Running head: Beliefs about Worry

Positive Beliefs about Worry Moderate the Association Between Heart Rate Variability and Pathological Worry

Research Thesis

Presented in partial fulfillment of the requirements to graduate *with research distinction* in Psychology in the undergraduate colleges of The Ohio State University

By

Grace M. Fishback

The Ohio State University

May 2019

Project Advisor: Professor Michael Vasey, Department of Psychology

Abstract

Research has demonstrated that a substantial subset of individuals experiencing uncontrollable worry, a hallmark symptom of generalized anxiety disorder (GAD), paradoxically have good capacity for top-down control over their thoughts. However, why individuals with good cognitive control worry excessively remains unclear. Research showing that positive beliefs about worry set those experiencing pathological worry apart from healthy controls, offers a possible explanation. Individuals with good capacity for cognitive control may intentionally engage in worry because they hold beliefs that it is adaptive to do so. This study tested this hypothesis using an objective index of cognitive control capacity (resting heart rate variability [HRV]). Questionnaire measures of generalized anxiety disorder symptom severity and beliefs about worry were administered and heart rate variability, as an objective measure of cognitive control, was measured in a sample of 109 undergraduate students at The Ohio State University (ages 18-28, M = 19.3, SD = 2.1, 65.1% female). Consistent with expectation, regression analyses revealed that positive beliefs about worry largely moderated the association between heart rate variability and pathological worry. The general pattern showed that individuals with high levels of HRV tended to report experiencing high GAD symptom severity when they strongly endorsed positive beliefs about worry. This indicates that such individuals at least initiate worry intentionally, although questions remain as to how such purposeful worry becomes excessive and uncontrollable.

Though generalized anxiety disorder (GAD) is relatively common and shown to be persistent over a lifetime, (with a 4.3% lifetime prevalence rate; Kessler et al., 2012) there is less research surrounding GAD than other anxiety and mood disorders. Furthermore, current treatments for GAD, such as cognitive-behavioral therapy (CBT) tend to be less effective than treatments for other disorders. In a meta-analysis by Cuijpers et al. (2014) it was demonstrated that CBT is effective in treating less than 50% of patients. The present research aims to elucidate physiological and motivational factors that may play a role in the development and maintenance of GAD in order to aid future treatment protocols.

GAD) is characterized by persistent, unmanageable, excessive worry regarding aspects of everyday life (Hoyer, Becker, and Roth, 2001). Such pathological worry is often associated with heightened levels of autonomic arousal (AA). Autonomic arousal includes symptoms such as dry mouth, shortness of breath, and increased heart rate. However, the extent to which AA symptoms accompany worry varies widely and appears to depend on the worrier's capacity for top-down control over their thoughts (Vasey, Chriki, & Toh, 2017; Toh and Vasey, 2017).

One theory highlighting the role of AA in pathological worry is the Cognitive Avoidance Model (Borkovec et al., 2004). This theory posits that individuals who experience pathological worry utilize their ability to shift these thoughts to a verbal-linguistic mode of processing (i.e., thinking in terms of words), rather than imaginal processing (i.e., thinking in terms of visual scenes). This serves to allow chronic worriers to suppress the AA symptoms triggered by threatening visual images, which negatively reinforces the verbal-linguistic mode of processing. A second model from Newman and Llera (2011), the Contrast Avoidance Model, suggests pathological worriers maintain a consistent state of heightened AA. This is used as mechanism to avoid aversive shifts from euthymic to anxious mood states when a potential threat actually

occurs. In this way, persistent worry is reinforced as a strategy to avoid such aversive spikes in emotion and instead maintain a constant emotional and physiological state.

These theories fail, however, to account for the heterogeneity in the levels of autonomic arousal seen amongst the GAD population. For example, Andor and colleagues (2008) observed no significant difference in heart rate between individuals with GAD and healthy control subjects at baseline. Similarly, Hohen-Saric and McLeod (2000) found that GAD patients, while self-reporting heightened AA, did not exhibit a higher heart rate than controls under non-specific stress conditions. This pattern was also found in a study utilizing skin conductance responses as a measure of AA (Fisher, Granger, and Newman, (2009). Conversely, results from Knepp and Friedman (2008) indicate that subjects considered high in worry exhibit increased heart rate across baseline and induced worry conditions. Increased mean heart rate for individuals with GAD was also found in a four-day ambulatory study conducted by Hoehn-Saric and colleagues (2004).

Vasey et al. (2017) have drawn attention to this heterogeneity in autonomic arousal symptoms and propose their Cognitive Control Model to account for it. In this model, the heterogeneity in AA within samples of chronic worriers can be explained by considering individual differences in cognitive control capacity across such samples. This model posits that persons with high levels of pathological worry must possess good capacity for cognitive control if they are to suppress autonomic arousal by constraining worry to a verbal mode of processing. Those lacking the capacity to do so must instead process potential threats imaginally, resulting in heightened AA. Vasey and colleagues have amassed substantial evidence supporting this model. For example, Vasey et al. (2017) showed that GAD symptom severity significantly predicted

symptoms of AA only when cognitive control capacity was low. This was true even in an analog GAD sample.

Thus far, the question as to why individuals with good cognitive control capacity would paradoxically report experiencing excessive and uncontrollable worry remains unanswered. One possible explanation may lie in beliefs about the function of worry. Borkovec and Roemer (1995) propose that worriers may believe worry serves an adaptive function and thus may initiate worry intentionally. Since feared outcomes rarely happen, worry may serve as a coping strategy that is negatively reinforced by virtue of this fact. Specifically, six possible reasons for worry were identified among the GAD population. First, worry may enhance motivation to complete tasks. Second, worry may aid in problem-solving. Third, worry may help them prepare for the worst. Fourth, worry may aid in planning to avoid negative events. Fifth, worry may serve to distract from more anxiety-provoking topics, Lastly, worriers may hold superstitious beliefs that worry will influence the likelihood of future events. Borkovec and Roemer (1995) showed that the motivation, preparation, and prevention reasons were consistently more highly endorsed by GAD subjects than both non-anxious and non-worried anxious individuals.

Similarly, Freeston and colleagues (1994) have also proposed that individuals with GAD may have primary adaptive motivations to worry. Specifically, they may believe that worry has positive effects (e.g., enhanced problem-solving) and worry prevents negative outcomes. Persons with GAD scored more highly on both of these measures than their non-clinical counterparts. These results indicate that persons with GAD may view worry as beneficial rather than maladaptive. In addition to these findings, research conducted by Iijima and Tanno (2013) showed that worry in response to stressful events was highest when individuals endorsed positive beliefs about worry. In a sample of children, Kerts and Woodruff-Borden also demonstrated that

positive beliefs about worry distinguished clinical participants from non-clinical on measures of worry.

Holding the beliefs that worry serves positive functions may partially account for the treatment resistance exhibited in patients with GAD. Therefore, addressing these reasons may be a key step in treating GAD. In support of this, Westra, Arkowitz, and Dozois (2009) found that adding the pre-treatment of motivational interviewing to cognitive-behavioral therapy helped significantly reduce endorsement of worry in GAD patients. Motivational interviewing was designed to decrease ambivalence about letting go of these positive beliefs about worry. However, more research is needed surrounding the effects of motivation behind worry on GAD symptom severity.

The present study aims to use an objective measure of cognitive control, resting heart rate variability (HRV). HRV represents high-frequency variability in the intervals between heartbeats. High HRV is hypothesized to characterize parasympathetic inhibitory control over the sympathetic autonomic nervous system and is primarily mediated by the vagus nerve. Previous research indicates HRV is positively correlated with measures of cognitive control (Holzman and Bridgett, 2016). For example, HRV has also been shown to correlate with enhanced activity in areas of the brain hypothesized to mediate cognitive control capacity, such as the prefrontal cortex (Jennings et al., 2016). Additionally, high heart rate variability has been associated with superior performance on tasks measuring executive functioning (Thayer et al., 2009). Thayer and Lane (2000) have proposed that disruptions in this parasympathetic control may lead to affective and or cognitive problems such as GAD. Additionally, findings from Free (2017) demonstrate that symptoms of autonomic arousal are rated more highly among high worriers when HRV is low, a pattern consistent with the Cognitive Control Model. Taken

together, these studies provide increasing evidence for HRV as an objective measure of cognitive control capacity.

A meta-analysis by Chalmers et al. (2014) suggests that individuals with GAD tend to have lower heart rate variability than controls. However, this pattern has failed to replicate in some instances. In a study using a clinical sample of GAD patients Hammel et al. (2010) found no differences in HRV between individuals with GAD and controls on any task condition. Research by Kollai and Kollai (1992) utilizing an invasive pharmacological method of measuring vagal tone also failed to find differences in HRV between clinical GAD subjects and controls. Furthermore, findings from a meta-analysis by Holley, (2017) found the difference in resting HRV between GAD samples and healthy controls was modest. Consistent with the Cognitive Control Model, these results indicate that a subset of individuals with GAD may possess the cognitive control capacity necessary to suppress autonomic arousal. However, the question of why they use this ability maladaptively to devote their attention to worrying rather than shifting attention away from negatively arousing stimuli remains. The heterogeneity in the literature surrounding heart rate variability indicates there may be influential factors in need of further investigation.

The present study aims to determine if individual differences positive beliefs about worry moderate the association between HRV and GAD symptom severity. I predict that resting HRV will be significantly negatively correlated with GAD symptom severity only when it is low. When positive beliefs about worry are high, HRV should be associated with high GAD symptoms.

Method

Participants and Procedure:

Participant data for this thesis was taken from a prior study conducted by Chriki (2015). Participants were recruited through the Research Experience Program (REP) at The Ohio State University. The total sample was comprised of 123 participants who completed two laboratory sessions separated by 1-2 weeks. However, due to participant drop-out only data for the first session will be used for the purpose of this thesis. The present study utilizes data from 109 participants who completed the first session and who had useable HRV data. The full sample could not be used due to missing data for some participants. From the sample, 65.1% self-identified as female and participants ranged in age from 18-28 (M = 19.3, SD = 2.1). The sample was primarily Caucasian (71.6%, African American: 7.3%, Asian American: 6.4%, Latino: 3.7%, Mixed Ethnicity: 5.5%, Other Ethnicity: 5.5%). All participants received credit in their Introduction to Psychology course for their participation.

Self-Report Questionnaires:

Generalized Anxiety Disorder Questionnaire – IV (GADQ-IV): Severity of GAD symptoms was assessed using the GADQ-IV, a self-report measure containing all diagnostic criteria for GAD based on the Diagnostic and Statistical Manual of Mental Disorders, 4th edition. The GADQ-IV is comprised of five yes/no questions that assess frequency and duration of excessive and uncontrollable worry, two items regarding how interfering and distressing worry is as well as physical symptoms, a checklist of symptoms commonly associated with worry, and a open-ended section in which topics of most frequent worry are listed. The GADQ-IV has been shown to have good agreement with structured clinical interviews (kappa of 0.67) as well as 83%

sensitivity and 89% specificity. Furthermore, this questionnaire has demonstrated good test-retest reliability and both convergent and discriminant validity (Newman et al., 2002).

Reasons to Worry Questionnaire (RWQ): The Reasons to Worry Questionnaire is a 6-item self-report questionnaire with subscales assessing reasons why subjects may worry (Borkovec and Roemer, 1995). Questions classify reasons to worry as serving the following functions: motivation to complete tasks, aids in problem solving, preparation for negative events, avoidance of negative events, distraction from emotional topics, and superstitious effects on possible outcomes. Subjects are asked to indicate how much they feel each item applies to them. Items are rated on a 5-point Likert scale ranging from "not at all" to "very much". GAD status correlates with higher scores on each of the six items (Borkovec and Roemer, 1995).

Why Worry? Questionnaire: The Why Worry? Questionnaire is a 20-item self-report measure in which individuals indicate the motivation behind their worry (Freeston et al., 1994). Items are classified in two categories: worry prevents negative outcomes (e.g. "I worry in order to avoid disappointment") and worry has positive effects (e.g. "By worrying I can stop bad things from happening"). Each item requires subjects to judge how characteristic the statement is of them and is rated on a 5-point Likert scale ranging from "not at all characteristic of me" to "entirely characteristic of me". For purposes of this experiment, a total score was used rather than subscale scores. Freeston et al. (1994) demonstrated the Why Worry? Questionnaire has good agreement with other measures used to assess worry as well as inter-item consistency (Chronbach's $\alpha = 0.88$ in the current sample). Results from Freeston et al. (1994) also show good discriminant validity and ability to distinguish pathological worriers from healthy controls.

Measures of Cognitive Control Capacity:

Heart Rate Variability (HRV): Five-minute periods of resting HRV were collected shortly after participants arrived for Session 1. To collect this physiological data the MindWare 2000D Impedance Cardiograph package was used. The package uses a 14 bit A/D converter with a maximum sample rate of 48k samples/second. This yielded an inter-beat interval time series (IBI),. Analysis of the data was performed using MindWare Technologies Signal Processing Applications. The index of HRV used in this study was the root-mean squares of successive differences (RMSSD), which is widely used in HRV research.

Results

Preliminary Analyses

All analyses were conducted with complete data from 109 participants (88.6% of the original data set). Descriptive statistics and correlations for all variables are included in Table 1. In order to test if the excluded data from the original 123 participants significantly affected the results for the present study, a Little's Missing Completely at Random (LMCAR) analysis was conducted. A chi-squared test revealed that participants were not removed from the study systematically ($p = 0.240$). It can therefore be concluded that exclusion of participants with incomplete data sets did not influence the present research.

Data Analytic Strategy

To increase reliability and reduce Type I error rate, a composite score of the WW and RWQ was created and used for the primary test of this study's prediction. Creation of the composite score consisted of converting raw scores of both questionnaires to z-scores in Step 1. In Step 2, the z-scores were averaged. The aforementioned hypothesis was tested using multiple

linear regression (MLR) analyses. MLR analyses involved two hierarchical steps. Specifically, to predict GAD symptom severity, positive beliefs about worry and heart rate variability were added in step 1. In Step 2, the interaction HRV x Beliefs was added. All models were tested using PROCESS for SPSS, which was also used to interpret interactions. Significant interactions were illustrated with predicted lines at one SD above and below the mean for the measure of beliefs about worry.

Prediction: HRV x Beliefs predict GAD symptom severity

Composite of RWQ and WW

As shown in Table 2, the overall model for predicting GAD symptom severity was significant (R^2 = 0.342, p < 0.001). The interaction term for the composite score of the RWQ and WW questionnaire was significant (*sr* = 0.18, p = 0.001). As shown in Figure 1, GAD symptom severity was significantly predicted by HRV when composite scores were low (B = -1.54, p = 0.002), but not high (B = 0.30, p = 0.47). Examination of the regions of significance showed that HRV was negatively correlated with GAD symptom severity when the Worry Beliefs Composite score was less than -0.78 SDs below its average. In contrast, HRV was significantly positively correlated with GAD symptom severity when the Worry Beliefs Composite score was greater than 1.68 SDs above its average.

RWQ

As shown in Table 3, the overall model for predicting GAD symptom severity from HRV and the Reasons for Worry Questionnaire was significant (R^2= 0.219, p < 0.001). The interaction term, HRV x Beliefs, was also significant (p < 0.001), showing that the magnitude of the association between HRV and GAD symptom severity depended on level of positive beliefs

about worry (See Figure 2). The GAD x HRV interaction accounted for nearly 9% of variance in GAD symptom severity ($\Delta R^2 = 0.088$ $p < 0.001$). Examination of the regions of significance using PROCESS revealed that HRV was significantly negatively correlated with GAD symptom severity when RWQ scores were less than 13.67. In contrast, HRV was significantly positively correlated with GAD symptom severity when RWQ scores were greater than 19.91.

Because Borkovec and Roemer (1995) found that certain items on the RWQ accounted for significantly more of the variance between GAD samples and control samples, regression analyses were run on the RWQ's individual items. Results revealed that several of the items individually influenced the magnitude of the association between HRV and GAD symptom severity. As shown in Table 4, for item 2 "Worry is an effective way to problem-solve" the overall regression was not significant. However, as shown by Figure 4, the HRV x Item 2 interaction was significant (sr = .19, p = 0.047). As shown in Table 5, the overall regression for item 4 "If I worry about something, I am more likely to actually figure out how to avoid or prevent something bad from happening" was significant ($R^2 = 0.381$, $p < 0.001$) As illustrated in Figure 5, the Item 4 x HRV interaction was significant (sr = .32, p = .001. As shown in Table 6, the model for item 5, "Worrying about most of the things I worry about is a way to distract myself from worrying about even more emotional things" was also significant ($R^2 = 0.216$, $p < 0.001$). As shown in Figure 6, the Item 5 x HRV interaction was significant (sr = .29, p = .001) and accounted for over 8% of score variance ($\Delta R^2 = 0.087$). Analyses for item 1, "Worry helps to motivate me to get things done that I need to get done", item 3, "If I worry about something, when something bad does happen, I'll be better prepared", and item 6, "Although it may not actually be true, it feels like if I worry about something, the worrying makes it less likely that something bad will happen" did not yield a significant interaction terms.

WW

A preliminary analysis revealed one high influence outlier (standardized DFFITS = 1.01). With that case included the overall model for predicting GAD symptom severity was significant ($R^2 = 0.417$, $p < 0.001$). However, the interaction term did not reach significance. With the high influence case dropped results remained unchanged. However, it should be noted that although the Why Worry x HRV interaction did not achieve significance (sr = .10, p = .195), the pattern of the interaction was as expected. However, whereas HRV was not significantly associated with GAD symptom severity at any level of positive beliefs about worry, such beliefs were significantly positively associated with GAD symptom except when HRV was low (i.e., LnRMSSD < 1.59).

Discussion

Research has shown that a certain subset of individuals with generalized anxiety disorder exhibit good cognitive control capacity (Vasey, Chriki, and Toh 2017). However, the reason behind why these individuals devote their attention to worry is unclear. Holding positive beliefs about worry may serve as a possible explanation to this paradox. Studies have demonstrated that individuals with GAD tend to endorse positive beliefs about worry more than their non-clinical counterparts (Freeston et al., 1994, Borkovec and Roemer, 1995). Therefore, I hypothesized that the association between HRV and GAD would be moderated by positive beliefs about worry.

Results from this study were largely consistent with this hypothesis. Heart rate variability interacted with a composite measure of beliefs about worry to predict GAD symptom severity as measured by the GADQ-IV. For the composite measure as well as the total score on the RWQ and three of its items, the pattern found was such that high levels of HRV were most strongly

negatively associated with GAD symptom severity among individuals holding high levels of beliefs that worry adaptive. At lower levels of such beliefs, HRV was significantly negatively associated with GAD symptoms. This suggests that individuals with high cognitive control capacity (i.e., high HRV) are not protected from high levels of GAD symptoms when they believe worry is adaptive.

Like the composite measure, the RWQ total score produced a significant interaction. However, the positive beliefs on the RWQ differed in their magnitude of their association with GAD and HRV. Specifically, the beliefs that worry aids in problem solving (Item 2), worry helps prepare for negative events (Item 4), and worry distracts for more emotional topics (Item 5) carried a large portion of the variance in this sample. This pattern is consistent with findings from Borkovec and Roemer (1995), who found that items 2 and 4 most distinguished a GAD sample from non worried-anxious and healthy control groups. It is interesting to note that the interaction involving item 4 accounted for the largest percentage of variance in GAD symptom severity. Item 4 was the only item to significantly differentiate those with GAD from controls in both of Borkovec and Roemer's samples. This item shows most clearly that higher levels of HRV are significantly associated with greater GAD symptom severity among those holding such a belief.

These results indicate that although individuals high in heart rate variability possess the ability to direct their attention away from worry, their belief that worry serves positive functions may play a role in the maintenance of GAD. However, is important to consider why the interaction between GAD and HRV was not significant on the Why Worry? Questionnaire alone. One explanation for this is suggested by the fact that scores on the Why Worry Questionnaire were much strongly correlated with GAD symptom severity (zero-order r = .65) than were scores

on the Reasons to Worry Questionnaire (r = .36). Consequently, there was much less room for individual differences in HRV to make a difference. This would make it particularly difficult to detect an interaction as the variance in the product term representing the interaction was constrained. It should be noted however, that the interaction did match the pattern found for the composite and the Reasons to Worry Questionnaire alone. However, it is unclear why the Why Worry? Questionnaire was so much more strongly correlated with GAD symptoms severity than the Reasons to Worry Questionnaire. It appears that the latter questionnaire may be more sensitive to differences in beliefs among high worriers than the latter measure.

In summary, this study's results largely support the prediction that high levels of cognitive control are most likely to be associated with GAD symptoms among individuals who believe that worry has adaptive value. Surprisingly, high levels of cognitive control do now appear to protect such individuals from their worries becoming excessive and uncontrollable.

Limitations and Future Directions

The present research has several limitations that should be taken into consideration when interpreting the results. Firstly, power to detect interactions is relatively low in small samples. With a sample size of 109 participants, this study likely lacked the power necessary to detect some interactions. This is salient in the case of the Why Worry? Questionnaire, since its stronger correlation with GAD symptoms than the Reasons to Worry Questionnaire also reduces power due to restrictions on the range of the product term representing its interaction with cognitive control. Generalizability of these results may also be limited given the constrained age range as well as lack of ethnic diversity among participants. Generalizability may be further limited by the fact that all participants were college students. Furthermore, causality cannot be determined

from this study given its cross-sectional design. Results from this study do, however, warrant further investigation with a larger and more representative sample.

While this study provides valuable insights, the accuracy of these positive belief about worry endorsed by individuals with GAD should be investigated. In other words, whether these beliefs actually aid individuals in the domain they are believed to. Future studies should also address why GAD individuals develop these positive beliefs about worry. Lastly, application of these findings should be investigated in the context of motivational interviewing for GAD individuals. Addressing these positive beliefs about worry in a clinical setting may be an important step in the treatment process, and a lack thereof may be involved in the treatment-resistance seen in GAD patients.

References

Andor, T., Gerlach, A. L., Rist, F. (2008). Superior perception of phasic physiological arousal and the detrimental consequences of the conviction to be aroused on worrying and metacognitions in GAD. *Journal of Abnormal Psychology, 117*(1), 193-205. doi:10.1037/0021-843X.117.1.193

Borkovec, T. D., Alcaine, O. M., & Behar, E. (2004). Avoidance theory of worry and generalized anxiety disorder. In R. G., Heimberg, C. L., Turk, & D. S. Mennin (Eds.) Generalized Anxiety Disorder: Advances in Research and Practice (pp. 77–109). New York, NY: The Guilford Press.

Borkovec, T.D., Roemer, L. (1995). Perceived functions of worry among generalized anxiety disorder subjects: Distraction from more emotionally distressing topics? *Journal of Behavioral Therapy and Experimental Psychology, 26*(1), 25-30. doi:10.1016/0005-7916(94)00064-S

Chalmers, J. A., Quintana, D. S., Abbott, M. J-A., Kemp, A. H. (2014). Anxiety disorders are associated with reduced heart rate variability: A meta-analysis. *Frontiers in Psychiatry, 5*(80), 1-11.

Chriki, L. (2015). Characteristics of Worriers as a Function of Individual Differences in Effortful Control. (Electronic Thesis or Dissertation). Retrieved from https://etd.ohiolink.edu/

Cuijpers, P., Sijbrandij, M., Koole, S., Huibers, M., Berking, M., &Andersson, G. (2014). Psychological treatment of generalized anxiety disorder: A meta-analysis. *Clinical Psychology Review, 34*(2), 130–140. doi:10.1016/j.cpr.2014.01.002

Davey, G. C. L., Tallis, F., Capuzzo, N. (1996). Beliefs about the consequences of worrying. *Cognitive Therapy and Research, 20*(5), 499-420.

Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology, 111*(2), 225-236. doi:10.1037//0021-843x.111.2.225

Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., Murphy, B.C., Losoya, S. H., & Guthrie, I. K. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development, 72*(4), 1112-1134.

Fisher, A. J., Grander, D. A., Newman, M. G. (2009). Sympathetic arousal moderates self-reported physiological arousal symptoms at baseline and physiological flexibility in response to a stressor in generalized anxiety disorder. *Biological Psychology, 83*(3), 191-200. doi:10.1016/j.biopsycho.2009.12.007

Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences, 17*(6), 791-802. doi:10.1016/0191-8869(94)90048-5

Hammel, J. C., Smitherman, T. A., McGlynn, F. D., Mulfinger, A. M. M., Lazarte, A. A., Gothard, K. D. (2011). Vagal influence during worry and cognitive challenge. *Anxiety, Stress & Coping, 24*(2), 121-136. doi: 10.1080/10615806.2010.490912

Hoehn-Saric, R., McLeod, D. R., Funderburk, F., Kowalski, P. (2004). Somatic symptoms and physiologic responses in generalized anxiety disorder and panic disorder: An ambulatory monitor study. *Archives of General Psychiatry, 61*(9), 913-921. doi:10.1001/archpsyc.61.9.913

Holley, J. M. (2017). Differences in human heart rate variability due to trait and state worry: A meta-analysis. (Electronic Thesis or Dissertation). Retrieved from https://etd.ohiolink.edu/

Holzman, J. B., Bridgett, D. J. (2017). Heart rate variability indices as bio-markers of top-down self-regulatory mechanisms: A meta-analytic review. *Neuroscience and Biobehavioral Reviews, 74,* 233-255. doi: 10.1016/j.neubiorev.2016.12.032

Hoyer, J., Becker, E. S., & Roth, W. T. (2001). Characteristics of worry in GAD patients, social phobics, and controls. *Depression and Anxiety, 13*(2), 89–96. doi: 10.1002/da.1021

Iijima, Y., Tanno, Y. (2013). The moderating role of positive beliefs about worry in the relationship between stressful events and worry. *Journal of Personality and Individual Differences, 55*(8), 1003-1006. doi: 10.1016/j.paid.2013.08.004

Jennings, J. R., Sheu, L. K., Kuan, D. C-H., Manuck, S. B., Gianaros, P. J., (2015). Resting state connectivity of the medial prefrontal cortex covaries with individual differences in high-frequency heart rate variability. *Psychophysiology, 53*(4), 444-454. doi:10.1111/psyp.12586

Kessler, R. C., Petuhkova, M., Sampson, N. A., Zaslavsky, A. M., Wittchen, H-U. (2012). Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States. *International Journal of Methods in Psychiatric Research, 21*(3), 169-184. doi: 10.1002/mpr.1359

Knepp, M. M., Friedman, B. H. (2008). Cardiovascular activity during laboratory tasks in women with high and low worry. *Biological Psychology, 79*(3), 287-293. doi:10.1016/j.biopsycho.2008.07.002

Kollai, M., Kollai, B. (1992). Cardiac vagal tone in generalised anxiety disorder. *British Journal of Psychiatry, 161,* 831-835.

Lengua, L., & Long, A. (2002). The role of emotionality and self-regulation in the appraisal–coping process: Tests of direct and moderating effects. *Journal of Applied Developmental Psychology, 23*(4), 471-493. doi.org/10.1016/S0193-3973(02)00129-6

McEvoy, P. M., Mahoney, A. E. J. (2013). Intolerance of uncertainty and negative metacognitive beliefs as transdiagnostic mediators of repetitive negative thinking in a clinical sample with anxiety disorders. *Anxiety Disorders, 27*(2), 216-224. doi:10.1016/j.janxdis.2013.01.006

Newman, M. G., & Llera, S. J. (2011). A novel theory of experiential avoidance in generalized anxiety disorder: A review and synthesis of research supporting a contrast avoidance

model of worry. *Clinical Psychology Review, 31,* 371–382. doi:10.1016/j.cpr.2011.01.008

Newman, M.G., Zuellig, A.R., Kachin, K.E., Constantino, M.J., Przeworski, A., Erickson, T., & Cashman-McGarth, L. (2002). Preliminary reliability and validity of the generalized anxiety disorder questionnaire-IV: A revised self-report diagnostic measure of generalized anxiety disorder. *Behavior Therapy, 33* (2), 215-233. doi:10.1016/S0005-7894(02)80026-0

O'Carroll, P. J., Fisher, P. (2013). Metacognitions, worry and attentional control in predicting OSCE performance test anxiety. *Medical Education, 47*(6), 562-568. doi:10.1111/medu.12125

Prados, J. M. (2011). Do beliefs about the utility of worry facilitate worry? *Journal of Anxiety Disorders, 25*(2), 217-223. doi: 10.1016/J.JANXDIS.2010.09.005

Pretorius, C., Walker, S. P., Esterhuyse, K. G. (2015). The applicability of the metacognitive model of worry and generalized anxiety disorder in a non-clinical multi-ethnic sample of university students. *South African Journal of Psychology, 45*(2), 234-248. doi:10.1177/0081246314567890

Rothbart, M. K., Ahadi, S. A., Hershey, K. L. (1994). Temperament and social behavior in childhood. *Merrill-Palmer Quarterly, 40*(1), 21-39.

Rothbart, M. K., Bates, J. E. (1998). Temperament. In N. Eisenberg & W. Damon (Eds.), Handbook of child psychology: Volume 3. Social, emotional, and personality development (pp. 105–176). New York: Wiley

Ruscio, A. M., Borkovec, T. D. (2003). Experience and appraisal of worry among high worriers with and without generalized anxiety disorder. *Behaviour and Research Therapy, 42*(12), 1469-1482. doi:10.1016/J.BRAT.2003.10.007

Tajrishi, K. Z., Mohammadkhani, S., Jadidi, F. (2011). Metacognitive beliefs and negative emotions. *Social and Behavioral Sciences, 30,* 530-533. doi:10.1016/j.sbspro.2011.10.103

Thayer, J. F., Hansen, A. L., Saus-Rose, E., Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Society of Behavioral Medicine, 37*(2), 141-153. doi:10.1007/s12160-009-9101-z

Thayer, J.F., Lane, R.D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders 61*(3), 201–216.

Vasey, M. W., Chriki, L., Toh, G. Y. (2016). Cognitive control and anxious arousal in worry and generalized anxiety: An initial test of an integrative model. *Cognitive Therapy and Research, 41(2),* 155-169. doi: 10.1007/s10608-016-9809-6

Wells, A. (2005). The metacognitive model of GAD: Assessment of meta-worry and relationship with DSM-IV generalized anxiety disorder. *Cognitive Therpy and Research, 29*(1), 107-121. doi: 10.1007/s10608-005-1652-0.

Westra, H. A., Arkowitz, H., Dozois, D. J. A. (2009). Adding a motivational interviewing pretreatment to cognitive behavioral therapy for generalized anxiety disorder: A preliminary randomized controlled trial. *Journal of Anxiety Disorders, 23*(8), 1106-1117. doi: 10.1016/J.JANXDIS.2009.07.014

Table 1

Variable	1	2	3	4	M	SD
1. GADQ-IV	-	-.018	**0.361**	**0.643**	3.36	3.69
2. HRV		-	.037	-.051	3.58	0.98
3. RWQ			-	**0.651**	14.39	5.08
4. WW				-	49.55	16.12

Note: N = 109. Bold correlations are significant at p < 0.01. GADQ-IV = Generalized Anxiety Disorder Questionnaire-IV total score, HRV = Heart Rate Variability, RWQ = Reasons for Worry Questionnaire, WW = Why Worry? Questionnaire

Table 2

Predicting GAD symptom severity from Composite Worry Beliefs scores and HRV

	R^2	**ΔR^2**	**Semi-Partial**	**B (SE)**	***p*-value**
DV: GADQ-IV	**0.34**				**< 0.001**
Constant				7.52 (1.17)	< 0.001
HRV			-0.07	-0.29 (0.315)	0.361
RWQ			-0.06	-1.23 (1.57)	0.436
HRV x RWQ		0.088	0.18	0.96 (0.42)	0.023

Table 3

Predicting GAD symptom severity from RWQ scores and HRV

	R^2	ΔR^2	Semi-Partial	B (SE)	*p*-value
DV: GADQ-IV	**0.22**				**< 0.001**
Constant				18.07 (4.63)	< 0.001
HRV			-0.29	-4.22 (1.24)	0.001
RWQ			-0.21	-0.68 (.28)	0.018
HRV x RWQ		0.088	0.30	0.26 (.07)	0.001

Table 4

Predicting GAD symptom severity from RWQ Item 2 scores and HRV

	R^2	ΔR^2	Semi- Partial	B (SE)	*p*-value
DV: GADQ-IV	**0.048**				**0.155**
Constant				10.58 (2.79)	< 0.001
HRV			-0.18	-1.42 (0.77)	0.486
RWQ2			-0.15	-1.57 (1.02)	< 0.001
HRV x RWQ2		0.037	0.19	0.56 (0.28)	0.056

Table 5

Predicting GAD symptom severity from RWQ Item 4 scores and HRV

	R^2	ΔR^2	Semi-Partial	B (SE)	*p*-value
DV: GADQ-IV	**0.14**				**< 0.001**
Constant				16.35 (3.60)	< 0.001
HRV			-0.36	-3.17 (0.95)	0.001
RWQ4			-0.26	-3.36 (1.19)	0.005
HRV x RWQ4		0.10	0.32	1.08 (0.31)	0.001

Table 6

Predicting GAD symptom severity from RWQ Item 5 scores and HRV

	R^2	ΔR^2	Semi-Partial	B (SE)	*p*-value
DV: Item 5	**0.22**				**< 0.001**
Constant				12.81 (2.64)	< 0.001
HRV			-0.28	-2.31 (0.70)	0.001
RWQ5			-0.21	-3.07 (1.25)	0.016
HRV x RWQ5		0.087	0.29	1.10 (0.32)	0.001

Table 7

Predicting GAD symptom severity from WW scores and HRV

	R^2	ΔR^2	Semi-Partial	B (SE)	*p*-value
DV: GADQ-IV	**0.42**				**< 0.001**
Constant				6.54 (0.27)	< 0.001
HRV			-0.**06**	-0.26 (0.29)	0.386
WW			0. 64	2.34 (0.27)	< 0.001
HRV x WW		0.0094	0.10	0.44 (0.34)	0.195

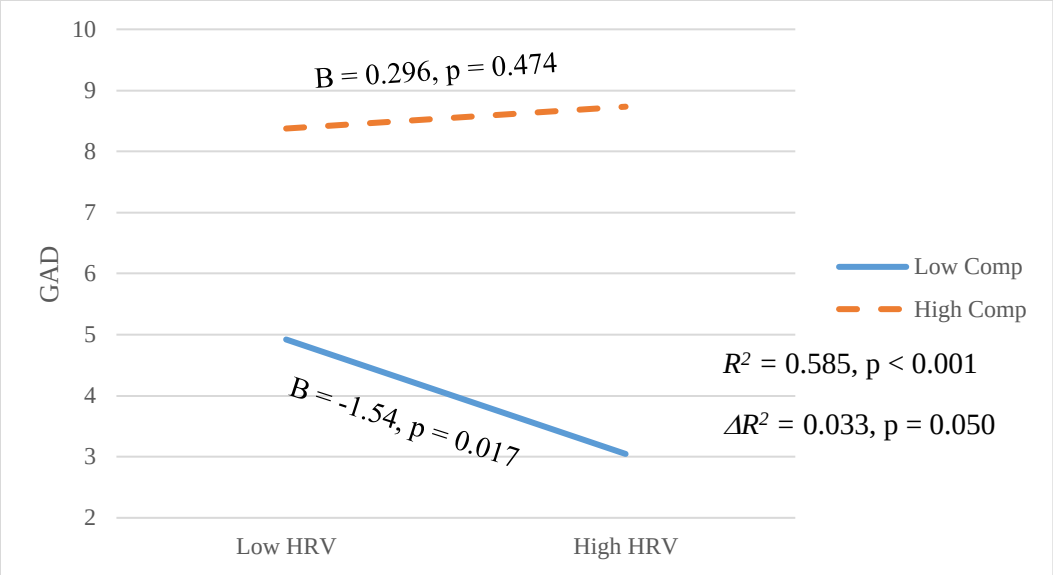

Figure 1. HRV predicting GAD symptom severity at varying levels of the Composite score.

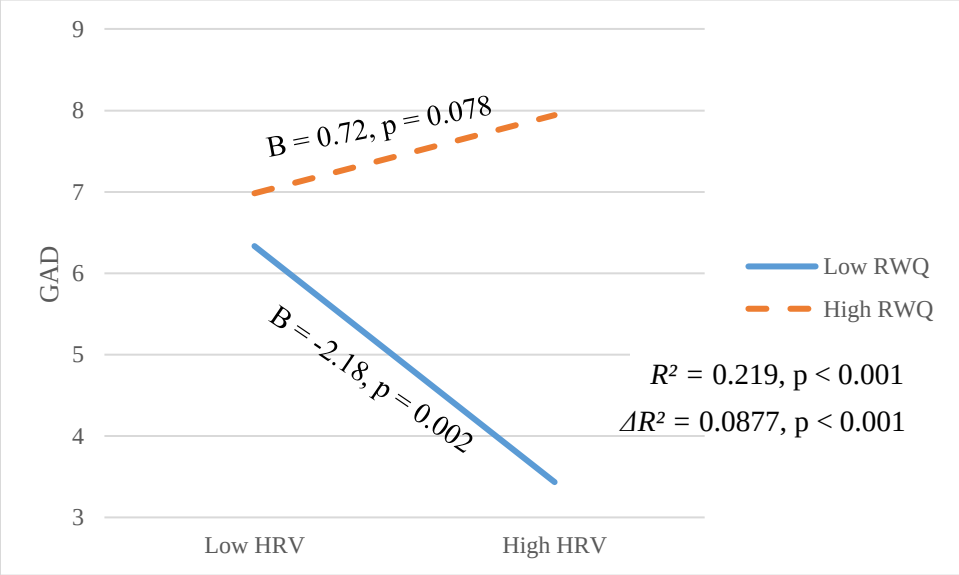

Figure 3. HRV predicting GAD symptom severity at varying levels of RWQ scores.

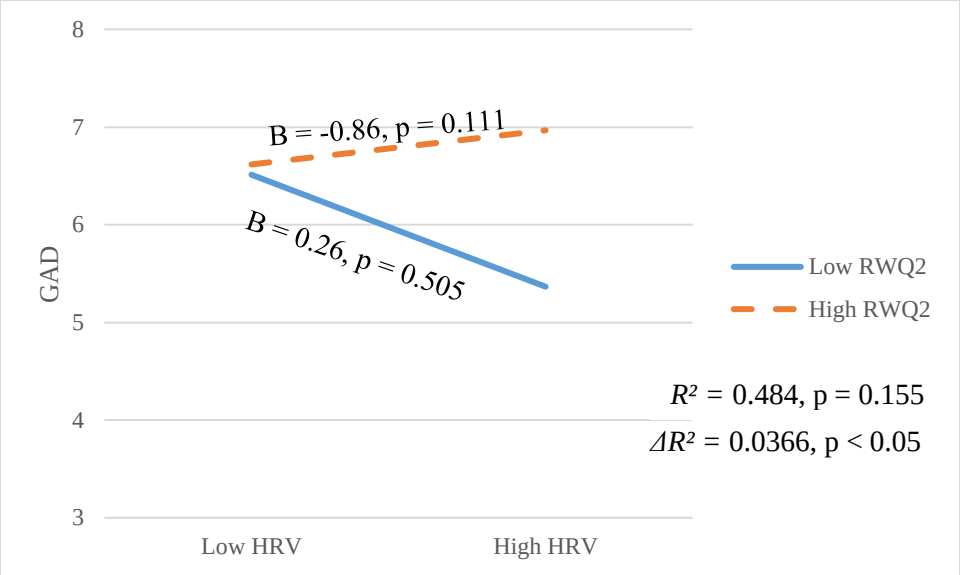

Figure 4. HRV predicting GAD symptom severity at varying levels of RWQ Item 2 scores.

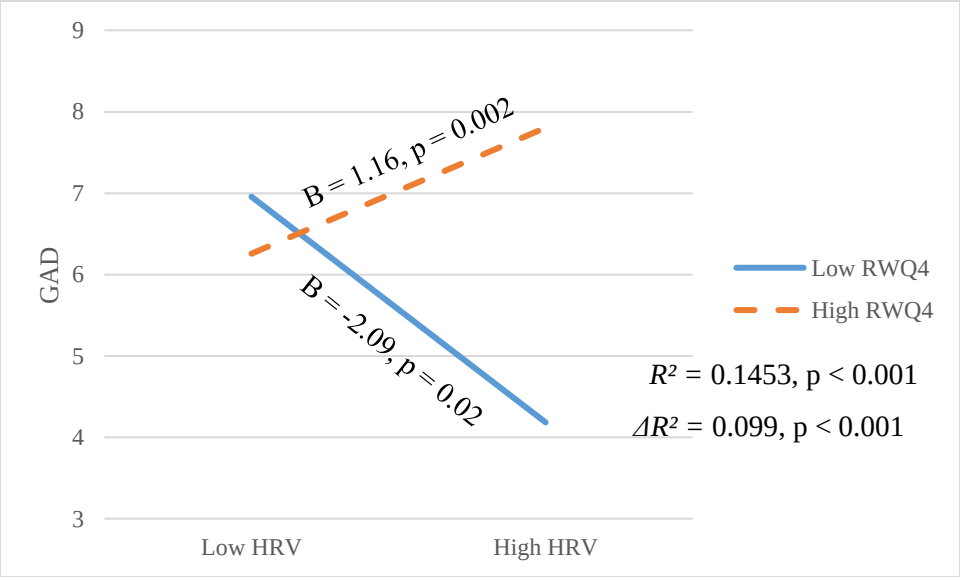

Figure 5. HRV predicting GAD symptom severity at varying levels of RWQ Item 4 scores.

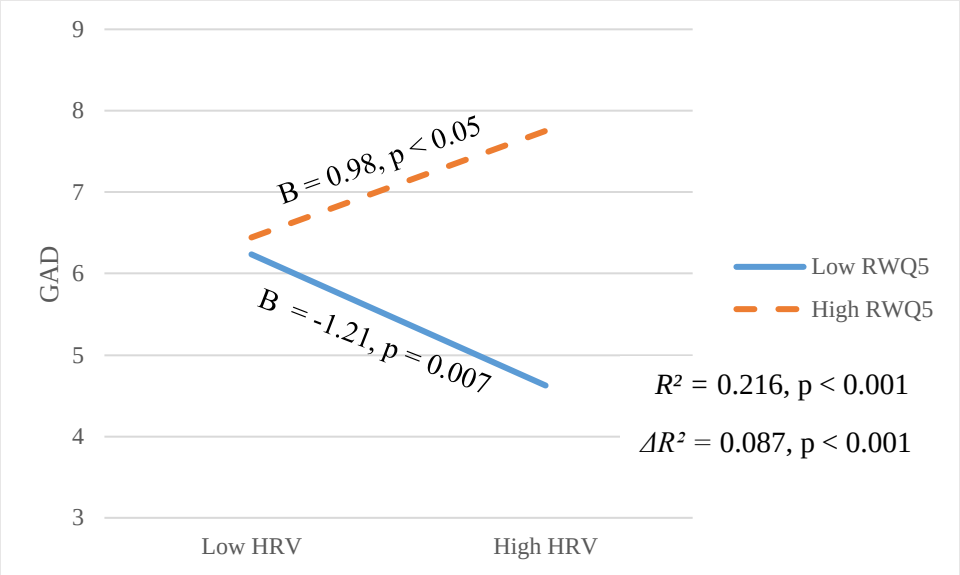

Figure 6. HRV predicting GAD symptom severity at varying levels of RWQ Item 5 scores.