI scores. Partial r correlation coefficients were also used to tests these relationships while also accounting for several important covariates.

An SPSS custom dialog called PROCESS (Hayes, 2012) was utilized to conduct analyses determining whether sex may moderate the association between HRV and trait rumination (total as well as subscale scores). In PROCESS, “Model 1” enabled us to specify an independent variable (IV: resting HRV), a moderating variable (M: Sex), and a dependent variable (DV: total, depressive, brooding, and reflective trait rumination). Important covariates were also included in this model. Bootstrapping confidence intervals (CI; 95% interval) with a sampling rate of 10,000 were used to determine the significance of each moderating effect. Statistics reported include unstandardized betas (B), standard error (SE), and the bootstrapping CI’s (lower limit, upper limit) for each model. See Figures 1 and 2 for the conceptual and statistical models respectively.

PROCESS (Hayes, 2012) was also utilized to conduct analyses determining whether sex may moderate the indirect effect of HRV on trait anxiety through rumination. In PROCESS, “Model 58” and “Model 7” enabled us to specify an independent variable (IV: resting HRV), a dependent variable (DV: trait anxiety), a mediating variable (M: reflective rumination), and a moderating variable (W: Sex). “Model 58” tests moderation on each of the two-legged mediation and “Model 7” tests a single-legged moderation. The same covariates discussed above were also included in this model. Bootstrapping confidence intervals (CI; 95% interval) with a sampling rate of 10,000 were used to determine the significance of each indirect effect. See Figures 4 and
5 for the conceptual and statistical representations of Model 58 and Figures 6 and 7 for the corresponding diagrams for Model 7.

Ethnic differences exist in resting HRV (Hill, et al., 2015), therefore ethnicity was included as a covariate (coded as 1 = European American, 2 = Other). Other covariates suggested to influence HRV included respiration (as indexed by HF peak values; Thayer et al, 2002), age (in years; Choi et al., 2006), and BMI (kg/m^2; Koenig et al., 2014; Williams et al., 2016). Study code was also included as a covariate to control for potential bias by pooling data across seven studies. In sum, age, ethnicity, respiration, BMI, and experiment number were controlled for in all partial r analyses and moderation analyses.
Chapter 3: Results

Descriptive Statistics

Group analyses indicated that individuals with lower resting HRV reported higher heart rate, trait anxiety, and trait rumination (including each of the three facets) compared to those with higher resting HRV ($p < .01$; see Table 1 for means and standard deviations for both high and low resting HRV groups). Apart from BMI ($p < .01$) and heart rate ($p < .01$), there were no significant group differences between men and women (see Table 2 for means and standard deviations for both men and women).

Correlations

Zero order correlations suggested that lower resting HRV was associated with higher heart rate ($r = - .67, p < .01$) as well as higher reports of trait anxiety ($r = - .30, p < .01$), total rumination ($r = - .25, p < .01$), depressive rumination ($r = - .28, p < .01$), brooding rumination ($r = - .19, p < .01$), and reflective rumination ($r = - .13, p < .05$). See Table 3A for zero order correlations in the total sample.

Partial r correlations controlling for important covariates including, age, ethnicity, BMI, respiration, and study code, showed significant negative associations between resting HRV and heart rate ($r = - .63, p < .01$), trait anxiety ($r = - .30, p < .01$), total rumination ($r = - .24, p < .01$), depressive rumination ($r = - .27, p < .01$), and brooding rumination ($r = - .15, p < .01$), but not between HRV and reflective rumination ($r = - .12, p
See Table 3B for partial r correlation coefficients between all variables. However, upon examination of the same correlations among men and women separately, there were significant differences between the sexes. Women exhibited the same negative correlations between HRV and heart rate \((r = -.69, p < .01)\), trait anxiety \((r = -.34, p < .01)\), total rumination \((r = -.33, p < .01)\), depressive rumination \((r = -.35, p < .01)\), and brooding rumination \((r = -.19, p < .01)\), as well as a now significant correlation between HRV and reflective rumination. In men, there only remained a negative correlation between HRV and both heart rate \((r = -.22, p < .01)\) and trait anxiety \((r = -.23, p < .05)\). It is important to note that these correlation coefficients did not significantly differ from one another. See Table 4 for zero order correlations among all variables for men and women, respectively. See Table 5 for partial r correlations among all variables for men and women, respectively.

**Moderation Analyses and Conditional Effects**

Controlling for the aforementioned covariates, sex did not significantly moderate the relationship between HRV and total rumination \((\Delta R^2 = .0083, F(1, 280) = 4.08, B = -4.49 \text{ (SE = 2.80), [-9.99, 1.02], } p = .110)\), depressive rumination \((\Delta R^2 = .0084, F(1, 280) = 2.62, B = -2.41 \text{ (SE = 1.49), [-5.33, .52], } p = .107)\), or brooding rumination \((\Delta R^2 = .0003, F(1, 280) = .1051, B = -.254 \text{ (SE = .78), [-1.79, 1.29], } p = .746)\). Sex did however significantly moderate the association between HRV and reflective rumination \((\Delta R^2 = .01, F(1, 280) = 4.08, B = -1.63 \text{ (SE = .81), [-3.22, -.04], } p = .044)\). Conditional analyses showed a significant negative association between HRV and reflective rumination in
women (B = -1.58 (SE = .51), [-2.57, -.58], p = .002), but not men (B = .16 (SE = .61), [-1.05, 1.05], p = .79; see Figure 3).

Two moderated mediation models were used to investigate whether a conditional effect of sex may impact the indirect effect of HRV on trait anxiety via reflective rumination. Figures 5 and 7 summarize these models. Figure 5 shows PROCESS Model 58, which included sex as a moderator of both the “a” and “b” pathways (see Figure 4 for conceptual illustration). The bootstrapped estimate of the indirect effect of the model was significant for women (point estimate = -2.29, 95% CI; -4.57, -.78) but nonsignificant for men (point estimate = .34, 95% CI(-1.02, 2.23)), suggesting sex differences in the link between HRV and anxiety, though reflective rumination. This may support the idea that reflective rumination may serve as part of a compensatory mechanism in women. The moderating effect of sex on individual pathways was also explored. The interaction of HRV and sex predicting reflective rumination was significant (B = -2.26, (SE = .97), [-4.17, -.36], p = .02), suggesting a moderating effect of sex in the “a” pathway. With regard to the “b” pathway, the interaction of reflective rumination and sex predicting trait anxiety was not significant (B = .04, (SE = .39), [-.74, .81], p = .92). Thus, the moderating effect of HRV seemed to be present in the “a” path but not the “b” path. Figure 7 shows PROCESS Model 7, which included sex as a moderator for only the “a” pathway (see Figure 6 for conceptual illustration). The bootstrapped estimate of the indirect effect of the model was significant for women (point estimate = -2.26, 95% CI; -4.30, -.80)) but nonsignificant for men (point estimate = .34, 95% CI(-1.15, 1.90)), confirming the results of PROCESS Model
58. The interaction of HRV and sex predicting reflective rumination in Model 7 was also significant (B = -2.26, (SE = .97), [-4.17, -.36], p = .02).
Chapter 4: Discussion

The purpose of the current investigation was to explore the possible moderating effect of sex on the association between resting HRV and facets of perseveration. Results indicated that all individuals with lower resting HRV reported higher trait rumination (total scores and each of the three subscale scores) compared to those with higher resting HRV. Controlling for age, ethnicity, BMI, respiration, and study code, sex significantly moderated the association between HRV and reflective rumination such that the relationship was significant for women, but not men. Sex did not significantly moderate the relationship between HRV and total rumination, depressive rumination, or brooding rumination. Extending these findings to associated psychological outcomes, results also suggest that sex may act as a moderator of the established indirect effect of HRV on trait anxiety via reflective rumination only. This is the first study to provide direct evidence that women, but not men, with lower resting HRV report higher reflective rumination, a form of perseverative cognition that is typically characterized as adaptive or not harmful (Williams et al., under review). Overall, results suggest that the relationship between resting HRV and perseveration, particularly reflective rumination may be more complex when considering sex differences. In women in particular, there appears to be a strong link between HRV and reflective rumination suggesting that this form of perseveration may be more maladaptive in women relative to men.
Implications: Compensation in Perseveration

The results of the present study build upon previous research describing depressive and brooding rumination as maladaptive and reflective rumination as non-harmful (Williams et al., *under review*). In my current results, the negative association between HRV and reflective rumination is significant for women, but not for men. Partial correlations controlling aforementioned covariates show that the association between reflective rumination and HRV in women is no longer significant ($r = -.046, p = .638$; see Table 6) when also controlling for the brooding and depressive facets of rumination. This is in line with previous research highlighting the overlap between the brooding and reflective facets of rumination (Vasey et al., in preparation; Takano & Tanno, 2009) and implies that these forms of perseverative cognition may share important variance in the link between HRV and reflective rumination in women but not men. These findings may also support the assertion by Heath (2016) that the RRS fails to distinguish between the brooding and reflective facets of rumination as well as capture the potentially adaptive nature of reflection. Reflective rumination mediated the relationship between HRV and trait anxiety in women, but not men. Women with high HRV did not appear to neither engage in this type of perseverative cognition nor show greater anxiety, seemingly having displayed successful compensation. These data therefore suggest reflective rumination as a more maladaptive form of perseverative cognition in women compared to men. Overall, reflective rumination seems to be non-harmful for men and maladaptive for women; here, I propose that research should not only consider different facets of perseverative
cognition, but also sex, in the link between stress vulnerability (i.e., HRV) and negative psychological outcomes (i.e., anxiety).

Limitations and Future Directions

One limitation of the current investigation is that it is cross-sectional and therefore causation cannot be determined. Research has described resting HRV as an endophenotype (Thayer & Lane, 2009), and it is therefore likely that resting HRV represents the integrity and flexibility of the neurophysiological pathway responsible for emotion regulation, which subsequently impacts emotion regulation strategies such as rumination. On the other hand, research also proposes that maladaptive/adaptive emotion regulation decreases/increases HRV reactivity (e.g., Aldao et al., 2013). Thus, it is plausible that those who are maladaptive in their emotional responding may have subsequent maladaptive chronic physiological responses. Future research should address how sex differences in neurophysiological pathways of emotion regulation impact both acute and chronic psychological (e.g., anxiety and depression) and physiological (e.g. HRV, cortisol) well-being.

A second consideration is that this study has solely discussed trait perseverative cognition, specifically self-report of general ruminative tendencies rather than state perseveration or reactivity to stressors. Future research on emotion regulation strategies and activity of the autonomic nervous system may benefit from examining state dependent reactions, as previous studies have found state perseveration to be associated with other measures of physiological activation such as cortical awakening response,
cortical reactivity to stressors, and basal cortisol (Zoccola, Dickerson, & Ilona, 2010; McCullough et al., 2007; Zoccola et al., 2008).

A third limitation is that we did not observe the significant difference in HRV between men and women in line with the literature discussed above. This study did however find heart rate to be significantly greater on average among women as opposed to men. Greater heart rate is a well-known risk factor for cardiovascular and other related diseases; however women have consistently displayed greater heart rate than men, without showing increased rates of mortality and morbidity compared to men (Cordero and Alegria, 2006). In fact, studies have shown that heart rate does not have the same predictive power for mortality and morbidity in women as it does in men (Palatini, 2001; Sacha, 2014). A meta-analysis by Koenig and Thayer (2016) proposes that this paradoxical situation is likely due to greater HRV (vagal tone) found in women. Future research should replicate our results in a sample of women who show significantly greater resting HRV compared to men.

Conclusion

This pattern of data is similar to aforementioned sex differences in the association between resting HRV and emotion regulation abilities, and extends them to the domain of emotion regulation strategies (i.e., rumination). Overall, the current results have implications for the Perseverative Cognition Hypothesis, suggesting that there may be sex differences in the effect of stress vulnerability, as indexed by HRV, on psychological outcomes such as anxiety through varying facets, in this instance reflective rumination, perseverative cognition.
References


### Appendix A

#### Table 1: HRV Group Comparisons for Variables of Interest

<table>
<thead>
<tr>
<th></th>
<th>Range of Data (min, max)</th>
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<th>Low HRV</th>
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<th>$p$</th>
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</thead>
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<tr>
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<td>145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
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<td>19.53 (2.09)</td>
<td>19.20 (1.75)</td>
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<td>.141</td>
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<td>BMI</td>
<td>14.98, 47.51</td>
<td>23.74 (4.72)</td>
<td>23.76 (4.81)</td>
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<td>.977</td>
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<td>Resting HRV</td>
<td>2.29, 5.18</td>
<td>4.21 (0.29)</td>
<td>3.40 (0.29)</td>
<td>-23.89</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Respiration</td>
<td>.15, .40</td>
<td>.256 (.053)</td>
<td>.254 (.062)</td>
<td>-.298</td>
<td>.766</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>39.41, 102.11</td>
<td>67.47 (9.55)</td>
<td>79.85 (8.51)</td>
<td>11.63</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Trait Anxiety</td>
<td>22, 74</td>
<td>39.09 (10.30)</td>
<td>44.01 (10.35)</td>
<td>3.45</td>
<td>.001</td>
</tr>
<tr>
<td>Total Rumination</td>
<td>22, 76</td>
<td>40.38 (11.11)</td>
<td>45.83 (11.66)</td>
<td>4.07</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Depressive</td>
<td>11, 40</td>
<td>20.02 (5.98)</td>
<td>22.92 (6.16)</td>
<td>4.06</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Brooding</td>
<td>5, 20</td>
<td>9.70 (3.02)</td>
<td>11.01 (3.31)</td>
<td>3.51</td>
<td>.001</td>
</tr>
<tr>
<td>Reflective</td>
<td>5, 20</td>
<td>9.00 (3.33)</td>
<td>9.93 (3.23)</td>
<td>2.41</td>
<td>.016</td>
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</table>

Note. Table 1 gives the range of data, mean, and standard deviation (in brackets) values on baseline measures. Independent samples t-test statistics include both $t$ and $p$ values on the difference between high and low HRV groups (significant $p$ values bolded). Age was
Table 1 continued

measured in years; body mass index (BMI) was measured in kg/m²; Resting HRV is represented as the natural log transform of the root mean square of successive differences in milliseconds (lnRMSSD); Heart Rate is measured in beats per minute; Trait Anxiety was indexed using the 20-item Spielberger Trait Anxiety Inventory; Total Rumination represents total score on the Ruminative Reponses Scale (RRS); “Depressive”: depressive rumination subscale of RRS; “Brooding”: brooding rumination subscale of RRS; “Reflective”: reflective rumination of the RRS.
Table 2: Sex Group Comparisons for Variables of Interest

<table>
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<th>Range of Data (min, max)</th>
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<td>168</td>
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<td>Age</td>
<td>18, 30</td>
<td>19.55 (2.01)</td>
<td>19.24 (1.87)</td>
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<td>BMI</td>
<td>14.98, 47.51</td>
<td>24.72 (4.93)</td>
<td>23.06 (4.53)</td>
<td>2.93</td>
<td>.004</td>
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<tr>
<td>Resting HRV</td>
<td>2.29, 5.18</td>
<td>3.83 (0.48)</td>
<td>3.78 (0.50)</td>
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<td>.419</td>
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<td>Respiration</td>
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<td>.254 (.060)</td>
<td>.255 (.057)</td>
<td>-.161</td>
<td>.872</td>
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<td>Heart Rate</td>
<td>39.41, 102.11</td>
<td>71.63 (10.56)</td>
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<td>.006</td>
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<tr>
<td>Trait Anxiety</td>
<td>22, 74</td>
<td>41.44 (10.19)</td>
<td>41.62 (10.96)</td>
<td>-.124</td>
<td>.902</td>
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<td>Total Rumination</td>
<td>22, 76</td>
<td>42.75 (10.87)</td>
<td>43.38 (12.28)</td>
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<td>.646</td>
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<td>Depressive</td>
<td>11, 40</td>
<td>21.52 (5.76)</td>
<td>21.44 (6.57)</td>
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<td>.912</td>
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<tr>
<td>Brooding</td>
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<td>10.18 (3.08)</td>
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<td>Reflective</td>
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<td>9.31 (3.21)</td>
<td>9.58 (3.38)</td>
<td>-.710</td>
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Note. Table 2 gives the range of data, mean, and standard deviation (in brackets) values on baseline measures. Independent samples t-test statistics include both t and p values on the difference between male and female sex groups (significant p values bolded). Age was measured in years; body mass index (BMI) was measured in kg/m²; Resting HRV is represented as the natural log transform of the root mean square of successive differences.
Table 2 continued

in milliseconds (lnRMSSD); Heart Rate is measured in beats per minute; Trait Anxiety was indexed using the 20-item Spielberger Trait Anxiety Inventory; Total Rumination represents total score on the Ruminative Responses Scale (RRS); “Depressive”: depressive rumination subscale of RRS; “Brooding”: brooding rumination subscale of RRS; “Reflective”: reflective rumination of the RRS.
Table 3: Zero-order and Partial r Correlation Matrices

(A) Zero-order Correlation Coefficients

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<td>Heart Rate</td>
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<td>Trait Anxiety</td>
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<td>.238**</td>
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<td>.942**</td>
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<td>Brooding</td>
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<td>.828**</td>
<td>.699**</td>
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<td>-.132*</td>
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<td>.413**</td>
<td>.780**</td>
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(B) Partial r Correlation Coefficients

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<td>HRV</td>
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<td>Heart Rate</td>
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<td>Trait Anxiety</td>
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<td>Rumination</td>
<td>-.239**</td>
<td>.178*</td>
<td>.720**</td>
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<td>Depressive</td>
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<td>.942**</td>
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<tr>
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<td>.635**</td>
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<td>.775**</td>
<td>.604**</td>
<td>.5493**</td>
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Note. Table 3A represents zero-order correlations between variables of interest and Table 3B represents partial correlations controlling for ethnicity, experiment, sex, body mass index, respiration, and age. “HRV” represents resting HRV (the natural log transform of the root mean square of successive differences; lnRMSSD); “Heart Rate” is measured in beats per minute; “Trait Anxiety” was indexed using the 20-item Spielberger Trait Anxiety Inventory; “Rumination”: represents total scores on the Ruminative Responses Scale (RRS); “Depressive”: depressive rumination subscale of RRS; “Brooding”: brooding rumination subscale of RRS; “Reflective”: reflective rumination of the RRS. *p < .05  **p < .01
Table 4: Zero-order Matrices Split by Sex

(A) Males

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<td>3. Trait Anxiety</td>
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<td>4. Rumination</td>
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<td>5. Depressive</td>
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<td>6. Brooding</td>
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<td>.822**</td>
<td>.677**</td>
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<td>7. Reflection</td>
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<td>.753**</td>
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(B) Females

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*Note. Table 4A represents zero-order correlations between variables of interest for men and Table 4B represents zero-order correlations between variables of interest for women. “HRV” represents resting HRV (the natural log transform of the root mean square of successive differences; lnRMSSD); “Heart Rate” is measured in beats per minute; “Trait Anxiety” was indexed using the 20-item Spielberger Trait Anxiety Inventory; “Rumination”: represents total scores on the Ruminative Responses Scale (RRS); “Depressive”: depressive rumination subscale of RRS; “Brooding”: brooding rumination subscale of RRS; “Reflective”: reflective rumination of the RRS.

*p < .05  **p < .01
Table 5: Partial $r$ Correlation Matrices Split by Sex

**Male**

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<td>2. Heart Rate</td>
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<td>.669**</td>
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<tr>
<td>7. Reflection</td>
<td>.050</td>
<td>.022</td>
<td>.338**</td>
<td>.726**</td>
<td>.512**</td>
<td>.461**</td>
<td>-</td>
</tr>
</tbody>
</table>

**Female**

<table>
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<tr>
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<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>1. HRV</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Heart Rate</td>
<td>-.638**</td>
<td>-</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3. Trait Anxiety</td>
<td>-.314**</td>
<td>.154</td>
<td>-</td>
<td></td>
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<tr>
<td>4. Rumination</td>
<td>-.322**</td>
<td>.132</td>
<td>.721**</td>
<td></td>
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<tr>
<td>5. Depressive</td>
<td>-.356**</td>
<td>.183</td>
<td>.725**</td>
<td>.950**</td>
<td>-</td>
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<td>6. Brooding</td>
<td>-.155</td>
<td>-.017</td>
<td>.632**</td>
<td>.829**</td>
<td>.708**</td>
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<td>7. Reflection</td>
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<td>.116</td>
<td>.447**</td>
<td>.804**</td>
<td>.661**</td>
<td>.515**</td>
<td>-</td>
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</table>

*Note.* Table 5 represents partial correlations controlling for ethnicity, experiment, body mass index, respiration, and age for men (5A) and women (5B) separately. “HRV” represents resting HRV (the natural log transform of the root mean square of successive differences; lnRMSSD); “Heart Rate” is measured in beats per minute; “Trait Anxiety” was indexed using the 20-item Spielberger Trait Anxiety Inventory; “Rumination”: represents total scores on the Ruminative Responses Scale (RRS); “Depressive”: depressive rumination subscale of RRS; “Brooding”: brooding rumination subscale of RRS; “Reflective”: reflective rumination of the RRS.

*p < .05   **p < .01
Table 6: Partial $r$ Correlation Matrices Split by Sex & Controlling for Other Facets of Rumination

(A) Males

<table>
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<tbody>
<tr>
<td>1. HRV</td>
<td>-</td>
<td></td>
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<td></td>
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<tr>
<td>2. Heart Rate</td>
<td>-.610**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trait Anxiety</td>
<td>-.233*</td>
<td>.269*</td>
<td>-</td>
<td></td>
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<tr>
<td>4. Reflection</td>
<td>.163</td>
<td>-.191</td>
<td>-.123</td>
<td>-</td>
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</tbody>
</table>

(B) Females

<table>
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<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HRV</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Heart Rate</td>
<td>-.613**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trait Anxiety</td>
<td>-.128</td>
<td>.087</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4. Reflection</td>
<td>-.046</td>
<td>.012</td>
<td>-.086</td>
<td>-</td>
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</tbody>
</table>

Note. Table 6 represents partial correlations controlling for ethnicity, experiment, body mass index, respiration, age for and both depressive and brooding facets of rumination for men (5A) and women (5B) separately. “HRV” represents resting HRV (the natural log transform of the root mean square of successive differences; lnRMSSD); “Heart Rate” is measured in beats per minute; “Trait Anxiety” was indexed using the 20-item Spielberger Trait Anxiety Inventory; “Reflective”: reflective rumination subscale of the Ruminative Responses Scale.

*p < .05  **p < .01
Appendix B

Figure 1. Conceptual Moderation Model (Model 1; Hayes, 2012)

Note. Figure 1 represents the moderation models conducted in the current study. HRV = vagally mediated natural log-transformed heart rate variability.
Figure 2. Statistical Moderation Model (Model 1; Hayes, 2012)

Note. $X = \text{HRV}$, $M = \text{Sex}$, $Y = \text{Reflective Rumination}$, and $XM = \text{HRV} \times \text{Sex}$
Figure 3. Graphical representation of the Moderating Effect of Sex

A: Note: Figure 3A represents the moderating effect sex has on the link between resting HRV and overall total rumination, as indexed by the RRS total score. Women with lower resting HRV report greater rumination in comparison to men, and this gap narrows as resting HRV increases. However, women with higher HRV show slightly less rumination compared to men – a gap that is projected to widen as HRV increases. A similar and significant pattern is seen when examining the reflective rumination subscale (Figure 3B).
Figure 4. Conceptual Moderated Mediation Model (Model 58; Hayes, 2012)

Note. Figure 4 represents the two-legged moderated mediation model conducted in the current study. HRV = vagally mediated natural log-transformed heart rate variability.
Figure 5. Statistical Moderated Mediation Model (Model 58; Hayes, 2012)

Note. $X = \text{HRV}$, $M_i = \text{Reflective Rumination}$, $Y = \text{Trait Anxiety}$, and $W = \text{Sex}$
Figure 6. Conceptual Moderated Mediation Model (Model 7; Hayes, 2012)

Note. Figure 6 represents the one-legged moderated mediation model conducted in the current study. HRV = vagally mediated natural log-transformed heart rate variability.
Figure 7. Statistical Moderated Mediation Model (Model 7; Hayes, 2012)

Note. \( X = \text{HRV}, M_i = \text{Reflective Rumination}, Y = \text{Trait Anxiety}, \) and \( W = \text{Sex} \)
Appendix C

Measures

Self-Report Questionnaires:

1) Ruminative Response Scale

2) State Trait Anxiety Inventory
Rumination Scale

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you generally do, not what you think you should do.

1 almost never  2 sometimes  3 often  4 almost always

1. Think about how alone you feel  D
2. Think “I won’t be able to do my job if I don’t snap out of this”  D
3. Think about your feelings of fatigue and achiness  D
4. Think about how hard it is to concentrate  D
5. Think “What am I doing to deserve this?”  B
6. Think about how passive and unmotivated you feel.  D
7. Analyze recent events to try to understand why you are depressed  R
8. Think about how you don’t seem to feel anything anymore  D
9. Think “Why can’t I get going?”  D
10. Think “Why do I always react this way?”  B
11. Go away by yourself and think about why you feel this way  R
12. Write down what you are thinking about and analyze it  R
13. Think about a recent situation, wishing it had gone better  B
14. Think “I won’t be able to concentrate if I keep feeling this way.”  D
15. Think “Why do I have problems other people don’t have?”  B
16. Think “Why can’t I handle things better?”  B
17. Think about how sad you feel  D
18. Think about all your shortcomings, failings, faults, mistakes  D
19. Think about how you don’t feel up to doing anything  D
20. Analyze your personality to try to understand why you are depressed  R
21. Go someplace alone to think about your feelings  R
22. Think about how angry you are with yourself  D

Note. R = Reflection; B = Brooding; D = Depression-Related
STAI FORM Y-2

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the response option to the right to indicate how you generally feel. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

Note. Items marked with an asterisk (*) are reverse scored.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Almost Never</th>
<th>Sometimes</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I feel pleasant*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. I feel nervous and restless</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I am satisfied with myself*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I wish I could be as happy as others seem to be</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I feel like a failure</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. I feel rested*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I am “calm, cool, and collected” *</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. I feel that difficulties are piling up so that I cannot overcome them</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I worry too much over something that really doesn’t matter</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. I am happy*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. I have disturbing thoughts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. I lack self-confidence</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. I feel secure*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14. I make decisions easily*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15. I feel inadequate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16. I am content*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17. Some unimportant thought runs through my mind and bothers me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18. I take disappointments so keenly that I can’t put them out of my mind</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19. I am a steady person*</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20. I get in a state of tension or turmoil as I think over my recent concerns and interests</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</tbody>
</table>