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Facets of Neuroticism as Predictors of Heart Rate Variability and Psychological Distress

Mikel Cressman
Brigham Young University

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Mikel Cressman

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Patrick Steffen, Chair
Wendy Birmingham
Jared Warren

Department of Psychology

Brigham Young University

ABSTRACT

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Mikel Cressman
Department of Psychology, Brigham Young University
Master of Science

Heart rate variability (HRV) and personality are related to both physical and mental health outcomes. Previous research has found a relationship between neuroticism and distress while the findings on the relationship between neuroticism and HRV are mixed. Studying the facets of neuroticism may provide a more nuanced view of the effects of personality on HRV and distress. Previous research has suggested that the vulnerability facet of neuroticism appears to be uniquely related to the cardiovascular response to stress. This study's first hypothesis is that individuals with higher scores on the vulnerability facet will have lower heart rate variability. The second hypothesis is that individuals with higher vulnerability facet scores will report higher levels of distress. Using SEM, this study evaluated the measurement model of the facets of neuroticism as well as the structural relationships between these facets and HRV as well as psychological distress. Our study's sample consisted of 374 college students, the majority of whom were young adults. The SEM results indicated that there was no significant relationship between vulnerability and HRV or psychological distress. The lack of a significant association among any of the facets of neuroticism with HRV in this study further supports the notion that the non-significant relationship between neuroticism and HRV extends even when examining neuroticism at the facet level.

Keywords: Heart rate variability, neuroticism, vulnerability, distress

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Facets of Neuroticism as Predictors of Heart Rate Variability and Psychological Distress

The personality trait neuroticism is defined by the individual differences in how people experience negative and distressing emotions (Costa Jr. & McCrae, 1987). Neuroticism is believed to be a fundamental personality trait and is included in most major models of personality (Widiger & Oltmanns, 2017). Neuroticism is sometimes labeled as negative emotionality or negative affectivity (Tackett & Lahey, 2017). Personality traits, such as neuroticism, are comprised of multiple facets. Personality facets measure specific aspects of a higher order trait and can provide a granular perspective on neuroticism. These facets share common variance, but they also maintain their own unique variance (Costa Jr. & McCrae, 1995). The six facets of neuroticism are: anxiety, depression, anger or hostility, self-consciousness, vulnerability, and impulsiveness (Johnson, 2014).

There is a growing concern in the literature about individuals who score higher on trait neuroticism (Marciano et al., 2020; Vittengl, 2017; Widiger & Oltmanns, 2017). This is because higher neuroticism is consistently correlated with multiple physical and mental health outcomes (Lahey, 2009; Malouff et al., 2005; Russo et al., 1997; Williams et al., 2004). Specifically, higher neuroticism is linked to decreased heart rate variability, a significant risk factor in health and wellbeing (Čukić & Bates, 2015). Additionally, higher neuroticism is associated with increased distress. Researchers hypothesize that genetics, increased exposure to stress, as well as increased reactivity to stress may explain the connection between neuroticism and health outcomes (Lahey, 2009).

The purpose of this study is to explore the relationships among the facets of neuroticism, psychological distress, and HRV. The first goal of this study was to examine the different facets of neuroticism in addition to looking at the overall effects. By looking at the facets of

neuroticism, we can identify which aspects of neuroticism are primarily contributing to the potential relationship between neuroticism, HRV, and distress. Secondly, this study collected a relatively larger sample size which allowed for improved statistical power. Using these key differences, this study intended to model the various facets of neuroticism and their association with the outcome variables of HRV and psychological distress. In particular, this study will focus on the facet of vulnerability.

Personality

Personality provides a useful framework for understanding human behavior. Personality traits are conceptualized as long-lasting and stable tendencies that result in distinctive ways of interacting with the world (Matthews et al., 2003). Personality traits are crucial in determining how we approach and experience our lives (Anglim et al., 2020; Parks & Guay, 2009). There is robust evidence that personality affects a variety of life outcomes (Roberts et al., 2007). Underlying these traits is believed to be a bio-psychosocial response to the environment (Olver & Mooradian, 2003). The Big 5 is currently the predominant model of personality traits. The five traits are: extroversion, neuroticism, conscientiousness, agreeableness, and openness (McCrae & Costa, Jr., 2007). These traits predict a wide range of outcomes such as occupational choice, life satisfaction, spirituality as well as physical and mental health (Ozer & Benet-Martínez, 2006). Research findings consistently demonstrate a connection between personality traits and health. Findings suggest that personality is related to physical health, mental health, and overall well-being (Leger et al., 2021; Srivastava & Das, 2015; Strickhouser et al., 2017).

Neuroticism

Neuroticism is correlated with physical health outcomes, with higher neuroticism predicting adverse physical and mental health conditions (Goodwin & Friedman, 2006).

Neuroticism is a predictor of increased risk of somatic disorders, smoking, and Alzheimer's disease (Mroczek et al., 2009; Neeleman et al., 2004; Terracciano et al., 2021). Those who score higher on neuroticism tend to have worse sleep than those who score lower on neuroticism (Duggan et al., 2014). One study found that increased neuroticism was related to a 9% increased risk of mortality after controlling for gender and age (Shipley et al., 2007). On the other hand, extraversion, openness, and conscientiousness are related to a perception of good health among participants who did not report experiencing medical problems. While neuroticism is associated with the self-perception of diminished health (Goodwin & Engstrom, 2002), Ormel & Wohlfarth (1991) found, in a longitudinal study, that increased neuroticism was associated with increased personal distress. Surprisingly, this effect was stronger than environmental factors such as long-term difficulties, and changes in one's life situation. One possible explanation for the profound importance that neuroticism has on health may have to do with its relationship to stress reactivity; research suggests that higher neuroticism may be related to increased reactivity to stressors.

Research has consistently linked high neuroticism with poorer mental health outcomes. One meta-analysis found that a common pattern identified in clinical disorders typically involved high neuroticism, along with low levels of conscientiousness, agreeableness, and extraversion (Malouff et al., 2005). Higher levels of neuroticism are linked with various mental health conditions, including phobias, agoraphobia, obsessive-compulsive disorder, panic disorder, generalized anxiety disorder, dysthymia, and major depressive disorder (Bienvenu et al., 2004; Ka et al., 2021). Higher neuroticism is linked to both an increased risk of developing PTSD as well as an increase in PTSD symptom severity (Breslau & Schultz, 2013; Ogle et al., 2017).

Facets of Neuroticism

Broad personality traits are composed of multiple facets. Studying facets may provide researchers with a more nuanced view of the effects of personality on physical and mental health (de Vos et al., 2022; Soye & O'Súilleabháin, 2019). By examining the facets of a trait, we can gain a better understanding of what aspect of that trait is most related to the construct under consideration. Individuals who score higher on each facet of neuroticism exhibit certain characteristics that might not be captured by looking at neuroticism holistically. For anxiety, this includes a predisposition towards fearfulness, worriedness, and nervousness, often accompanied by tension and unease. Those with high hostility scores typically show signs of anger and may also experience frustration and bitterness. High depression scores often indicate a predisposition to feeling guilty, sad, or hopeless. When looking at those who score high on self-consciousness, individuals tend to feel uneasy in social situations, are sensitive to mockery, and often feel inferior. Impulsiveness is marked by a lack of control over desires and urges. Lastly, high scores in the vulnerability facet are characterized by difficulties in handling stress, a tendency to feel overwhelmed and helpless in crisis situations, and a dependence on others for support (Costa and McCrae 1992, as cited in O'Súilleabháin et al., 2019).

Butler et al. (2023) argue that focusing on the broad personality trait of neuroticism may hide important relationships between health and personality that may be found at the level of the facets of neuroticism. O'Súilleabháin et al. (2019) found the personality facet of vulnerability to be associated with cardiovascular response to ongoing stress. One study suggested that the facets of depression and positive emotions were more highly correlated with life satisfaction than the higher order traits of neuroticism and extraversion (Schimmack et al., 2004). Apostolov & Geldenhuys (2022) found that facets of depression and vulnerability were negatively related to

academic performance. The authors argued that vulnerability is likely linked to a sense of hopelessness that impacted their ability to succeed academically. Perhaps surprisingly, this effect was stronger than environmental factors such as long-term difficulties, and changes in one's life situation. Newby et al. (2017) found that higher scores on the neuroticism facets of self-consciousness, immoderation, and vulnerability uniquely predicted increased anxiety. Findings suggest that vulnerability is associated with a higher mortality rate (Butler et al., 2023; Chapman et al., 2020).

Distress

Neuroticism is commonly associated with distress even though they are separate and distinct concepts. Psychological distress is a broad term used to describe a wide range of undifferentiated combinations of psychological and emotional symptoms, which can include symptoms of anxiety and depression. Researchers often examine psychological distress as a general indicator of mental health (Matthews, 2016). Psychological distress is believed to have a significant impact on an individual's mental health and well-being. Barry et al. (2020) found that psychological distress consistently has a negative effect on health, and this effect occurred regardless of the population, measurement tool, or specific health outcomes that were examined in their review. Their study revealed that individuals experiencing higher levels of distress were more likely to face various health challenges, including an elevated risk of mortality, the onset of asthma later in life, diminished physical capabilities in cancer patients, and reduced adherence to medication regimens in those with chronic illnesses. Understanding psychological distress and its measurement is critical in identifying those who may be at risk for mental health problems and providing effective interventions to promote mental wellness.

Research suggests that there is likely a connection between psychological distress and personality. Personality traits can serve as a protective factor against psychological distress (Pai & Carr, 2010). A study by Bolger & Schilling (1991) suggested that the mechanisms behind neuroticism leading to increasing psychological distress may be an increased reactivity to distressing situations. Rantanen et al. (2005) found that high neuroticism and low agreeableness were related to increased rates of psychological distress. Of the facets of neuroticism, vulnerability appears to be related to an increased sensitivity to reoccurring stress exposure (O'Súilleabháin et al., 2019). The vulnerability-stress model posits that stressful events are experienced more strongly by those who are more vulnerable (Zubin & Spring, 1977). Consequently, focusing on the vulnerability facet may provide a better insight into distress when compared to the other facets of neuroticism.

Heart Rate Variability

Heart Rate Variability **(**HRV) refers to the variation in time between consecutive heartbeats (Shaffer et al., 2014). Variations within heart beats are controlled by the cardiac sinoatrial node which is modulated by both the parasympathetic and sympathetic divisions of the nervous system (Berntson et al., 1997). HRV and personality are related to both physical and mental health (Ebstein et al., 2020; Perna et al., 2020; Young & Benton, 2018). Having low HRV is associated with an increased risk of coronary heart disease and mortality (Dekker et al., 2000). Research suggests that HRV can be used as a biomarker for mental health and self-regulation (Beauchaine & Thayer, 2015). Young & Benton (2018) examined the literature on associations between HRV and health outcomes such as poor nutrition, obesity, inflammation, diabetes, psychiatric disorders, and cardiovascular disease, finding that decreased HRV is consistently related to worse health outcomes.

HRV is also used as a noninvasive method to provide information about heart disease patients' prognoses (Rajendra Acharya et al., 2006). Higher baseline HRV is associated with improved performance on tasks related to executive functioning (Hansen et al., 2004). Quintana et al. (2012) found that higher HRV was significantly related to one's ability to recognize the emotions of others. Brugnera et al. (2019) examined the relationship between depressive symptoms, HRV, and stress reactivity. They found that depressive symptoms were positively correlated with higher resting-state HRV, suggesting that individuals with higher levels of depressive symptoms may experience irregular cardiovascular responses to stressful situations.

HRV is measured through multiple metrics. When examining time domain measurements of HRV, the root mean square of successive difference (RMSSD) reflects the variance between consecutive heart beats and is considered to be an effective way to assess for changes in HRV that are mediated by vagal activity (Shaffer & Ginsberg, 2017). Using spectral analyses, HRV data can be separated into different frequency bands that can be quantifiably measured. It is believed that the respiratory frequency band provides an index of overall vagal activity (Berntson et al., 1997). High Frequency HRV (HF HRV) is a frequency domain measure that operates within the frequency range of 0.15–0.40 Hz and corresponds to the respiration cycle (Berntson et al., 1997; Shaffer & Ginsberg, 2017).

Personality and HRV

Previous research has examined the relationship between personality traits and heart rate variability. Zohar et al. (2013) found that the trait openness was negatively correlated with multiple measures of HRV such as the standard deviation of NN intervals (SDNN), root mean square of successive differences (RMSSD), and the LF/HF ratio. In addition, they found that agreeableness had a positive correlation with HF HRV. However, they were not able to find a

significant relationship between HRV and neuroticism, extraversion, or conscientiousness. Oveis et al. (2009) conducted a study on 80 university students and measured their HRV during a 90-second baseline period. The findings suggest that individuals with higher baseline HRV reported greater levels of agreeableness, extraversion, optimism, and state-positive affect. They also found that baseline HRV was inversely related to neuroticism.

Meanwhile, research on the relationship between neuroticism and HRV are mixed. Multiple studies have found significant relationships between trait anxiety and HRV (Bleil et al., 2008; Miu et al., 2009; Shepherd et al., 2015). Lin et al. (2017) found that neuroticism was associated with lower levels of HRV. HRV was also found to be associated with distressed personality types (Martin et al., 2011). However, many other studies have not found such relationships. Ode et al. (2010) examined the relationship between neuroticism and HRV and their findings revealed no statistically significant association. However, this study did have a smaller sample size (n = 38), which may have affected the results. Kang et al. (2015) found that Type D personality, characterized by negative affectivity and social inhibition, showed no relationship with short-term HRV in short-term measurements in a non-clinical sample. O'Súilleabháin et al. (2019) found that when examining the personality facets of the NEO-PI-R, the facet of vulnerability was the only one associated with cardiovascular adaptation.

Sloan et al. (2017) argued that the previous literature on the relationship between HRV and personality traits consisted of primarily smaller sample sizes. In their study, they measured the personality traits and HF-HRV of 967 participants. They found that contentiousness, agency, openness, agreeableness, and neuroticism were not significantly related to HF-HRV when they adjusted for covariates of HRV. When they additionally controlled for covariates such as sex, age, and body mass index, they were able to find a significant inverse relationship between HF-

HRV and neuroticism. Another study further examined 239 young adults and found that there was no significant relationship between neuroticism, extraversion, openness, agreeableness, and contentiousness with HRV (Silvia et al., 2014). In another study, the baseline HRV of 98 college students was measured and researchers found baseline HRV correlated positively with positive affectivity. However, no significant correlation was observed between baseline HRV and negative affectivity (Wang et al., 2013). An alternative study, which included 47 participants, examined how neuroticism and extraversion related to participant's HRV both before and after a stressor. Results indicated that there was no association between HRV and neuroticism or extraversion (Brouwer et al., 2013). In a study involving 327 adolescents, similar non-significant results were obtained when exploring the relationship between neuroticism, extraversion, and HRV (Evans et al., 2016). Previous research indicates that a highly neurotic personality is closely linked to worse self-regulation of negative emotions and generally suggests a dysregulated personality system (Silverman et al., 2019; Yang et al., 2020).

Researchers have identified HRV as an indicator of self-regulation (Reynard et al., 2011). When examining this relationship, (Segerstrom & Nes, 2007) found that higher HRV values predicted better performance on tasks that required self-regulation. In addition, they found that higher HRV was associated with higher self-regulatory behavior. Their findings suggested that HRV could serve as an index for self-regulatory effort and strength. A meta-analysis of 123 studies showed a consistent yet small association between higher HRV and better top-down self-regulation across various contexts and groups. These findings support the idea that HRV can be seen as an indicator of top-down self-regulation (Holzman & Bridgett, 2017). Thus, in the context of self-regulation, it stands to reason that neuroticism and heart rate variability (HRV) are inversely related.

Porges (1992) proposed that vagal tone could serve as an index for stress vulnerability. This idea aligns with the vulnerability facet of neuroticism, which is characterized by difficulties in coping with stress, often feeling overburdened and incapacitated in crisis situations, and relying on others for assistance (Costa and McCrae 1992, as cited in O'Súilleabháin et al., 2019). This could suggest that the vulnerability facet is particularly relevant when examining HRV. Consequently, this study will concentrate on the vulnerability facet of neuroticism and how that compares to other facets when examining physiological and psychological outcomes.

Current Study

This study primarily seeks to examine how personality facets of neuroticism relate to HRV and psychological distress. Specifically, this paper has two different hypotheses. The first hypothesis is that individuals with higher scores on the vulnerability facet will have lower RMSSD and HF HRV when holding constant the other facets of neuroticism. The second hypothesis is that individuals with higher vulnerability facet scores will report higher levels of distress when controlling for the other facets.

Methods

Participants

Using data collected from three previous studies, 374 participants were recruited through an online research participation system at Brigham Young University, hereafter referred to as BYU. Some 65% of the participants were female and 35% were male. The participants' mean age was 20.31, with a range spanning from 17 to 41 years. 92.74% of the individuals in the study were white, 5.1% were Asian, 0.81% were Black, 0.81% were Hawaiian or Pacific islander, and 0.53% were Native American. The three studies received approval from the Institutional Review Board (IRB) at BYU. All participants were informed of their rights, the purpose of the study, and

informed that they could withdraw from the study at any time without penalty. The confidentiality of the participant's personal information and data was maintained throughout the study. Prior to participation in the study, participants were excluded if they had a history of heart disease or were taking medication for heart disease or high blood pressure.

Physiological Measures

HRV was measured by a NEXUS 4 biofeedback device. This biofeedback device uses a three-lead system to continuously measure the electrical activity of the heart. In this configuration, one electrode was placed on each collarbone of the participant, and one was placed on the lowest left rib. The biofeedback device collects data on the intervals between each heartbeat measured in milliseconds. Artifacts in HRV data are a common occurrence and can potentially skew the data. The raw data was cleaned using the Kubios HRV software using the "medium" correction threshold to find and correct for various artifacts (Tarvainen et al., 2014). Calculations of HRV, including RMSSD and HF HRV, were calculated from the Kubios software. The study used log-transformed HF HRV values as spectral analyses of HF HRV yields exponentially distributed values which can pose challenges for analysis (Ellis et al., 2008). To address the nonlinear relationship between RMSSD and HF HRV, I applied a logarithmic transformation to RMSSD.

Psychological Measures

Psychological distress was measured through the Depression, Anxiety, and Stress Scale (DASS). The DASS is a self-report measure comprised of 21 items. The DASS was designed to broadly measure depressive and anxious symptoms (Sinclair et al., 2012). Studies examining the psychometric properties of the DASS suggest that it is a valid tool to measure anxiety and depression (AKIN & Çetin, 2007; Sinclair et al., 2012).

The Depression and Anxiety Scale (DASS) is one tool used to measure psychological distress, and specific symptoms related to depression, anxiety, and stress (Lovibond & Lovibond, 1995). The DASS was validated as a reliable and valid measure of psychological distress (AKIN & Çetin, 2007). Estimates of internal validity for each scale using Cronbach's alpha ranged from .84 to .91. Construct validity of the DASS has generally been positive as it is able to discriminate between diagnostic groups and has shown moderate to large correlations with similar measures (Sinclair et al., 2012). The DASS will be scored by summing the raw scores in the depression, anxiety, and stress subscale.

The facets and items of neuroticism used in this study are from the IPIP-NEO-120 (Johnson, 2014). This study will treat each facet as a latent variable with 4 items loading onto each facet. Derived from Johnson's (2014) study, Cronbach's alpha values for each facet are provided below: Anxiety (α = .78), Anger (α = .87), Depression (α = 0.85), Self-consciousness (α = .70), Immoderation (α = .69), Vulnerability (α = .79). Descriptive statistics for the outcome variables in this study can be found in Table 1.

Table 1

Descriptive Statistics for Outcome Variables

Variable	Minimum	Maximum	Mean	Std. Deviation
DASS	21	80	37.30	10.88
Log of RMSSD	2.65	5.26	3.96	.51
Log of HF HRV	4.15	9.55	6.97	.99

Procedure

Participants first signed up for the study through an online Qualtrics survey. In the survey, data was collected on the IPIP-NEO-120 and the DASS. The participants were then taken to a signup page where they scheduled an appointment with a research assistant. When participants arrived at the lab, they were asked to sit down and were connected to the Biotrace biofeedback machine by a research assistant. The research assistant placed an electrode on each collarbone and placed one on the participant's lowest left rib. The participants were instructed to not cross their legs or look at their phones during the 10-minute baseline recording.

Design and Analysis

To analyze this data, I used confirmatory factor analysis (CFA) to analyze the measurement aspect of my model. I then examined model fit by examining factor loadings and multiple fit indices such as chi-square, comparative fit index (CFI), and root mean square error of approximation (RMSEA). I then used structural equation modeling (SEM) to examine the structural paths related to my two hypotheses. One of the advantages of using structural equation modeling is that I will be able to both evaluate the measurement of each facet of neuroticism as well as the structural relationships between these facets and RMSSD, HF HRV, and distress as measured by the DASS (Tomarken & Waller, 2005). Due to concerns regarding multicollinearity between my two HRV measures, I split my analysis into two models. The first model examines the neuroticism facets and their potential relationship to RMSSD and distress. The second model will examine the relationship between the facets of neuroticism and HF HRV. To handle missing data, I used full information maximum likelihood (FIML) to estimate missing values. FIML is recommended as an effective technique to estimate missing values (Cham et al.,

2017). Both models in this analysis were fully identified using Bollen's two step rule (Bollen, 1989).

Results

Preliminary Analyses

Correlation analyses found significant correlations between DASS scores and every facet of neuroticism. Additionally, there were significant correlations among all facets of neuroticism. As expected, RMSSD and HF HRV were significantly correlated with each other. Results of preliminary correlation analysis for each study variable can be found in table 2.

Table 2

Correlations of all Study Variables

Variable	1	2	3	4	5	6	7	8	9
1. Anxiety	1.0								
2. Anger	**0.40**	1.0							
3. Depression	**0.55**	**0.31**	1.0						
4. Self-Consciousness	**0.46**	**0.17**	**0.40**	1.0					
5. Immoderation	**0.26**	**0.21**	**0.29**	**0.26**	1.0				
6. Vulnerability	**0.78**	**0.36**	**0.52**	**0.19**	**0.25**	1.0			
7. DASS	**0.54**	**0.27**	**0.59**	**0.25**	**0.19**	**0.55**	1.0		
8. Log of RMSSD	-0.03	0.03	-0.01	-0.04	-0.07	-0.08	-0.07	1.0	
9. Log of HF HRV	-0.01	0.04	-0.02	-0.02	-0.06	-0.07	-0.04	**0.96**	1.0

Bolded values indicate a statistically significant correlation ($p < 0.5$).

Measurement Model

The neuroticism facets on the IPIP-NEO-120 were used as latent variables, with each having four items loaded onto their respective latent variable. Measurement of this model was evaluated using confirmatory factor analysis. In this analysis, values indicative of good fit were a nonsignificant chi-square test ($p > .05$), a CFI greater than .90 and a RMSEA value less than .05. The fit indices for our CFA model indicated that the model fit the data moderately well (X^2 (237) = 561.17, $p < .001$, CFI = .909, and RMSEA = .061). The chi-square test was statistically significant which indicated there was some discrepancy between this model and the observed data. However, the CFI and RMSEA values indicated that the model fit ranged from moderate to good. Additionally, all indicators significantly loaded onto their respective factors ($p < .001$). Item loadings can be found in table 3.

Table 3

Item Loadings for Each Facet of Neuroticism

		IPIP-NEO-120 items	Standardized loadings
Anxiety	1	Worry about things	0.70
	31	Fear for the worst	0.71
	61	Am afraid of many things	0.67
	91	Get stressed out easily	0.77
Anger	6	Get angry easily	0.89
	36	Get irritated easily	0.76
	66	Lose my temper	0.84
	96	Am not easily annoyed (R)	0.45
Depression	11	Often feel blue	0.85
	41	Dislike myself	0.66
	71	Am often down in the dumps	0.88
	101	Feel comfortable with myself (R)	0.49
Self-consciousness	16	Find it difficult to approach others	0.75
	46	Am afraid to draw attention to myself	0.56
	76	Only feel comfortable with my friends	0.58
	106	Am not bothered by difficult social situation (R)	0.55
Immoderation	21	Go on binges	0.59
	51	Rarely overindulge (R)	0.66
	81	Easily resist temptations	0.42
	111	Am able to control my cravings (R)	0.67
Vulnerability	26	Panic easily	0.78
	56	Become overwhelmed by events	0.70
	86	Feel that I'm unable to deal with things	0.67
	116	Remain calm under pressure (R)	0.49

(R) indicates items are reverse scored.

Structural Model

Model 1

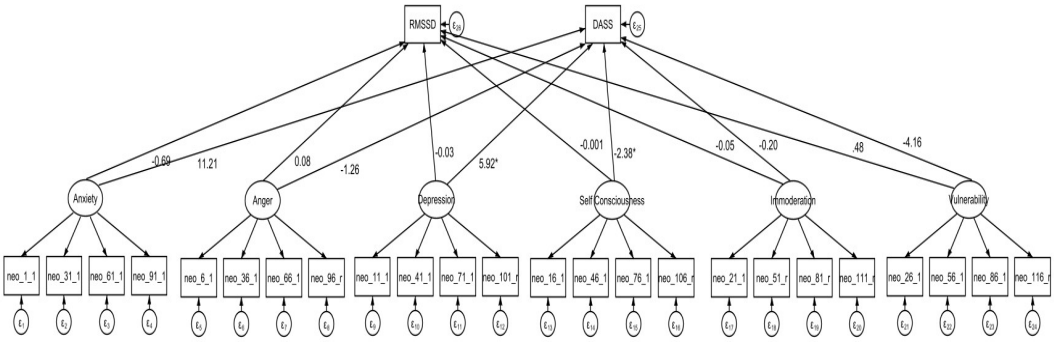
The first model revealed the structural relationships between the latent variables representing six different facets of neuroticism and the observed outcome variables, log-transformed RMSSD and total distress as measured by DASS. The results indicated that vulnerability did not significantly predict RMSSD (β = .48 p = .39) or distress (β = -4.16 p = .56) when holding the other facets constant. For the outcome variable RMSSD, the path coefficients for the other facets are as follows: Anxiety (β = -0.69, p = 0.36), Anger (β = 0.08, p = 0.12), Depression (β = -0.03, p = 0.69), Self-Consciousness (β = -0.001, p = 0.98), and immoderation (-0.05, p = 0.46). Notably, none of these path coefficients reached statistical significance, suggesting that the facets of neuroticism do not significantly predict RMSSD. When looking at the outcome variable of distress, the coefficients for each other facet of neuroticism were estimated as follows: Anxiety (β = 11.21, p = 0.24), Anger (β = -1.26, p = 0.08), Depression (β = 5.92, p < 0.01), Self-Consciousness (β = -2.38, p = 0.03), and immoderation (β = -0.20, p = 0.82). Of these facets, depression and self-consciousness exhibited statistically significant relationships with distress when controlling for the other facets. These results indicated that individuals scoring higher on the depression facet reported higher DASS scores, while individuals who scored higher on the self-consciousness facet reported lower DASS scores.

When looking at the outcome variable of distress, the coefficients for each facet of neuroticism were estimated as follows: Anxiety (β = 11.35, p = 0.238), Anger (β = -1.27, p = 0.081), Depression (β = 5.85, p < 0.001), Self-Consciousness (β = -2.34, p = 0.033), and immoderation (β = -0.17, p = 0.850). Of these facets, depression and self-consciousness exhibited statistically significant relationships with distress when controlling for the other facets.

This indicates that individuals scoring higher on the depression facet reported higher DASS scores, while higher scores on the self-consciousness were associated with lower DASS scores.

Figure 1

SEM Path Diagram of the First Model

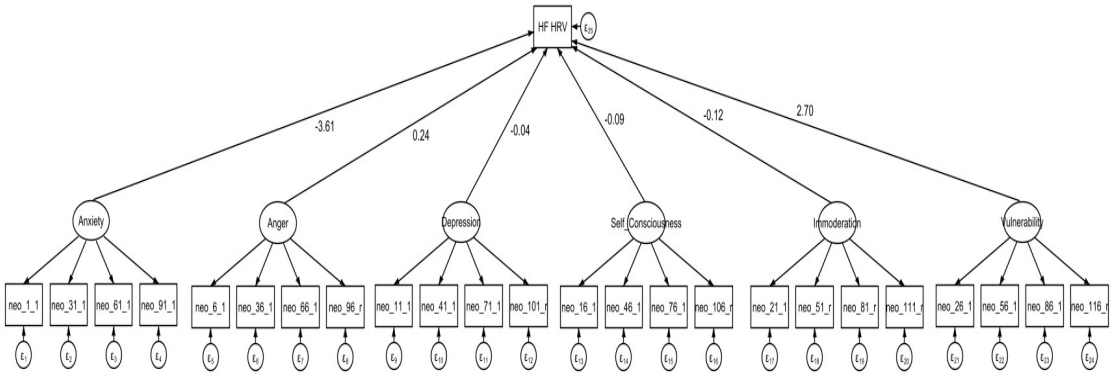


Model 2

The second model of this analysis examined the structural relationship between the facets of neuroticism with HF HRV. The results of this model indicated that when the other facets of neuroticism were held constant, the vulnerability facet did not significantly predict HF HRV (β = 2.70 *p* = .58). The structural coefficients for the other neuroticism facets are as follows. Anxiety (β = -3.61, p = 0.57), Anger (β = 0.24, p = 0.42), Depression (β = -0.04, p = 0.86), Self-Consciousness (β = -0.09, p = 0.80), and Immoderation (β = -0.12, p = 0.64). None of these coefficients reached statistical significance, indicating that the facets of neuroticism did not show a significant predictive relationship with HF HRV. A visual representation of the model can be found in figure 2.

Figure 2

SEM Path Diagram of the Second Model



Discussion

This study examined the potential relationship between the facets of neuroticism including anxiety, depression, self-consciousness, immoderation, vulnerability with HRV, and distress. The first hypothesis was that higher scores on the vulnerability facet would be associated with a decrease in both RMSSD and HF HRV. The results of this study did not support this hypothesis, as there was no statistically significant relationship between vulnerability and RMSSD or HF HRV in either of the models. One reason that could potentially explain these null findings is that our sample largely consisted of young and healthy college students. It is possible that most of the participants' HRV was in a relatively healthy range and the variation needed to detect significant differences may have been limited.

The second hypothesis is that an increase in the vulnerability facet would predict an increase in distress. The SEM results did not support this hypothesis. There was no significant relationship between vulnerability and distress when holding the other facets constant. The depression facet was not significantly related to distress. This indicated individuals who scored

higher on the depression facet were more likely to report distress. This finding is consistent with previous research that indicated that the effects of trait neuroticism on anxious and depressive symptoms are limited to the depression facet (Lyon et al., 2020). Based on our preliminary analyses, vulnerability was significantly correlated with distress. However, it appears that when controlling for the other facets, the variability in distress is largely explained by both depression and self-consciousness.

The finding that increased self-consciousness led to a decrease in distress is inconsistent with the current literature (Panayiotou & Kokkinos, 2006). It is unclear what could explain this discrepant finding. One theorist linked the construct of self-consciousness to self-awareness and suggested that increased self-awareness could help with self-regulation (Carver & Scheier, 2001). This theory could suggest that increased self-consciousness could be indirectly related to better self-regulation. If this is the case, it could imply that self-consciousness, in certain contexts, might serve as a protective factor against distress, a hypothesis that merits further exploration.

The lack of a significant association among any of the facets of neuroticism with HRV in this study further supports the notion that the non-significant relationship between neuroticism and HRV extends even when examining neuroticism at the facet level. Numerous previous studies did not find a significant association between neuroticism and HRV (Ode et al., 2010; Silvia et al., 2014; Sloan et al., 2017; Wang et al., 2013). Additionally, the non-significant relationship between vulnerability and distress is at odds with previous research. Taken at face value this would contradict the assertion individuals who are more vulnerable experience an increased response to stressful events as suggested by Zubin & Spring (1977). However, it is possible that participants need to be experiencing a stressor in order for higher levels of

vulnerability to impact their distress levels. This highlights the need for additional research into this area to better understand the inconsistent results in the literature related to neuroticism, HRV, and distress.

Limitations and Future Research

There are multiple limitations with this study. The majority of participants in this sample were young college students who are likely healthy. Research suggests that HRV measures tend to decrease with age (Jandackova et al., 2016; Shaffer & Ginsberg, 2017). As HRV measures were taken at a baseline it is likely that there was limited variability within this young and healthy sample, thereby restricting the models' ability to detect meaningful differences within participants. Additionally, the sample was fairly homogenous in terms of gender, race, and age limiting the generalizability of this study. This study depended on participants subjective responses to measure distress as well as the facets of neuroticism and this could have introduced various biases that may have impacted the results. Future research could examine the potential relationship between the facets of neuroticism and HRV in other contexts such as during a stressor or recovery period. It is possible that these facets do influence HRV but only during specific circumstances. Future research could examine these research questions with a sample that has a more diverse range of ages.

Conclusion

Overall, the findings from the two SEM models did not support the hypotheses of this paper. There was no significant relationship between the facet vulnerability and HRV (e.g., RMSSD, HF HRV). Additionally, vulnerability did not significantly predict distress when holding the other facets constant. It appears that the effect of neuroticism on distress is mostly impacted by depression and self-consciousness. This study did have limitations that could have

impacted the overall findings. Future research could explore these hypotheses in a more diverse sample with a larger age range of participants. In addition, future research could explore if a potential relation between the facets of neuroticism and HRV exists in different contexts.

References

Anglim, J., Horwood, S., Smillie, L. D., Marrero, R. J., & Wood, J. K. (2020). Predicting psychological and subjective well-being from personality: A meta-analysis. *Psychological Bulletin*, 146(4), 279.

AKIN, A., & Çetin, B. (2007). The Depression Anxiety and Stress Scale (DASS): The study of validity and reliability. *Educational Sciences: Theory and Practice*, *7*, 241–268.

Apostolov, N., & Geldenhuys, M. (2022). The role of neuroticism and conscientious facets in academic motivation. *Brain and Behavior*, *12*(8), e2673. https://doi.org/10.1002/brb3.2673

Barry, V., Stout, M. E., Lynch, M. E., Mattis, S., Tran, D. Q., Antun, A., Ribeiro, M. J., Stein, S. F., & Kempton, C. L. (2020). The effect of psychological distress on health outcomes: A systematic review and meta-analysis of prospective studies. *Journal of Health Psychology*, *25*(2), 227–239. https://doi.org/10.1177/1359105319842931

Beauchaine, T. P., & Thayer, J. F. (2015). Heart rate variability as a transdiagnostic biomarker of psychopathology. *International Journal of Psychophysiology*, *98*(2, Part 2), 338–350. https://doi.org/10.1016/j.ijpsycho.2015.08.004

Berntson, G. G., Bigger, J. T., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Nagaraja, H. N., Porges, S. W., Saul, J. P., Stone, P. H., & van der Molen, M. W. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, *34*(6), 623–648. https://doi.org/10.1111/j.1469-8986.1997.tb02140.x

Bienvenu, O. J., Samuels, J. F., Costa, P. T., Reti, I. M., Eaton, W. W., & Nestadt, G. (2004). Anxiety and depressive disorders and the five-factor model of personality: A higher- and

lower-order personality trait investigation in a community sample. *Depression and Anxiety*, *20*(2), 92–97. https://doi.org/10.1002/da.20026

Bleil, M. E., Gianaros, P. J., Jennings, J. R., Flory, J. D., & Manuck, S. B. (2008). Trait negative affect: Toward an integrated model of understanding psychological risk for impairment in cardiac autonomic function. *Psychosomatic Medicine*, *70*(3), 328–337. https://doi.org/10.1097/PSY.0b013e31816baefa

Bolger, N., & Schilling, E. A. (1991). Personality and the problems of everyday life: The role of neuroticism in exposure and reactivity to daily stressors. *Journal of Personality*, *59*(3), 355–386. https://doi.org/10.1111/j.1467-6494.1991.tb00253.x

Bollen, K. A. (1989). Structural equation models with observed variables. In *Structural equations with latent variables* (pp. 80–150). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118619179.ch4

Breslau, N., & Schultz, L. (2013). Neuroticism and post-traumatic stress disorder: A prospective investigation. *Psychological Medicine*, *43*(8), 1697–1702. https://doi.org/10.1017/S0033291712002632

Brouwer, A.-M., van Schaik, M., van Erp, J., & Korteling, H. (2013). Neuroticism, Extraversion and Stress: Physiological Correlates. *2013 Humaine Association Conference on Affective Computing and Intelligent Interaction*, 429–434. https://doi.org/10.1109/ACII.2013.77

Brugnera, A., Zarbo, C., Tarvainen, M. P., Carlucci, S., Tasca, G. A., Adorni, R., Auteri, A., & Compare, A. (2019). Higher levels of depressive symptoms are associated with increased resting-state heart rate variability and blunted reactivity to a laboratory stress task among healthy adults. *Applied Psychophysiology and Biofeedback*, *44*(3), 221–234. https://doi.org/10.1007/s10484-019-09437-z

Butler, M., Turiano, N., Buckley, L., McGeehan, M., & O'Súilleabháin, P. S. (2023). Neuroticism facets and mortality risk in adulthood: A systematic review and narrative synthesis. *Journal of Psychosomatic Research*, *175*, 111500. https://doi.org/10.1016/j.jpsychores.2023.111500

Carver, C. S., & Scheier, M. F. (2001). *On the self-regulation of behavior*. Cambridge University Press.

Cham, H., Reshetnyak, E., Rosenfeld, B., & Breitbart, W. (2017). Full information maximum likelihood estimation for latent variable interactions with incomplete indicators. *Multivariate Behavioral Research*, *52*(1), 12–30. https://doi.org/10.1080/00273171.2016.1245600

Chapman, B. P., Elliot, A., Sutin, A., Terraciano, A., Zelinski, E., Schaie, W., Willis, S., & Hofer, S. (2020). Mortality risk associated with personality facets of the big five and interpersonal circumplex across three aging cohorts. *Psychosomatic Medicine*, *82*(1), 64–73. https://doi.org/10.1097/PSY.0000000000000756

Costa Jr., P. T., & McCrae, R. R. (1987). Neuroticism, somatic complaints, and disease: Is the bark worse than the bite? *Journal of Personality*, *55*(2), 299–316. https://doi.org/10.1111/j.1467-6494.1987.tb00438.x

Costa Jr, P. T., & McCrae, R. R. (1995). Domains and facets: Hierarchical personality assessment using the Revised NEO Personality Inventory. *Journal of Personality Assessment*, *64*(1), 21–50.

Čukić, I., & Bates, T. C. (2015). The association between neuroticism and heart rate variability is not fully explained by cardiovascular disease and depression. *PLOS ONE*, *10*(5), e0125882. https://doi.org/10.1371/journal.pone.0125882

Dekker, J. M., Crow, R. S., Folsom, A. R., Hannan, P. J., Liao, D., Swenne, C. A., & Schouten, E. G. (2000). Low heart rate variability in a 2-minute rhythm strip predicts risk of coronary heart disease and mortality from several causes. *Circulation*, *102*(11), 1239–1244. https://doi.org/10.1161/01.CIR.102.11.1239

de Vos, J. A., Radstaak, M., Bohlmeijer, E. T., & Westerhof, G. J. (2022). Exploring associations between personality trait facets and emotional, psychological and social well-being in eating disorder patients. *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity*, *27*(1), 379–386. https://doi.org/10.1007/s40519-021-01107-6

Duggan, K. A., Friedman, H. S., McDevitt, E. A., & Mednick, S. C. (2014). Personality and healthy sleep: The importance of conscientiousness and neuroticism. *PLOS ONE*, *9*(3), e90628. https://doi.org/10.1371/journal.pone.0090628

Ebstein, R. P., Jiang, Y., Zhang, X., & Chew, S. H. (2020). Personality and health. In K. J. Saudino & J. M. Ganiban (Eds.), *Behavior genetics of temperament and personality* (pp. 153–191). Springer. https://doi.org/10.1007/978-1-0716-0933-0_6

Ellis, R. J., Sollers Iii, J. J., Edelstein, E. A., & Thayer, J. F. (2008). Data transforms for spectral analyses of heart rate variability. *Biomedical Sciences Instrumentation*, *44*, 392–397.

Evans, B. E., Stam, J., Huizink, A. C., Willemen, A. M., Westenberg, P. M., Branje, S., Meeus, W., Koot, H. M., & van Lier, P. A. C. (2016). Neuroticism and extraversion in relation to physiological stress reactivity during adolescence. *Biological Psychology*, *117*, 67–79. https://doi.org/10.1016/j.biopsycho.2016.03.002

Goodwin, R. D., & Friedman, H. S. (2006). Health status and the five-factor personality traits in a nationally representative sample. *Journal of Health Psychology*, *11*(5), 643–654. https://doi.org/10.1177/1359105306066610

Goodwin, R., & Engstrom, G. (2002). Personality and the perception of health in the general population. *Psychological Medicine*, *32*(2), 325–332. https://doi.org/10.1017/S0033291701005104

Hansen, A. L., Johnsen, B. H., Sollers, J. J., Stenvik, K., & Thayer, J. F. (2004). Heart rate variability and its relation to prefrontal cognitive function: The effects of training and detraining. *European Journal of Applied Physiology*, *93*(3), 263–272. https://doi.org/10.1007/s00421-004-1208-0

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*(Pt A), 233–255. https://doi.org/10.1016/j.neubiorev.2016.12.032

Jandackova, V. K., Scholes, S., Britton, A., & Steptoe, A. (2016). Are changes in heart rate variability in middle-aged and older people normative or caused by pathological conditions? Findings from a large population-based longitudinal cohort study. *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*, *5*(2), e002365. https://doi.org/10.1161/JAHA.115.002365

Johnson, J. A. (2014). Measuring thirty facets of the Five Factor Model with a 120-item public domain inventory: Development of the IPIP-NEO-120. *Journal of Research in Personality*, *51*, 78–89. https://doi.org/10.1016/j.jrp.2014.05.003

Lyon, K., Elliott, R., Ware, K., Juhasz, G., & Brown, L. Associations between facets and aspects of big five personality and affective disorders: A systematic review and best evidence synthesis. *Journal of Affective Disorders*, *288*, 175–188. https://doi.org/10.1016/j.jad.2021.03.061

Kang, N., Lim, J.-S., Hwang, T.-G., Joe, S.-H., & Lee, M.-S. (2015). The Relationship between type D personality and heart rate variability in community mental health center users. *Psychiatry Investigation*, *12*(2), 197–203. https://doi.org/10.4306/pi.2015.12.2.197

Lahey, B. B. (2009). Public health significance of neuroticism. *American Psychologist*, *64*(4), 241–256. https://doi.org/10.1037/a0015309

Leger, K. A., Turiano, N. A., Bowling, W., Burris, J. L., & Almeida, D. M. (2021). Personality traits predict long-term physical health via affect reactivity to daily stressors. *Psychological Science*, *32*(5), 755–765. https://doi.org/10.1177/0956797620980738

Lin, I.-M., Wang, S.-Y., Chu, I.-H., Lu, Y.-H., Lee, C.-S., Lin, T.-H., & Fan, S.-Y. (2017). The association of type D personality with heart rate variability and lipid profiles among patients with coronary artery disease. *International Journal of Behavioral Medicine*, *24*(1), 101–109. https://doi.org/10.1007/s12529-016-9571-x

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy*, *33*(3), 335–343. https://doi.org/10.1016/0005-7967(94)00075-U

Lyon, K. A., Juhasz, G., Brown, L. J. E., & Elliott, R. (2020). Big Five personality facets explaining variance in anxiety and depressive symptoms in a community sample. *Journal of Affective Disorders*, *274*, 515–521. https://doi.org/10.1016/j.jad.2020.05.047

Malouff, J. M., Thorsteinsson, E. B., & Schutte, N. S. (2005). The relationship between the five-factor model of personality and symptoms of clinical disorders: A meta-analysis. *Journal of Psychopathology and Behavioral Assessment*, *27*(2), 101–114. https://doi.org/10.1007/s10862-005-5384-y

Marciano, L., Camerini, A.-L., & Schulz, P. J. (2020). Neuroticism in the digital age: A meta-analysis. *Computers in Human Behavior Reports*, *2*, 100026. https://doi.org/10.1016/j.chbr.2020.100026

Martin, L. A., Doster, J. A., Critelli, J. W., Purdum, M., Powers, C., Lambert, P. L., & Miranda, V. (2011). The 'distressed' personality, coping and cardiovascular risk. *Stress and Health*, *27*(1), 64–72. https://doi.org/10.1002/smi.1320

Matthews, G. (2016). *Stress: Concepts, cognition, emotion, and behavior*. Handbook of Stress Series, Volume 1. Elsevier. eBook ISBN: 9780128011379

Matthews, G., Deary, I. J., & Whiteman, M. C. (2003). *Personality traits* (2nd edition). Cambridge University Press. https://doi.org/10.1017/CBO9780511812736

McCrae, R. R., & Costa, Jr., P. T. (2007). Brief versions of the NEO-PI-3. *Journal of Individual Differences*, *28*(3), 116–128. https://doi.org/10.1027/1614-0001.28.3.116

Miu, A. C., Heilman, R. M., & Miclea, M. (2009). Reduced heart rate variability and vagal tone in anxiety: Trait versus state, and the effects of autogenic training. *Autonomic Neuroscience: Basic & Clinical*, *145*(1–2), 99–103. https://doi.org/10.1016/j.autneu.2008.11.010

Mroczek, D. K., Spiro III, A., & Turiano, N. A. (2009). Do health behaviors explain the effect of neuroticism on mortality? Longitudinal findings from the VA Normative Aging Study. *Journal of Research in Personality*, *43*(4), 653–659.

Neeleman, J., Bijl, R., & Ormel, J. (2004). Neuroticism, a central link between somatic and psychiatric morbidity: Path analysis of prospective data. *Psychological Medicine*, *34*(3), 521–531. https://doi.org/10.1017/S0033291703001193

Newby, J., Pitura, V. A., Penney, A. M., Klein, R. G., Flett, G. L., & Hewitt, P. L. (2017). Neuroticism and perfectionism as predictors of social anxiety. *Personality and Individual Differences*, *106*, 263–267. https://doi.org/10.1016/j.paid.2016.10.057

Ode, S., Hilmert, C. J., Zielke, D. J., & Robinson, M. D. (2010). Neuroticism's importance in understanding the daily life correlates of heart rate variability. *Emotion*, *10*(4), 536–543. https://doi.org/10.1037/a0018698

Ogle, C. M., Siegler, I. C., Beckham, J. C., & Rubin, D. C. (2017). Neuroticism increases PTSD symptom severity by amplifying the emotionality, rehearsal, and centrality of trauma memories. *Journal of Personality*, *85*(5), 702–715. https://doi.org/10.1111/jopy.12278

Olver, J. M., & Mooradian, T. A. (2003). Personality traits and personal values: A conceptual and empirical integration. *Personality and Individual Differences*, *35*(1), 109–125. https://doi.org/10.1016/S0191-8869(02)00145-9

Ormel, J., & Wohlfarth, T. (1991). How neuroticism, long-term difficulties, and life situation change influence psychological distress: A longitudinal model. *Journal of Personality and Social Psychology*, *60*(5), 744–755. https://doi.org/10.1037/0022-3514.60.5.744

O'Súilleabháin, P. S., Hughes, B. M., Oommen, A. M., Joshi, L., & Cunningham, S. (2019). Vulnerability to stress: Personality facet of vulnerability is associated with cardiovascular adaptation to recurring stress. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *144*, 34–39. https://doi.org/10.1016/j.ijpsycho.2019.06.013

Oveis, C., Cohen, A. B., Gruber, J., Shiota, M. N., Haidt, J., & Keltner, D. (2009). Resting respiratory sinus arrhythmia is associated with tonic positive emotionality. *Emotion,* 9(2), 265 –270. https://doi.org/10.1037/a0015383

Ozer, D. J., & Benet-Martínez, V. (2006). Personality and the prediction of consequential outcomes. *Annual Review of Psychology*, *57*(1), 401–421. https://doi.org/10.1146/annurev.psych.57.102904.190127

Pai, M., & Carr, D. (2010). Do personality traits moderate the effect of late-life spousal loss on psychological distress? *Journal of Health and Social Behavior*, *51*(2), 183–199. https://doi.org/10.1177/0022146510368933

Panayiotou, G., & Kokkinos, C. M. (2006). Self-consciousness and psychological distress: A study using the Greek SCS. *Personality and Individual Differences*, *41*(1), 83–93. https://doi.org/10.1016/j.paid.2005.10.025

Parks, L., & Guay, R. P. (2009). Personality, values, and motivation. *Personality and Individual Differences*, *47*(7), 675–684. https://doi.org/10.1016/j.paid.2009.06.002

Perna, G., Riva, A., Defillo, A., Sangiorgio, E., Nobile, M., & Caldirola, D. (2020). Heart rate variability: Can it serve as a marker of mental health resilience?: Special Section on "Translational and Neuroscience Studies in Affective Disorders" Section Editor, Maria Nobile MD, PhD. *Journal of Affective Disorders*, *263*, 754–761. https://doi.org/10.1016/j.jad.2019.10.017

Porges, S. W. (1992). Vagal tone: A physiologic marker of stress vulnerability. *Pediatrics*, *90*(3), 498–504. https://doi.org/10.1542/peds.90.3.498

Quintana, D. S., Guastella, A. J., Outhred, T., Hickie, I. B., & Kemp, A. H. (2012). Heart rate variability is associated with emotion recognition: Direct evidence for a relationship between the autonomic nervous system and social cognition. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *86*(2), 168–172. https://doi.org/10.1016/j.ijpsycho.2012.08.012

Rajendra Acharya, U., Paul Joseph, K., Kannathal, N., Lim, C. M., & Suri, J. S. (2006). Heart rate variability: A review. *Medical and Biological Engineering and Computing*, *44*(12), 1031–1051. https://doi.org/10.1007/s11517-006-0119-0

Rantanen, J., Pulkkinen, L., & Kinnunen, U. (2005). The big five personality dimensions, work-family conflict, and psychological distress: A longitudinal view. *Journal of Individual Differences*, *26*(3), 155–166. https://doi.org/10.1027/1614-0001.26.3.155

Reynard, A., Gevirtz, R., Berlow, R., Brown, M., & Boutelle, K. (2011). Heart rate variability as a marker of self-regulation. *Applied Psychophysiology and Biofeedback*, *36*(3), 209–215. https://doi.org/10.1007/s10484-011-9162-1

Roberts, B. W., Kuncel, N. R., Shiner, R., Caspi, A., & Goldberg, L. R. (2007). The power of personality: The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science*, *2*(4), 313–345. https://doi.org/10.1111/j.1745-6916.2007.00047.x

Russo, J., Katon, W., Lin, E., Von Korff, M., Bush, T., Simon, G., & Walker, E. (1997). Neuroticism and extraversion as predictors of health outcomes in depressed primary care patients. *Psychosomatics*, *38*(4), 339–348. https://doi.org/10.1016/S0033-3182(97)71441-5

Schimmack, U., Oishi, S., Furr, R. M., & Funder, D. C. (2004). Personality and life satisfaction: A facet-level analysis. *Personality & Social Psychology Bulletin*, *30*(8), 1062–1075. https://doi.org/10.1177/0146167204264292

Segerstrom, S. C., & Nes, L. S. (2007). Heart rate variability reflects self-regulatory strength, effort, and fatigue. *Psychological Science*, *18*(3), 275–281. https://doi.org/10.1111/j.1467-9280.2007.01888.x

Shaffer, F., & Ginsberg, J. P. (2017). An overview of heart rate variability metrics and norms. *Frontiers in Public Health*, *5*, 258. https://doi.org/10.3389/fpubh.2017.00258

Shaffer, F., McCraty, R., & Zerr, C. L. (2014). A healthy heart is not a metronome: An integrative review of the heart's anatomy and heart rate variability. *Frontiers in Psychology*, *5*. https://www.frontiersin.org/articles/10.3389/fpsyg.2014.01040

Shepherd, D., Mulgrew, J., & Hautus, M. J. (2015). Exploring the autonomic correlates of personality. *Autonomic Neuroscience*, *193*, 127–131. https://doi.org/10.1016/j.autneu.2015.05.004

Shipley, B. A., Weiss, A., Der, G., Taylor, M. D., & Deary, I. J. (2007). Neuroticism, extraversion, and mortality in the UK Health and Lifestyle Survey: A 21-year prospective cohort study. *Psychosomatic Medicine*, *69*(9), 923–931. https://doi.org/10.1097/PSY.0b013e31815abf83

Silverman, M. H., Wilson, S., Ramsay, I. S., Hunt, R. H., Thomas, K. M., Krueger, R. F., & Iacono, W. G. (2019). Trait neuroticism and emotion neurocircuitry: Functional magnetic resonance imaging evidence for a failure in emotion regulation. *Development and Psychopathology*, *31*(3), 1085–1099. https://doi.org/10.1017/S0954579419000610

Silvia, P. J., Jackson, B. A., & Sopko, R. S. (2014). Does baseline heart rate variability reflect stable positive emotionality? *Personality and Individual Differences*, *70*, 183–187. https://doi.org/10.1016/j.paid.2014.07.003

Sinclair, S. J., Siefert, C. J., Slavin-Mulford, J. M., Stein, M. B., Renna, M., & Blais, M. A. (2012). Psychometric evaluation and normative data for the Depression, Anxiety, and Stress Scales-21 (DASS-21) in a nonclinical sample of U.S. adults. *Evaluation & the Health Professions*, *35*(3), 259–279. https://doi.org/10.1177/0163278711424282

Sloan, R. P., Schwarz, E., McKinley, P. S., Weinstein, M., Love, G., Ryff, C., Mroczek, D., Choo, T.-H., Lee, S., & Seeman, T. (2017). Vagally-mediated heart rate variability and indices of well-being: Results of a nationally representative study. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *36*(1), 73–81. https://doi.org/10.1037/hea0000397

Soye, A., & O'Súilleabháin, P. S. (2019). Facets of openness to experience are associated with cardiovascular reactivity and adaptation across both active and passive stress exposures. *International Journal of Psychophysiology: Official Journal of the International Organization of Psychophysiology*, *140*, 26–32. https://doi.org/10.1016/j.ijpsycho.2019.03.016

Srivastava, K., & Das, R. C. (2015). Personality and health: Road to well-being. *Industrial Psychiatry Journal*, *24*(1), 1–4. https://doi.org/10.4103/0972-6748.160905

Strickhouser, J. E., Zell, E., & Krizan, Z. (2017). Does personality predict health and well-being? A metasynthesis. *Health Psychology*, *36*(8), 797–810. https://doi.org/10.1037/hea0000475

Tackett, J. L., & Lahey, B. B. (2017). Neuroticism. In T. A. Widiger (Ed.), *The Oxford Handbook of the Five Factor Model* (p. 0). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199352487.013.14

Tarvainen, M. P., Niskanen, J.-P., Lipponen, J. A., Ranta-aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV – Heart rate variability analysis software. *Computer Methods and Programs in Biomedicine*, *113*(1), 210–220. https://doi.org/10.1016/j.cmpb.2013.07.024

Terracciano, A., Aschwanden, D., Passamonti, L., Toschi, N., Stephan, Y., Luchetti, M., Lee, J. H., Sesker, A. A., O'Súilleabháin, P. S., & Sutin, A. R. (2021). Is neuroticism

differentially associated with risk of Alzheimer's disease, vascular dementia, and frontotemporal dementia? *Journal of Psychiatric Research*, *138*, 34–40. https://doi.org/10.1016/j.jpsychires.2021.03.039

Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: Strengths, limitations, and misconceptions. *Annual Review of Clinical Psychology*, *1*, 31–65. https://doi.org/10.1146/annurev.clinpsy.1.102803.144239

Vittengl, J. R. (2017). Who pays the price for high neuroticism? Moderators of longitudinal risks for depression and anxiety. *Psychological Medicine*, *47*(10), 1794–1805. https://doi.org/10.1017/S0033291717000253

Wang, Z., Lü, W., & Qin, R. (2013). Respiratory sinus arrhythmia is associated with trait positive affect and positive emotional expressivity. *Biological Psychology*, *93*(1), 190–196. https://doi.org/10.1016/j.biopsycho.2012.12.006

Widiger, T. A., & Oltmanns, J. R. (2017). Neuroticism is a fundamental domain of personality with enormous public health implications. *World Psychiatry*, *16*(2), 144–145. https://doi.org/10.1002/wps.20411

Williams, P. G., O'Brien, C. D., & Colder, C. R. (2004). The effects of neuroticism and extraversion on self-assessed health and health-relevant cognition. *Personality and Individual Differences*, *37*(1), 83–94. https://doi.org/10.1016/j.paid.2003.08.001

Yang, J., Mao, Y., Niu, Y., Wei, D., Wang, X., & Qiu, J. (2020). Individual differences in neuroticism personality trait in emotion regulation. *Journal of Affective Disorders*, *265*, 468–474. https://doi.org/10.1016/j.jad.2020.01.086

Young, H. A., & Benton, D. (2018). Heart-rate variability: A biomarker to study the influence of nutrition on physiological and psychological health? *Behavioural Pharmacology*, *29*(2 and 3-Spec Issue), 140–151. https://doi.org/10.1097/FBP.0000000000000383

Zohar, A. H., Cloninger, C. R., & McCraty, R. (2013). Personality and heart rate variability: Exploring pathways from personality to cardiac coherence and health. *Open Journal of Social Sciences*, *01*(06), Article 06. https://doi.org/10.4236/jss.2013.16007

Zubin, J., & Spring, B. (1977). Vulnerability: A new view of schizophrenia. *Journal of Abnormal Psychology*, *86*(2), 103–126. https://doi.org/10.1037/0021-843X.86.2.103