VANTAGE SENSITIVITY TO PERCEIVED PARTNER RESPONSIVENESS: EXAMINE THE MODERATING ROLE OF HEART RATE VARIABILITY

A Thesis

Presented to the Faculty of the Graduate School

of Cornell University

in Partial Fulfillment of the Requirements for the Degree of

Masters of Art

by

Jieni Zhou

May 2018

© 2018 Jieni Zhou

ABSTRACT

Perceived partner responsiveness (PPR) is defined as being accurately understood, appreciated and cared for. Previous research has demonstrated that perceived partner responsiveness is an essential component of close relationships that predicts emotional and physical well-being. However, not all the people benefit from having a responsive partner to the same degree. Motivated by vantage sensitivity hypothesis, the current study examined heart rate variability (HRV) as a potential vantage resource that moderates the link between perceived partner responsiveness and hedonic and eudaimonic well-being ten years later using the second and third waves of Midlife in the United States (MIDUS) dataset. Longitudinal analyses revealed that there was no significant interaction between heart rate variability and perceived partner responsiveness in predicting either hedonic or eudaimonic well-being. These findings are first to test vantage sensitivity hypothesis in the context of romantic relationships.

Keywords: perceived partner responsiveness, heart rate variability, vantage sensitivity

BIOGRAPHICAL SKETCH

In May 2017, Jieni Zhou graduated from Bryn Mawr College with Bachelor of Arts degree in Psychology and completed an honored thesis. During her four years at Bryn Mawr College, she was a leader of the StoryCORE, an organization advocating for diversity on campus. During her junior and senior year, she was a teaching assistant for both Intro to Psychology and Research Methods and Statistics. Jieni Zhou is currently pursuing a master's in Human Development Program at Cornell University. In May 2018, She will graduate with a Master of Arts degree, with a focus in close relationships and health psychology. She will continue to pursue a doctoral degree. in social psychology at University of North Carolina, Chapel Hill starting in August 2018.

ACKNOWLEDGEMENT

First and foremost, I would like to thank my advisor, Dr. Anthony Ong, who has always inspired me with many insightful ideas. I also want to thank Dr. Felix Thoemmes for helping me use statistical software to present my results. I want to thank Dr. Qi Wang as well for giving me constructive feedback on my thesis. Next, I would like to thank my lab fellows Samuel Gardner and Betul Urganci for giving me support in time of challenges. Last but not least, I would like to thank my close friends and family. Thank them for constantly providing me with responsive support, which really helps me thrive at Cornell University.

Introduction

In times of joy or sorrow, people tend to seek validation and support from significant others especially romantic partners. When individuals feel cared for and understood by their responsive partner, they feel happier in relationships and more satisfied in life. Indeed, previous relationship research has demonstrated that having a responsive romantic partner is beneficial to relationship quality and well-being (Reis, 2012; Reis, Clark, & Holmes, 2004).

Reis and Gable (2015) have conceptualized responsiveness in terms of three components: understanding partner's core self, validation of partner's view of self and caring for partner's well-being. Furthermore, responsiveness is subjected to individual perception. The extent to which individuals can benefit from a responsive partner largely depends on their interpretations of their partner's intended responsive behaviors (Reis & Gable, 2015). Responsiveness can be observed through felt understanding meaning that the self is "accurately perceived, understood, appreciated and cared for" (Oishi, Krochik &Akimoto, 2010). The feeling of being understood in the context of close relationships enhances intimacy and commitment (Reis, Clark & Holmes 2004), both of which contribute to better relationship quality. Better relationship quality plays an essential role in subjective well-being (Diener et al., 1999; Ryff & Singer, 1998).

Responsiveness, embodied in felt understanding and emotional support, is considered as a primary aspect of close relationships that contributes to well-being. An increasing amount of research has examined the role of perceived partner responsiveness and its impact on physical and emotional well-being (Reis, 2012; Feeney & Collins, 2015). People who perceived their romantic partners as more responsive when they disclosed a personal problem recover faster from distressed mood. (Collins & Feeney, 2000). In a longitudinal national study, perceived partner responsiveness predicted healthier cortisol slope in the 10-year follow-up by alleviating negative affect (Slatcher, Selcuk & Ong, 2015). With the same national sample, higher perceived partner responsiveness was linked to higher concurrent eudaimonic and hedonic well-being. However, higher perceived partner responsiveness only predicts eudaimonic well-being ten year later. (Selcuk, Gunaydin, Ong & Almeida, 2015).

As we can see from the previous study, the mechanisms through which perceived partner responsiveness predicts hedonic and eudaimonic well-being differ. This phenomenon could attribute to distinct conceptions of hedonic and eudaimonic well-being. Hedonic well-being is defined as the experience of pleasure while minimizing the pain (Kahneman, Diener & Schwarz, 1999). Thus, researchers operationalized hedonic well-being in terms of three aspects: presence of positive affect, absence of negative affect and life satisfaction (Lucas et al., 1996). The eudaimonic view of well-being emphasizes achieving one's potential and finding meaning and purpose of life (Keyes et al., 2002; Ryan & Deci, 2001). One of the most comprehensive definitions of eudaimonic well-being today consists of six components: self-acceptance, environmental mastery, positive relationships, autonomy, purpose of life and personal growth (Ryff, 1989). Therefore, built upon the work of Selcuk and his colleagues (2015), the current study will also examine the influence of perceived partner responsiveness on hedonic and eudaimonic well-being separately and further explore potential factors that contribute to individual differences in the link between perceived partner responsiveness and well-being.

Many people may equate partner responsiveness to support transactions. On the contrary, researchers have distinguished the level of responsiveness from the amount of emotional support. In a national study of middle aged adults in the United States, Selcuk and Ong (2013) evaluated received emotional support by recording the hours of support people received monthly. Perceived partner responsiveness was assessed by asking people to rate the degree to which they consider their partner understand, appreciate and care for them. This study discovered that more emotional support is associated with higher mortality risk only when people perceive their partner as less responsive. When people rated their partner as responsive in terms of understanding and caring for them, the amount of emotional support is unrelated to mortality risk. This study suggests that emotional support comes with potential costs to health outcomes by posing threat on individual independence and self-efficacy. However, when people consider that the amount of emotional support meets their needs, indicating high level of perceived partner responsiveness, the potential harms of emotional support were mitigated. This study highlights that the benefits of emotional support vary along with the extent to which the support people receive matches their needs.

The study above shows that people's subjective perception of partner responsiveness contributes to differences in the link between emotional support and physical health. The current study intends to further explore whether all people benefit from having a responsive partner to the same degree. As previous research indicates, perception and interpretation of partner responsiveness are highly subjective. Therefore, it is paramount not to overlook different people benefit from having a responsive partner to various degrees. Researchers have paid considerable attention to the mechanism through which responsiveness, as a key aspect of close relationships, relates to individual well-being. Not many studies have examined individual differences in their sensitivity to such positive experience in close relationships and to investigate whether differing levels of sensitivity change the connection between perceived partner responsiveness and well-being. The present study aims to examine whether individuals vary in their sensitivity to a specific positive experience in close relationships: perceived partner responsiveness. In this study, sensitivity is conceptualized as the extent to which people's hedonic and eudaimonic well-being can be positively predicted by having a responsive partner. The more sensitive individuals are to partner responsiveness; the better such positive experience can predict well-being on the long-term.

Vantage Sensitivity: A Framework for Individual Differences in Response to Positive Environmental Influences

Individual differences have been intensely studied mostly in the context of negative experiences such as stress and psychopathology. In terms of positive experiences such as perceived partner responsiveness, it is still not clear whether people differ in their reactions to positive experiences and what drives the individual differences. Vantage sensitivity is defined as variations to positive experiences. Vantage is an abbreviation for advantage, which refers to “a position, condition, or opportunity that is likely to provide superiority or an advantage” (Pluess & Belsky, 2012). The concept of vantage sensitivity also highlights variations in individual response to exclusively positive experiences are driven by innate or endogenous factors (Pluess & Belsky, 2012). Endogenous factors include a variety of factors ranging from personality to genetics. These endogenous factors that heighten people’s receptiveness to supportive experiences are defined as vantage sensitivity factors. In other words, these factors could amplify the advantages of such experiences (Pluess & Belsky, 2012). Below I will distinguish vantage sensitivity from other theoretical perspectives on individual differences in response to environment.

Diathesis-Stress versus Vantage Sensitivity

In the area of stress research, some individuals are more susceptible to adversity and more easily to develop psychopathology (Monroe & Simons, 1991). The diathesis-stress theory suggests that potential risks of developing mental illness are not only contingent upon the intensity of stress but also rely on the genetic or personal liability that can be triggered by different degrees of stress (Monroe & Simons, 1991). Relationship scientists have incorporated attachment theory into diathesis-stress model to predict potential psychopathology induced by stressors internal and external to the relationships (Simpson & Rholes, 2012). For instance, lack of support from partners during transition to parenthood makes women who are high on attachment anxiety more susceptible to postpartum depression (Bowlby, 1988). There are two distinct differences between diathesis-stress model and vantage sensitivity hypothesis. Firstly, vantage sensitivity hypothesis only evaluates positive experiences while diathesis-stress model focuses only on stressors. Secondly, different from vantage sensitivity that focuses only on endogenous factors, diathesis-stress model takes into account both the degree of stress and the level of genetic liability.

Differential Susceptibility versus Vantage Sensitivity

Expanding the diathesis-stress model that describes personal vulnerability to stress, the differential susceptibility hypothesis is proposed as individual plasticity and susceptibility to the environmental influences in general including both positive and negative experiences. The differential susceptibility posits that people who are more vulnerable to stressors may also thrive more in a nurturing environment (Belsky & Pluess, 2009). The classic example is the comparison between dandelions and orchids. Dandelions adjust well regardless of the environment they grow in. Orchids bloom in nurturing environment and wither in harsh environment. This hypothesis is also demonstrated in research on family processes and romantic relationships. Participants exposed to more aggressive and violent parenting behaviors during adolescence showed more hostile behaviors to their romantic partner when they scored higher on genetic plasticity. Participants exposed to more positively engaged parenting behaviors during adolescence displayed more positive interactions with romantic partners if they had higher scores on the genetic plasticity (Masarik et al., 2014). The vantage sensitivity hypothesis separates individual proneness to benefit from supportive environment from their vulnerability to adverse environment. We could consider vantage sensitivity hypothesis as the bright side of differential susceptibility hypothesis. It is implied from vantage sensitivity hypothesis that people who are more attuned to positive experiences may not necessarily more susceptible to negative experiences.

Resilience versus Vantage Sensitivity

Besides theories that focus on how much people can tolerate stress, positive psychologists also see the individual potential to thrive and grow from adversity. Resilience is defined as people's capacity to adapt to disadvantageous environment and to function normally (Luthar, 2006). Even though both resilience and vantage sensitivity are both considered positive traits, resilience is different from the concept of vantage sensitivity. Resilience highlights factors that protect individuals from challenging experiences while vantage sensitivity emphasizes factors that amplify the advantages of supportive experiences (Pluess & Belsky, 2012).

Empirical Evidence (For a review, see Pluess & Belsky, 2012)

As pointed out above, vantage sensitivity is relevant to endogenous factors. Specifically, vantage sensitivity functions as individual differences in these three categories: behavioral, physiological and genetic factors. In terms behavioral factors, infant temperament and sensitivity personality traits can be examples of vantage sensitivity factors (Pluess & Belsky, 2012). Difficult temperament is demonstrated to be a vantage sensitivity factor. Children with difficult temperament tend to have more social and academic skills, better self-regulation and more secure attachment in later years when they are exposed to constructive and supportive parenting in early life (Roisman et al., 2012; Pluess & Belsky, 2009; Stright, Cranley Gllagher & Kelley, 2008; Pluess & Belsky, 2010; Ramchandani, Van Ijzendoorn & Bakermans-Kranenburg, 2010; Kim & Kochanska, 2012). Regarding personality traits, sensory processing sensitivity measured by Highly Sensitive Person Scale (Aron & Aron, 1997, e.g. I find it unpleasant to have a lot going on at once) is also considered a vantage sensitivity factor. It is shown that the school-based depression treatment reduced depression symptoms effectively among 11-year-old girls who scored high on sensory-processing sensitivity. On contrary, the treatment failed among girls who were low on sensory-processing sensitivity (Pluess & Boniwell, 2015).

Based on Boyce and Ellie's (2005) Biological Sensitivity to Context hypothesis, physiological reactivity is commonly a reflection of people's response to the environment. Even though there is not much evidence that tests physiological reactivity as a potential vantage resource, some researchers have found that cortisol reactivity and Respiratory Sinus Arrhythmia reactivity (RSA, an indicator of cardiac reactivity) could be vantage sensitivity factors. For instance, less exposure to family adversity is associated with more school engagement only among students with high RSA. Students with high cortisol reactivity engage more in prosocial behaviors if they experience less family adversity. (Obradovic et al., 2010).

In regard to genetic factor, researchers have illustrated that D4R4 7-repeat allele and 5-HTTLPR short allele can be indicators of susceptibility to adversity and stress. Built upon the genetic evidence for differential susceptibility, these two types of "plasticity genes" can also be indicators of vantage sensitivity (Pluess & Belsky, 2012). After receiving the parenting intervention, only children carrying the D4R4 7-repeat allele showed reduced externalizing behaviors compared to their counterparts in the treatment condition (Bakermans-Kranenburg et al., 2008). Similarly, a six-month cognitive behavioral therapy for reducing anxiety was more effective for teenagers who carried the 5-HTTLPR short allele (Eley et al., 2012).

Heart Rate Variability as a Vantage Resource

Heart rate variability (HRV) is one important vantage sensitivity factor that researchers have discovered previously (Obradovic et al., 2010; Isgett et. al, 2016), which is defined as the variation in time between each heartbeat. Researchers claimed that heart rate variability reflects activity of vagus nerve, which plays an important role in human's adaptation to environment (Kemp, Koening & Thayer, 2017). A variety of research has linked heart rate variability to positive affect, cognitive functioning, emotion regulations as well as health outcomes (Kemp, Koening & Thayer, 2017). There are different measures used to evaluate heart rate variability including Respiratory Sinus Arrhythmia (RSA) and high-frequency heart rate variability (HF-HRV). Heart rate variability can also be measured in different conditions: at rest or during cognitive challenged tasks. HRV measured at rest is also known as vagal tone while HRV measured during a cognitive challenged task is known as vagal activity. The changes between HRV at rest and during cognitive challenged task is called vagal flexibility.

For instance, Oveis and his associates (2009) found that people with higher RSA measured at rest is associated with more positive emotional states and personality traits in terms of extraversion and agreeableness. With regard to cognitive functioning, vagal recovery, indexed by the changes between heart rate variability at rest and after a cognitive challenge, is related to executive functioning. Individuals with faster vagal recovery have better abilities in attention-switching and behavioral inhibition (Kimhy et al., 2013). In addition, heart rate variability is associated with people's ability to regulate emotions. Participants with lower heart rate variability at baseline showed stronger negative emotional responses to negative films and were less capable of modulating their facial expressions (Demaree, Robinson, Everhart & Schmeichel, 2004). Heart rate variability is also predictive of health outcomes and mortality. Decreasing vagal function displayed by lower heart rate variability is associated with increasing inflammation (Thayer & Lane, 2007). Last but not least, heart rate variability measured at rest also buffers stress. High level of heart rate variability protects children against increased externalizing and internalizing behaviors, and health problems related to exposure to parental conflicts (El-Sheikh, Harger & Whitson, 2003). Accumulating evidence has suggested that individual differences in heart rate variability directly contribute to emotional and physical well-being.

As heart rate variability (HRV) is pertinent to people's attention and emotions, HRV evidences the potential to influence people's sensitivity and engagement with positive environment. Even though growing evidence has pointed out the direct connections between better functioning and high HRV, not many researchers have examined HRV as a potential vantage sensitivity factor which increases people's propensity to benefit from positive experiences. The goal of the current study is to test heart rate variability as a vantage sensitivity factor that will augment the influence of perceived partner responsiveness on well-being. Below I will review several studies that examined heart rate variability as a moderator in the context of positive experiences.

Isgett and her associates (2016) investigated heart rate variability (HRV) as a moderator of the link between perceived event sociality and positive emotions among 57 middle-aged adults. HRV was measured by Respiratory Sinus Arrhythmia (RSA) at rest. Perceived event sociality was assessed by self-report Event Reconstruction Model Survey online. Participants were instructed to recall the frequency and the last time they experienced every one of the fourteen events listed such as spending time outdoors. Participants also rated the sociality and stressfulness of the events they frequently experienced and reported the presence of others. Positive emotions during those self-reported social events were evaluated using the modified Differential Emotions Scale (mDES) asking participants to rate their most intense experience of 20 positive emotions from 0 (=”not at all”) to 4 (=”extremely”). Both surveys were completed two days before the lab visit. The study shows that people high on RSA, suggesting higher heart rate variability, experienced more positive emotions in social events compared to their counterparts in equivalent social events (Isgett et. al, 2016). The evidence supports heart rate variability as a vantage sensitivity factor that strengthens the link between engaging in social events and positive emotions.

Similar results were also discovered among a group of adults with average age of 37 years old. During a period of 63 days, participants were asked to list three interactions and to rate these interactions using the UCLA Loneliness scale (e.g. During the interactions, I felt close to the person/s.) on a 7-point scale (1=not at all true, 7= very true). In addition, participants also provided daily emotion reports using the mDES with which individuals rated their strongest experiences of 20 emotions within the day on a 5-point Likert scale (0=not at all to 4=extremely). Given an opportunity to reflect upon their daily experiences for 63 days, adults with higher vagal tone measured by RSA at baseline experienced more increase in social connectedness and positive emotions over time than their counterparts with lower vagal tone (Kok & Fredrickson, 2010).

Heart rate variability (HRV) does not only shape how much people can benefit from daily experiences but also predicts the effectiveness of intervention on people’s emotionality and social connectedness. Faculty and staff at the University of North Carolina, Chapel Hill were recruited for a study on the effect of love-kindness meditation. Participants were randomly assigned to either control group or experiment group which receives a one-hour meditation practice every week for 6 weeks. For sixty-one days, participants consistently reported the amount of time they spent practicing meditation and other spiritual activities. They also rated their strongest perception of 20 different emotions (9 positive and 11 negative emotions) within the past day using the mDES. At the same time, they were instructed to recall three social interactions and rated their experience using the UCLA Loneliness Scale. Heart rate variability was measured with high-frequency heart rate variability (HF-HRV) for two minutes at rest. As a result, the love-kindness meditation was more efficient in increasing positive emotions and social connectedness for people who reported higher heart rate variability at baseline (Kok et al., 2013).

It is important to note here that our primary conceptualization of the interaction in the present analysis has considered heart rate variability (HRV) to be the moderator of the association between perceived partner responsiveness (PPR) and well-being. Other work (Cote al.,2011; Hopp et., 2013) has tended to frame this hypothesized interaction in reverse, with the contextual factor (e.g., social support) as the moderator and organismic factor (e.g., HRV) as the predictor. Although this distinction has important theoretical implications, whether one or the other factor is described as the moderator versus the predictor does not change the present results.

Cote and his colleagues (2011) found a significant interaction between heart rate variability (HRV) and a sense of power in predicting empathic accuracy. This study used RSA (an indicator of HRV) as a physiological index for prosocial orientation. The sample consisted of 118 undergraduates of University of California, Berkeley. Participants were paired up into same-sex dyad and took turns to talk about an upsetting event that involves pain and suffering in the past five years for five minutes. Empathic accuracy was assessed by taking the differences between self-reported perception of the partner's emotions and partner's report of their own emotions during the interaction. Among individuals with a high sense of power, those who have high RSA (i.e. are more prosocial oriented) exhibited higher level of empathic accuracy during a face-to-face interaction with a stranger compared to their counterparts with low RSA (Cote et al., 2011).

Previous studies have highlighted the significance of heart rate variability (HRV) in the context of social interactions. Hopp and his associates (2013) also found a significant interaction between HRV and social support in predicting depressive symptoms among a group of 156 individuals from the Denver Metropolitan Area. HRV was assessed using RSA data collected during an emotionally neutral 2-minute film clip. Perceived social support was evaluated by asking participants to answer 12 questions on the Interpersonal Support Evaluation List (e.g. There are several different people with whom I enjoy spending time) on a scale ranging from 1 (= "definitely false") to 4 (= "definitely true"). Depressive symptoms were assessed at the beginning of the study and six months later using the Beck Depression Inventory which includes 21 items. The results revealed that RSA predicted fewer depressive symptoms six months later only among individuals with high level of social support (Hopp et al., 2013). According to previous work on HRV, we can conclude that HRV is not only associated with both emotional and physical health directly but also shapes how people respond to either negative or positive experiences.

However, it's also important to acknowledge that the findings on heart rate variability (HRV) as a vantage resource are not consistent. Demaree and his colleagues (2004 & 2006) have found that RSA (index for HRV) did not predict greater increase in positive facial expressions in response to positive films. In accordance with these findings, Oveis and his associates (2009) did not find people with high RSA showed greater increase in positive emotions after watching compassion-, awe-, pride-inducing slides. Furthermore, using a national sample from Midlife in the United States Study (MIDUS), researchers did not find any evidence to support that HRV is associated with positive affect, hedonic well-being and eudaimonic well-being (Sloan et al., 2017).

In addition to studies that did not find significant results of high heart rate variability (HRV) as a vantage resource, a few studies demonstrated that high HRV could be a diathesis in times of stress. Women with high RSA (i.e. high HRV) experienced and expressed more negative emotions while watching and talking about upsetting films (Butler, Wilhelm & Gross, 2006). Supporting this finding among women, Zhang and his associates (2017) found gender differences in the role of HRV. For women with high HRV, martial conflicts positively predicted internet addiction. An opposite pattern emerged among men (Zhang et al., 2017).

The Present Study

The supportive evidence above points out that heart rate variability is potentially a vantage resource that amplifies the positive impact of supportive and enriching experiences on different aspects of psychological functioning. However, as we can see, previous studies on heart rate variability as a potential vantage resource used relatively small sample sizes and may not be generalized to a larger population. In addition, previous studies also took a cross-sectional approach and only investigated the concurrent impact of heart rate variability on the link between positive experiences and positive outcomes. The current study will use the national sample from "Midlife in the United States" (MIDUS), which tracks people across two waves (10 years) inquiring information including family, work and health aspects. This longitudinal study with a national sample will allow us to examine heart rate variability among people who are more representative of the general population. We will also look into whether the moderating effect of heart rate variability sustains across 10 years. Using the same dataset, researchers have found that perceived partner responsiveness concurrently predicted hedonic and eudaimonic well-being while only prospectively predicts eudaimonic well-being among married couples (Selcuk, Gunaydin, Ong & Almeida, 2015). Using the second wave and the third wave of the MIDUS study, the goal of the current study is to confirm whether perceived partner responsiveness will only prospectively predict eudaimonic well-being but not hedonic well-being. My first hypothesis is that perceived partner responsiveness will predict eudaimonic but not hedonic well-being.

More importantly, the current study aims to examine vantage sensitivity to perceived partner responsiveness in the context of close relationships. I want to investigate whether there are individual differences in the amount of benefits one can obtain from having a responsive partner. Based on previous literature review on heart rate variability as a potential vantage resource, I hypothesize that perceived partner responsiveness will be a better predictor of eudaimonic well-being over 10 years among individuals who have high heart rate variability. The current study will enable application of vantage sensitivity hypothesis to areas outside of emotion science. The results will illustrate individual differences in response to positive experiences that relationship researchers have overlooked, and inform therapists of potential individual differences that affect the effectiveness of marital interventions.

Method

Participants and Procedures

The current study used the second (Ryff et al., 2007) and third waves (Ryff et al., 2014) of the Midlife in the United States Study. I used data from two different projects within the MIDUS: the National Survey of Midlife Development in the United States project as well as the Biomarker Project. In 1995- 1996, 7108 individuals in the United States aged from 25-74 participated in the first wave of the MIDUS study. The goal of the study was to examine how behavioral, psychological and social factors contribute to aging differences in physical and mental health. The first-wave respondents completed a phone interview and then a self-administered questionnaire. The second wave of the MIDUS project collected data from 2004 to 2006. A total of 4963 individuals aged 35-85 years participated in the MIDUS II National Survey. Of these participants, 1255 also participated in the Biomarker Project. These individuals stayed overnight at one of three general clinical research centers and went through a comprehensive assessment of physical health and a laboratory-based psychophysiology protocol. Between 2013 and 2014, the third wave of the MIDUS study followed up with 3294 individuals through both a phone interview and a self-administered questionnaire. Among people who participated in the MIDUS II National Survey and the Biomarker Project, 945 of 1255 people also completed the MIDUS III National Survey. 599 of the 945 individuals are consistently married across MIDUS II and III.

Of the 599 married individuals, 501 have complete information on perceived partner responsiveness and heart rate variability in MIDUS II, hedonic well-being and eudaimonic well-being in both MIDUS II and III. The current study also included a variety of covariates: well-being variables, demographics (age, gender, income and race), physical health (BMI and number of chronic conditions), health behaviors (sleep and exercise), psychological and relationship characteristics (neuroticism, extraversion, marital risk and current relationship ratings). Twelve people (2.4%) did not provide information on the total household income and two people (.4%) refused to rate their current relationship quality in MIDUS II National Survey. Fifteen people (3%) did not have BMI scores due to missing data in MIDUS II biomarker assessment. All these individuals with missing data on any covariate were excluded from the analytic sample, leaving us with 473 people who have complete data on all measures.

Measures

Perceived partner responsiveness (PPR). Perceived partner responsiveness was measured with three items in MIDUS II survey. Participants reported how much their spouse cares about them, understands the way they feel about thing and appreciates them according to their perception (1= a lot to 4=not at all). We reversed scores so higher scores indicate greater partner responsiveness perceived by individuals. The final scores of PPR took the average scores of the three items.

Heart rate variability (HRV). Heart rate variability was indexed by High Frequency Heart Rate Variability (HF-HRV). HF-HRV reflects variations in the normal RR intervals within 0.15-0.50 Hz including the typical resting respiratory rate. Previous research demonstrates cardiac vagal control is the exclusive source that shapes HF-HRV through the parasympathetic system. HF-HRV was measured using ECG records and analyzed based on specific guidelines (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). During an 11-minute seated resting period, a microcomputer collected the analog ECG signal digitized at 500 Hz. The ECG waveform was submitted to R-wave detection software and produced an RR interval series. High frequency (0.15-0.40 Hz) HRV was computed in 300-second epoch, using an interval method for computing Fourier transforms. The average HF-HRV from the two base-line 300-second epochs was computed excluding the last 60 second from the analysis.

Hedonic well-being. Hedonic well-being was evaluated from three aspects: life satisfaction, positive affect and negative affect. Life satisfaction was measured by one item asking the participants to rate their overall life from 0=the worst possible to 10=the best possible. The positive affect was measured by 4 items using the Positive and Negative Affect Scales (PANAS). Participants were asked to report the amount of time they felt “enthusiastic”, “attentive”, “proud” and “active”. All the items were reverse scored and averaged so that higher scores stand for higher level of positive affect. The negative affect was measured by 5 items from PANAS. Participants were asked to report the amount of time they felt “afraid”, “jittery”, “irritable”, “ashamed”, and “upset” in the past 30 days from 1=all of the time to 5=none of the time. The scores of negative affect took the average of the ratings on these five items. Higher scores indicate lower level of negative affect. Hedonic well-being scores were computed by taking the mean value of the standardized scores of all three components.

Eudaimonic well-being. Eudaimonic well-being consists of six components including self-acceptance (e.g. I like most parts of my personality). environmental mastery (e.g. I often feel overwhelmed by my responsibilities), autonomy (e.g. I am not afraid to voice my opinions, even when they are in opposition to the opinions of most people), purpose in life (e.g. I have a sense of direction and purpose in life), personal growth (e.g. I have the sense that I have developed a lot as a person over time) and positive relationships identified by Ryff (1989). The positive relationship component was excluded as I am looking at the influence of relationship on well-being in the present study. The remaining five components were measured by seven items respectively on a seven-point Likert scale (1=strongly agree to 7= strongly disagree). Some items were reverse-coded and the ratings of seven items were added up to create the total scores of each component, so higher scores represent higher standing on the scale. Eudaimonic well-being scores took the average of the scores of five components.

Covariates. A variety of covariates measured at Wave 2 were included in the analyses. Demographic information including gender, age, race (white vs. non-white and household total income were acquired through a telephone survey as part of the MIDUS study. Individuals who participated in the MIDUS II Biomarker Project had a clinic visit when the medical comorbidity information was obtained through a checklist of 20 physician-diagnosed chronic conditions such as heart disease, high blood pressure, diabetes and etc. The current study included the total number of chronic conditions as a continuous covariate. Body mass index (BMI) was calculated using information of height and weight measured during the clinic visit. Physical activities were evaluated with one item asking whether the individual engaged in physical activities for 20 minutes or more at least 3 times per week (1=20 minutes of light and moderate activity 3 times/week or more and 0=fewer than 3 times/week). Sleep quality was evaluated using one item from the Pittsburg Sleep Quality Inventory (PSQI), which asks for the overall quality of individual sleep during the past month on a four-point scale (from 1=very good to 4=very bad).

In addition to physical health and health behaviors, a few variables portraying psychological and relationship characteristics are included as covariates: extraversion, neuroticism, marital risk, and current relationship quality. Both personality traits were measured by Midlife Development Inventory Personality Scales (Lachman & Weaver, 1997). The extraversion scale included five items (outgoing, friendly, lively, active, talkative) and the neuroticism scale consisted of four items (moody, worrying, nervous, calm). Participants reported how much each item described them on a four-point scale (1=a lot to 4=not at all). The marital risk scores consisted of two items asking participants to report: how often they thought their relationship might be in trouble over the past year (1=never to 5=all the time); the possibility of separation (1=very likely to 4=not at all likely). In terms of relationship quality, the National Survey asked participants to rate their current relationship from 0 ("the worst possible marriage or close relationship) to 10 ("the best possible marriage or close relationship").

Data Analysis. In order to test the vantage sensitivity hypothesis, I examined the interaction between heart rate variability and perceived partner responsiveness in predicting hedonic and eudaimonic well-being at Wave 3 by running a moderation analysis using the PROCESS macro package for the statistical software SPSS. Specifically, I constructed five multiple regression models. Model 1 included PPR, HRV and its interaction to predict hedonic and eudaimonic well-being at Wave 3 controlling for initial hedonic and eudaimonic well-being respectively at Wave 2. Model 2 repeated the procedure of the first model and also controlled for hedonic well-being at Wave 2 for predicting eudaimonic well-being and vice versa. Model 3 added demographic covariates: age, gender, race and income. Model 4 controlled for physical health and health behaviors including BMI, sleep quality, regular exercise and the number of chronic conditions. Finally, Model 5 adjusted for psychological and relationship characteristics as well incorporating neuroticism, extraversion, marital risk and relationship ratings.

Results

Descriptive Statistics

The main analyses were conducted among 473 people who have complete data on all measures. Table 1 listed all descriptive statistics and correlations on all variables. The average age of the final sample is 54.25 years old (*SD*=10.60) ranging from 34 to 83 years old. About half of people in this cohort are males (48.6%) and the other half are females (51.4%). The majority of the sample are Caucasians (94.5%) and the rest 5.5% are from other racial backgrounds. Of these 473 participants, the average household total income is 90360.35 dollars (*SD*=64579.60). Half of the participants reported a household total income above 73750 dollars.

Vantage Sensitivity Hypothesis Tested in Predicting Hedonic Well-being

As displayed in Model 1 in Table 2, perceived partner responsiveness (PPR) at Wave 2 has no main effect on hedonic well-being at Wave 3, controlling for hedonic well-being at Wave 2 (*B*=.0784, *SE*=.0672, *p*=.2376). This pattern is consistent across all five models after we controlled for eudaimonic well-being at Wave 2, demographics, physical health and health behaviors, along with psychological and relationship characteristics.

To investigate whether vantage sensitivity hypothesis applies in the link between perceived partner responsiveness at Wave 2 and hedonic well-being at Wave 3, I conducted five multiple regression models to test whether there is a significant interaction between heart rate variability (HRV) and perceived partner responsiveness (PPR) predicting hedonic well-being at Wave 3. The results did not support the vantage sensitivity hypothesis. Model 1 did not exhibit a significant interaction between PPR and HRV predicting hedonic well-being (*B*= -.0294, *SE*=.0545, *p*=.5879). The interaction between PPR and HRV remains insignificant across all five models. The results didn't alter after we controlled for a variety of covariates including eudaimonic well-being at Wave 2 (Model 2), demographics (Model 3), physical health and health behaviors (Model 4) as well as psychological and relationship characteristics (Model 5).

Vantage Sensitivity Hypothesis Tested in Predicting Eudaimonic Well-being

We also want to test whether vantage sensitivity hypothesis is applicable in predicting eudaimonic well-being. The same five multiple regressions were conducted to investigate whether there is an interaction between perceived partner responsiveness (PPR) and heart rate variability (HRV). However, we did not find significant main effect of PPR at Wave 2 on eudaimonic well-being at Wave 3 across five models. The unadjusted model (Model 1) indicated no interaction between PPR and HRV (*B* = .1398, *SE*= .3304, *p*=.6723). Interaction effects between PPR and HRV were also highly consistent across all five models. The results of regression analyses are summarized in Table 3. Adding hedonic well-being at Wave 2 (Model 2), demographics (Model 3), physical and health behaviors (Model 4), and psychological and relationship factors (Model 5) did not change the results. In summary, I found that PPR and HRV are not related to eudaimonic well-being ten year later. [1]

Gender Differences in Vantage Sensitivity

Previous studies demonstrated gender differences in the moderating role of HRV (Butler, Wilhelm & Gross, 2006; Zhang et al., 2017). I also conducted a three-way interaction between gender, perceived partner responsiveness (PPR) and heart rate variability (HRV), which did not yield significant results.

Discussion

Motivated by vantage sensitivity hypothesis (Belsky & Pluess, 2012) and previous work on the connection between perceived partner responsiveness and well-being, the current study investigates the interaction between heart rate variability (HRV) and perceived partner responsiveness (PPR) in predicting both hedonic and eudaimonic well-being over a ten-year period. However, contradicting existing evidence that high HRV amplified the advantages of positive experiences (Kok & Fredrickson, 2010; Kok et al., 2013; Isgett et. al, 2016), I did not find evidence to confirm my hypothesis that individuals with high HRV benefit more from PPR

[1] After multiple imputations on the covariates, five regression models were conducted on PPR, HRV for predicting hedonic and eudaimonic well-being respectively. No significant interaction between PPR and HRV were found.

and have better well-being ten years later. In addition, PPR was not able to predict either hedonic well-being or eudaimonic well-being before and after adjusted for covariates. Different from previous work on the association between PPR and well-being (Selcuk, Gunaydin, Ong & Almeida, 2015), I did not find that perceived partner responsiveness was able to predict eudaimonic well-being over the 10 years.

What are some possible reasons why the interaction between perceived partner responsiveness (PPR) and heart rate variability (HRV) was not significant? As mentioned above, previous research found that HRV amplifies positive affect with exposure to positive experiences. For instance, researchers found that HRV is associated with emotional states (Demaree et al., 2004; Porges, Doussard-Roosevelt & Maiti, 1994). Higher HRV measured at rest is associated with more positive emotional states (Oveis et al., 2009). Incorporating previous evidence that HRV amplifies positive affect (Kok et al., 2013; Kok & Fredrickson, 2010; Isgett et. al, 2016), I will assume that HRV functions as a vantage sensitivity factor that mainly intensifies positive affect when individuals are exposed to positive experiences. However, the outcome variable in the current study is not only positive affect but the more complex conceptions of eudaimonic and hedonic well-being which cover different aspects of social and psychological functioning. The mechanisms through which HRV may shape the connections between PPR and these more complicated variables have not been well established in the literature.

Furthermore, the findings on how variations in heart rate variability (HRV) contribute to psychological and physical functioning are mixed. As mentioned in the introduction, RSA (Respiratory Sinus Arrhythmia, a measure of HRV) was found unrelated to increase in positive facial expressions in response to positive films (Demaree et al., 2004, 2006). Even though researchers found a direct association between RSA and positive personality traits and moods, they failed to find that high RSA at rest leads to more increase in positive affect prompted by compassion-, awe-, and pride-inducing slides (Oveis et al., 2009). Previous studies not only demonstrate that HRV may not be a vantage sensitivity factor, but also that high RSA could be a potential diathesis with exposure to stressors. Furthermore, Sloan and his colleagues (2017) also used the MIDUS II dataset and did not find significant associations between HRV and positive affect, hedonic well-being and eudaimonic well-being. It's important to notice that previous studies that have found supportive evidence were based on small sample sizes and undergraduates in college while MIDUS data provides a more representative sample and the findings are more applicable to the general population. Thus, these inconsistent findings from previous studies urge more future research to confirm the impact of HRV on psychological functioning by evaluating the contexts in which these studies are situated and the constructs that are linked to HRV using more representative samples.

Strengths and Limitations

Although no significant interaction between perceived partner responsiveness (PPR) and heart rate variability (HRV) was observed, the current study highlights the importance of investigating HRV in daily processes of social interaction specifically in the context of romantic relationships. Built upon the notion that PPR is considered a constructing concept that closely relates to interpersonal well-being and flourishing (Reis, 2012), a growing number of studies have examined how PPR is associated with sleep quality, mortality risk, stress reactivity and well-being in general. The degree of correlations between PPR and these psychosocial constructs varies across individuals. However, not much research has been conducted to explore potential factors that contribute to these individual differences.

This study expands the application of vantage sensitivity in relationship science. Relationship research largely focuses on individual differences in response to negative experiences while overlooking individual differences in response to positive experiences. The present study identifies heart rate variability (HRV) as an innate characteristic that may lead to individual variations in response to positive experiences. While many previous studies obtained observations in the laboratory settings or through interventions on college undergraduates, this study was based on individual daily experiences using a national sample of adults and thus suggests higher potential to generalize its findings to a larger population. The current study also included two waves of MIDUS data collected ten years apart, which enabled me to investigate the effect of HRV as a vantage resource over time.

There are also several limitations of the current study. Firstly, participants are predominantly Caucasians. Thus, the results may not be valid among people from different ethnic backgrounds. Secondly, this current study used HF-HRV as a measure for heart rate variability (HRV) while more studies used RSA (Isgett et. al, 2016; Kok & Fredrickson, 2010; Obradovic et al., 2010; Cote al.,2011; Hopp et., 2013). Porges (2009) has claimed that RSA is a more precise representation of vagal activity. Nevertheless, HF-HRV and RSA are both influenced by respiratory rates (Laborde, Mosley & Thayer, 2017). The HRV data from MIDUS II Biomarker Project did not eliminate participants who have abnormally faster or slower breathing rates, which may create biases in the HRV data. Last but not least, we used information on perceived partner responsiveness (PPR) and HRV at Wave 2 to predict hedonic and eudaimonic well-being at Wave 3. The design of the study requires that these two constructs PPR and HRV are stable over the 10-year period so that these two individual characteristics are able to predict well-being in the long-term. However, some evidence implied that PPR and HRV change over time. Previous researchers demonstrated that PPR is associated with attachment styles which changes along with age. As individuals get older, they tend to become more securely attached. More securely attached individuals are more like to perceive their partners as responsive (Reis, Clark & Holmes, 2004; Zhang & Labouvie-vief, 2004). Therefore, it is suggested that aging could impact perceived partner responsiveness through attachment styles over the ten years in this present study. Furthermore, age is also inversely associated with HRV through certain types of aging disease such as high blood pressure (Fukusaki, Kawakubo &Yamamoto, 2000). As age is relevant to both HRV and PPR, the results of the current study may be influenced by individual aging processes. In other words, individual HRV and PPR may change over time along with aging and are less capable of predicting well-being ten year later. In order to assure and adjust the influence of aging processes on the stability of PPR and HRV, future longitudinal studies could measure PPR and HRV repeatedly over a long period of time.

Future Directions

Overall, the mixed findings on the role of heart rate variability (HRV) encourage more studies to be conducted to examine HRV as a potential vantage sensitivity factor in different contexts. This also leads us to explore whether certain vantage sensitivity factors are domain specific meaning that a vantage sensitivity factor may only be effective in amplifying certain type of positive experiences.

In addition, the current study only used HRV measured at rest. As far as we know, HRV can be measured either at rest or during cognitively challenged tasks. HRV measured at rest is define as vagal tone while HRV measured in cognitively challenged conditions is defined as vagal activity. Vagal flexibility is conceptualized as the difference between vagal activation in relaxing and in challenging mental states. Similar to previous findings that vagal tone is associated with social connectedness (Kok & Fredrickson, 2010), vagal flexibility is also related to sensitivity to social and emotional information in the environment (Muhtadie et al., 2015). Therefore, it is also important for future researchers to compare how vagal tone and vagal flexibility differ in their influences on people's emotional experiences and emotion regulations. Researchers have conducted studies to differentiate the impacts of vagal tone and vagal flexibility on psychosocial functioning (Muhtadie et al., 2015). Vagal tone is negatively associated with depression, anxiety and perceived stress but not related to self-reported loneliness. By contrast, higher vagal flexibility is associated with lower level of self-reported loneliness only. Greater vagal flexibility predicts stronger negative responses to social rejection cues and more sociable behaviors in response to social acceptance. However, this pattern did not emerge with individual variations in vagal tone. These findings imply that vagal flexibility is more influential than vagal tone in social contexts. As perceived partner responsiveness is conceptualized in a social context, future studies can examine vagal flexibility as a potential physiological marker that moderates the link between perceived partner responsiveness and well-being. In addition, as I mentioned in the limitations that RSA (Respiratory Sinus Arrhythmia) is more widely used as a measure of vagal activity, future researchers could investigate this question using RSA as an index of both vagal tone and vagal flexibility.

Conclusion

In summary, in order to test vantage sensitivity hypothesis, the present study investigates whether heart rate variability is a potential vantage resource that heightens the impact of perceived partner responsiveness on both hedonic and eudaimonic well-being over the 10 years. However, I did not find a significant interaction between heart rate variability and perceived partner responsiveness for predicting hedonic or eudaimonic well-being. The present study calls for more attention to individual variations in response to positive experiences specifically in the context of romantic relationships. With more research that examines differing levels of individual sensitivity to constructive experiences in close relationships, findings of such research will have important practical implications for marital therapy and interventions and help therapists identify individual characteristics that contribute to discrepancies in the effectiveness of marital interventions across individuals.

References

Aron, E. N., & Aron, A. (n.d.). Sensory-Processing Sensitivity and Its Relation to Introversion and Emotionality, 24.

Belsky, J., & Pluess, M. (2009). Beyond diathesis stress: Differential susceptibility to environmental influences. *Psychological Bulletin*, *135*(6), 885–908. https://doi.org/10.1037/a0017376

Bowlby, J. (1988). *A secure base: Clinical applications of attachment theory*. London: Routledge.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary–developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*(02). https://doi.org/10.1017/S0954579405050145

Collins, N. L., & Feeney, B. C. (n.d.). A Safe Haven: An Attachment Theory Perspective on Support Seeking and Caregiving in Intimate Relationships, 21.

Côté, S., Kraus, M. W., Cheng, B. H., Oveis, C., van der Löwe, I., Lian, H., & Keltner, D. (2011). Social power facilitates the effect of prosocial orientation on empathic accuracy. *Journal of Personality and Social Psychology*, *101*(2), 217–232. https://doi.org/10.1037/a0023171

Demaree, H., Pu, J., Robinson, J., Schmeichel, B., & Everhart, E. (2006a). Predicting facial valence to negative stimuli from resting RSA: Not a function of active emotion regulation. *Cognition & Emotion*, *20*(2), 161–176. https://doi.org/10.1080/02699930500260427

Demaree, H., Pu, J., Robinson, J., Schmeichel, B., & Everhart, E. (2006b). Predicting facial valence to negative stimuli from resting RSA: Not a function of active emotion regulation. *Cognition & Emotion*, *20*(2), 161–176. https://doi.org/10.1080/02699930500260427

Diener, E., Suh, E. M., Lucas, R. E., & Smith, H. L. (n.d.). Subjective Weil-Being: Three Decades of Progress, 27.

Eley, T. C., Hudson, J. L., Creswell, C., Tropeano, M., Lester, K. J., Cooper, P., … Collier, D. A. (2012). Therapygenetics: the 5HTTLPR and response to psychological therapy. *Molecular Psychiatry*, *17*(3), 236–237. https://doi.org/10.1038/mp.2011.132

Feeney, B. C., & Collins, N. L. (2015). A New Look at Social Support: A Theoretical Perspective on Thriving Through Relationships. *Personality and Social Psychology Review*, *19*(2), 113–147. https://doi.org/10.1177/1088868314544222

Fukusaki, C., Kawakubo, K., & Yamamoto, Y. (2000). Assessment of the primary effect of aging on heart rate variability in humans. *Clinical Autonomic Research*, *10*(3), 123–130. https://doi.org/10.1007/BF02278016

Hopp, H., Shallcross, A. J., Ford, B. Q., Troy, A. S., Wilhelm, F. H., & Mauss, I. B. (2013). High cardiac vagal control protects against future depressive symptoms under conditions of high social support. *Biological Psychology*, *93*(1), 143–149. https://doi.org/10.1016/j.biopsycho.2013.01.004

Isgett, S. F., Kok, B. E., Baczkowski, B. M., Algoe, S. B., Grewen, K. M., & Fredrickson, B. L. (2017). Influences of oxytocin and respiratory sinus arrhythmia on emotions and social behavior in daily life. *Emotion*, *17*(8), 1156–1165. https://doi.org/10.1037/emo0000301

Kahneman, D., Diener, E., & Schwarz, N. (Eds.). (1999). *Well-being: Foundations of hedonic psychology*. Russell Sage Foundation.

Kemp, A. H., Koenig, J., & Thayer, J. F. (2017). From psychological moments to mortality: A multidisciplinary synthesis on heart rate variability spanning the continuum of time. *Neuroscience & Biobehavioral Reviews*, *83*, 547–567. https://doi.org/10.1016/j.neubiorev.2017.09.006

Keyes, C. L. M., Shmotkin, D., & Ryff, C. D. (2002). Optimizing well-being: The empirical encounter of two traditions. *Journal of Personality and Social Psychology*, *82*(6), 1007–1022. https://doi.org/10.1037//0022-3514.82.6.1007

Kim, S., & Kochanska, G. (2012). Child Temperament Moderates Effects of Parent-Child Mutuality on Self-Regulation: A Relationship-Based Path for Emotionally Negative Infants: Temperament, Relationships, and Self-Regulation. *Child Development*, *83*(4), 1275–1289. https://doi.org/10.1111/j.1467-8624.2012.01778.x

Kimhy, D., Crowley, O. V., McKinley, P. S., Burg, M. M., Lachman, M. E., Tun, P. A., … Sloan, R. P. (2013). The association of cardiac vagal control and executive functioning – Findings from the MIDUS study. *Journal of Psychiatric Research*, *47*(5), 628–635. https://doi.org/10.1016/j.jpsychires.2013.01.018

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., … Fredrickson, B. L. (2013). How Positive Emotions Build Physical Health: Perceived Positive Social Connections Account for the Upward Spiral Between Positive Emotions and Vagal Tone. *Psychological Science*, *24*(7), 1123–1132. https://doi.org/10.1177/0956797612470827

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological Psychology*, *85*(3), 432–436. https://doi.org/10.1016/j.biopsycho.2010.09.005

Lachman, M. E., & Weaver, S. L. (1997). The Mid- life Development Inventory (MIDI) Personality Scales: Scale construction and scoring. Retrieved from http://www.brandeis.edu/ departments/psych/lachman/pdfs/midi- personality-scales.pdf (May 5, 2017)

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart Rate Variability and Cardiac Vagal Tone in Psychophysiological Research – Recommendations for Experiment Planning, Data Analysis, and Data Reporting. *Frontiers in Psychology*, *08*. https://doi.org/10.3389/fpsyg.2017.00213

Lucas, R. E., Diener, E., & Suh, E. (1996). Discrim- inant validity of well-being measures. *Journal of Personality and Social Psychology,71,* 616–628. https://doi:10.1037/0022-3514.71.3.616

Luthar, S. S. (2006). Resilience in development: A synthesis of research across five decades. In D. Cicchetti & D. J. Cohen (Eds.), *Developmen- tal psychopathology: Vol. 3. Risk, disorder, and adaptation* (2nd ed., pp. 739–795). Hoboken, NJ: Wiley.

Mona El-Sheikh, JoAnn Harger, & Stephanie M. Whitson. (2001). Exposure to Interparental Conflict and Children's Adjustment and Physical Health: The Moderating Role of Vagal Tone. *Child Development*, *72*(6), 1617–1636.

Muhtadie, L., Koslov, K., Akinola, M., & Mendes, W. B. (2015). Vagal flexibility: A physiological predictor of social sensitivity. *Journal of Personality and Social Psychology*, *109*(1), 106–120. https://doi.org/10.1037/pspp0000016

Obradović, J., Bush, N. R., Stamperdahl, J., Adler, N. E., & Boyce, W. T. (2010). Biological Sensitivity to Context: The Interactive Effects of Stress Reactivity and Family Adversity on Socioemotional Behavior and School Readiness. *Child Development*, *81*(1), 270–289. https://doi.org/10.1111/j.1467-8624.2009.01394.x

Oishi, S., Krochik, M., & Akimoto, S. (2010). Felt Understanding as a Bridge between Close Relationships and Subjective Well-Being: Antecedents and Consequences Across Individuals and Cultures: Felt Understanding as a Bridge. *Social and Personality Psychology Compass*, *4*(6), 403–416. https://doi.org/10.1111/j.1751-9004.2010.00264.x

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

Pluess, M., & Belsky, J. (2013). Vantage sensitivity: Individual differences in response to positive experiences. *Psychological Bulletin*, *139*(4), 901–916. https://doi.org/10.1037/a0030196

Pluess, M., & Boniwell, I. (2015). Sensory-Processing Sensitivity predicts treatment response to a school-based depression prevention program: Evidence of Vantage Sensitivity. *Personality and Individual Differences*, *82*, 40–45. https://doi.org/10.1016/j.paid.2015.03.011

Porges, S. W., Doussard-Roosevelt, J. A., & Maiti, A. K. (1994). Vagal Tone and the Physiological Regulation of Emotion. *Monographs of the Society for Research in Child Development*, *59*(2/3), 167. https://doi.org/10.2307/1166144

Porges, S. W. (2009). The polyvagal theory: New insights into adaptive reactions of the autonomic nervous system. *Cleveland Clinic Journal of Medicine*, *76*(Suppl_2), S86–S90. https://doi.org/10.3949/ccjm.76.s2.17

Ramchandani, P. G., IJzendoorn, M. van, & Bakermans-Kranenburg, M. J. (2010). Differential susceptibility to fathers' care and involvement: The moderating effect of infant reactivity. *Family Science*, *1*(2), 93–101. https://doi.org/10.1080/19424621003599835

Reis, H. T. (2012). Perceived partner responsive- ness as an organizing theme for the study of relationships and well-being. In L. Campbell & T. J. Loving (Eds.), Interdisciplinary research on close relationships: The case for integration (pp. 27–52). Washington, DC: American Psycho- logical Association.

Reis, H. T., & Gable, S. L. (2015). Responsiveness. *Current Opinion in Psychology*, *1*, 67–71. https://doi.org/10.1016/j.copsyc.2015.01.001

Reis, H. T., Clark, M. S., & Holmes, J. G. (2004). Perceived partner responsiveness as an organizing construct in the study of intimacy and closeness. In D. Mashek & A. Aron (Eds.), The handbook of closeness and intimacy (pp. 201–225). Mahwah, NJ: Erlbaum.Roisman, G. I., Newman, D. A., Fraley, R. C., Haltigan, J. D., Groh, A. M., & Haydon, K. C. (2012). Distinguishing differential susceptibility from diathesis–stress: Recommendations for evaluating interaction effects. *Development and Psychopathology*, *24*(02), 389–409. https://doi.org/10.1017/S0954579412000065

Ryan, R. M., & Deci, E. L. (2001). On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. *Annual Review of Psychology*, *52*(1), 141–166. https://doi.org/10.1146/annurev.psych.52.1.141

Ryff, C. D. (n.d.). Happiness Is Everything, or Is It? Explorations on the Meaning of Psychological Well-Being, 13.

Ryff, C. D., & Singer, B. (1998). The Contours of Positive Human Health. *Psychological Inquiry*, *9*(1), 1–28. https://doi.org/10.1207/s15327965pli0901_1

Ryff, C. D., Almeida, D. M., Ayanian, J. S., Carr, D. S., Cleary, P. D., Coe, C., ... Williams, D. (2007, March 22). Midlife Development in the United States (MIDUS II), 2004–2006 [Com- puter file]. ICPSR04652-v1. Ann Arbor, MI: Inter-University Consortium for Political and Social Research [distributor]. https://doi:10.3886/ICPS R04652

Ryff, C., Almeida, D., Ayanian, J., Binkley, N., Carr, D., Coe, C., ... Williams, D. (2014). Mid- life in the United States (MIDUS 3). ICPSR36346-v5. Ann Arbor, MI: Inter- university Consortium for Political and Social Research [distributor], 2017–03–09. https://doi.org/10.3886/ICPSR36346.v5

Selcuk, E., Gunaydin, G., Ong, A. D., & Almeida, D. M. (2016). Does Partner Responsiveness Predict Hedonic and Eudaimonic Well-being? A 10-Year Longitudinal Study: Partner

Responsiveness and Well-being. *Journal of Marriage and Family*, *78*(2), 311–325. https://doi.org/10.1111/jomf.12272

Selcuk, E., & Ong, A. D. (2013). Perceived partner responsiveness moderates the association between received emotional support and all-cause mortality. *Health Psychology*, *32*(2), 231–235. https://doi.org/10.1037/a0028276

Simpson, J. A., & Rholes, W. S. (2012). Adult Attachment Orientations, Stress, and Romantic Relationships. In *Advances in Experimental Social Psychology* (Vol. 45, pp. 279–328). Elsevier. https://doi.org/10.1016/B978-0-12-394286-9.00006-8

Sloan, R. P., Schwarz, E., McKinley, P. S., Weinstein, M., Love, G., Ryff, C., … Seeman, T. (2017). Vagally-mediated heart rate variability and indices of well-being: Results of a nationally representative study. *Health Psychology*, *36*(1), 73–81. https://doi.org/10.1037/hea0000397

Thayer, J. F., & Lane, R. D. (2007). The role of vagal function in the risk for cardiovascular disease and mortality. *Biological Psychology*, *74*(2), 224–242. https://doi.org/10.1016/j.biopsycho.2005.11.013

Zhang, H., Spinrad, T. L., Eisenberg, N., Luo, Y., & Wang, Z. (2017a). Young adults' internet addiction: Prediction by the interaction of parental marital conflict and respiratory sinus arrhythmia. *International Journal of Psychophysiology*, *120*, 148–156. https://doi.org/10.1016/j.ijpsycho.2017.08.002

Zhang, H., Spinrad, T. L., Eisenberg, N., Luo, Y., & Wang, Z. (2017b). Young adults' internet addiction: Prediction by the interaction of parental marital conflict and respiratory sinus arrhythmia. *International Journal of Psychophysiology*, *120*, 148–156. https://doi.org/10.1016/j.ijpsycho.2017.08.002

Table 1. Descriptive Statistics and Correlations among Variables

	M2 HWB	M2 EWB	M3 HWB	M3 EWB	M2 PPR	M2 HRV	M2 Age	M2 Sex	M2 INC	M2 WHI	M2 BMI	M2 PHY	M2 Sleep	M2 CHR	M2 EXT	M2 NEU	M2 MR	M2 RR
M2 EWB	.662**																	
M3 HWB	.620**	.474**																
M3 EWB	.524**	.703**	.636**															
M2 PPR	.246**	.226**	.198**	.162**														
M2 HRV	-.033	-.055	-.015	-.052	.057													
M2 Age	.280**	.149**	.223**	.101*	.153**	-.295**												
M2 Sex	-.004	-.037	-.019	-.022	-.117*	.122**	-.149**											
M2 INC	.020	.051	.110*	.133**	-.052	-.048	-.214**	.024										
M2 WHI	.000	-.026	-.020	-.012	-.007	.040	-.070	.004	-.020									
M2 BMI	-.140**	-.070	-.116*	-.096*	-.106*	-.070	.027	-.093*	-.041	.108*								
M2 PHY	.079	.056	.046	.000	.010	-.073	.101*	-.080	.012	.001	.080							
M2 Sleep	-.273**	-.180**	-.269**	-.211**	-.118*	.007	-.100*	.115*	-.018	-.012	.109*	.043						
M2 CHR	-.320**	-.201**	-.298**	-.215**	-.006	-.086	.093*	.156**	-.058	-.021	.229**	-.026	.259**					
M2 EXT	.431**	.523**	.324**	.375**	.123**	-.028	.074	.030	-.012	.006	-.071	-.027	-.076	-.117*				
M2 NEU	-.529**	-.461**	-.393**	-.367**	-.031	-.001	-.238**	.112*	.053	.011	-.022	-.116*	.236**	.208**	-.199**			
M2 MR	-.267**	-.195**	-.206**	-.154**	-.573**	-.006	-.228**	.010	.049	.090	.066	-.055	.161**	.020	-.075	.165**		
M2 RR	.352**	.222**	.256**	.159**	.699**	.006	.274**	.012	-.099*	-.003	-.076	.066	-.081	.001	.176**	-.104*	-.578**	
M	.012	39.428	.00051	39.407	3.642	4.791	54.25	-	90360.35	-	27.487	-	1.92	1.98	3.117	1.981	2.88	8.35
SD	.786	5.459	.789	5.260	.446	1.170	10.60	-	64579.60	-	5.061	-	.639	1.919	.567	.627	1.247	1.535
Cronbach's α	.814	.909	.772	.911	.728	-	-	-	-	-	-	-	-	-	.773	.756	.603	-

Note. M2 = MIDUS II; M3 = MIDUS III; HWB = Hedonic well-being; EWB = Eudaimonic well-being; PPR = Perceived partner responsiveness; EXT = Extraversion; NEU = Neuroticism; INC = Household total income; WHI = White or non-white; BMI=Body mass index; PHY= Physical activities at least 20 mins 3 times/week; CHR= Number of chronic conditions; EXT=Extraversion; NEU=Neuroticism; MR= Marital risk; RR=Rate current relationship. For continuous variables, higher scores reflect higher standing on the variable. The sample size was 450 for all measures.
[a] 0 = *male*, 1 = *female*; 0=non-white, 1=white; 1=yes, 2=no (regular physical activity);0* $p < .05$. ** $p < .01$

Table 2

The interaction between perceived partner responsiveness and heart rate variability at Wave 2 predicting hedonic well-being at Wave 3

	Model 1		Model 2		Model 3		Model 4		Model 5	
Parameter	B (SE)	p	B(SE)	p	B(SE)	p	B(SE)	p	B(SE)	p
Intercept	-.0015(.0286)	.9579	**-.6179(.2765)**	**.0259**	**-1.0897(.3873)**	**.0051**	**-.9886(.4192)**	**.0188**	**-.9595(.5154)**	**.0633**
PPR2	.0784(.0672)	.2376	.0670(.0671)	.3188	.0650(.0674)	.3356	.0780(.0673)	.2467	.0579(.0960)	.5469
HRV2	.0015(.0245)	.9516	.0042(.0244)	.8632	.0266(.0257)	.3008	.0200(.0255)	.4323	.0167(.0255)	.5146
PPR2 * HRV2	-.0294(.0545)	.5879	-.0257(.0543)	.6359	-.0023(.0542)	.9656	-.0013(.0535)	.9799	-.0068(.0537)	.8993
HWB2	**.6130(.0375)**	**<.0001**	**.5403(.0487)**	**<.0001**	**.5134(.0499)**	**<.0001**	**.4418(.0525)**	**<.0001**	**.3949(.0567)**	**<.0001**
EWB2			**.0157(.0070)**	**.0255**	**.0157(.0070)**	**.0241**	**.0164(.0069)**	**.0172**	**.0104(.0076)**	**.1698**
Demographics										
Age					**.0070(.0031)**	**.0228**	**.0087(.0031)**	**.0051**	**.0079(.0031)**	**.0126**
Gender					-.0042(.0576)	.9416	.0484(.0590)	.4119	.0498(.0600)	.4067
White/non-white					-.0320(.1217)	.7931	-.0380(.1210)	.7536	-.0408(.1215)	.7370
Income					**<.0001(<.0001)**	**.0017**	**<.0001(<.0001)**	**.0020**	**<.0001(<.0001)**	**.0010**
Physical health and health behaviors										
Body Mass Index							.0004(.0058)	.9384	-.0004(.0058)	.9518
Chronic conditions							**-.0492(.0167)**	**.0033**	**-.0487(.0167)**	**.0036**
Physical activities							-.0083(.0728)	.9092	-.0128(.0733)	.8615
Sleepi quality							**-.1011(.0465)**	**.0303**	**-.0973(.0470)**	**.0391**
Psychological and relationship characteristics										
Extraversion									.0895(.0591)	.1305
Neuroticism									-.0962(.0561)	.0867
Martial risk									.0036(.0294)	.9028
Rate current relationship									.0197(.0283)	.4864
R^2	.3875		.3940		.4100		.4308		.4375	

Note. PPR2= Perceived partner responsiveness at Wave 2. HRV2= Heart rate variability at Wave 2. HWB2=Hedonic well-being at Wave 2. EWB2= Eudaimonic well-being at Wave 2.

Table 3

The interaction between perceived partner responsiveness and heart rate variability at Wave 2 predicting eudaimonic well-being at Wave 3

	Model 1		Model 2		Model 3		Model 4		Model 5	
Parameter	B (SE)	p	B(SE)	p	B(SE)	p	B(SE)	p	B(SE)	p
Intercept	**12.7641(1.2972)**	**<.0001**	**15.2958(1.6744)**	**<.0001**	**14.7583(2.3534)**	**<.0001**	**16.5158(2.5698)**	**<.0001**	**17.7514(3.1743)**	**<.0001**
PPR2	.0808(.4047)	.8418	-.0484(.4064)	.9053	.0051(.4096)	.9008	.0387(.4122)	.9253	.0969(.5912)	.8698
HRV2	-.0638(.1484)	.6675	-.0619(.1477)	.6751	-.0481(.1562)	.7584	-.0778(.1560)	.6181	-.0921(.1573)	.5583
PPR2 * HRV2	.1398(.3304)	.6723	.1250(.3288)	.7040	.2269(.3294)	.4913	.2445(.3280)	.4564	.2390(.3309)	.4706
EWB2	**.6756(.0326)**	**<.0001**	**.6033(.0423)**	**<.0001**	**.6046(.0423)**	**<.0001**	**.6080(.0421)**	**<.0001**	**.5974(.0466)**	**<.0001**
HWB2			**.6112(.2946)**	**.0180**	**.7120(.3034)**	**.0194**	.4713(.3220)	.1439	.3746(.3493)	.2840
Demographics										
Age					-.0014(.0186)	.9394	.0045(.0189)	.8131	.0023(.0191)	.9063
Gender					-.0071(.3498)	.9839	.1122(.3615)	.7565	.1434(.3693)	.6981
White/non-white					.1370(.7397)	.8531	.1730(.7414)	.8156	.1975(.7486)	.7920
Income					**<.0001(<.0001)**	**.0033**	**<.0001(<.0001)**	**.0036**	**<.0001(<.0001)**	**.0033**
Physical health and health behaviors										
Body Mass Index							-.0201(.0356)	.5722	-.0234(.0359)	.5150
Chronic conditions							-.1201(.1022)	.2404	-.1164(.1026)	.2573
Physical activities							-.5454(.4464)	.2224	-.5754(.4512)	.2029
Sleep quality							-.5099(.2851)	.0744	-.4738(.2897)	.1027
Psychological and relationship characteristics										
Extraversion									.0467(.3638)	.8980
Neuroticism									-.3263(.3453)	.3452
Martial risk									-.0313(.1808)	.8628
Rate current relationship									-.0175(.1741)	.9199
R^2	.4941		.5002		.5102		.5190		.5201	

Note. PPR2= Perceived partner responsiveness at Wave 2. HRV2= Heart rate variability at Wave 2. HWB2=Hedonic well-being at Wave 2. EWB2= Eudaimonic well-being at Wave 2.