2018-03-01

# Well-Being and Physiological Reactivity to Stress

Sheilagh Fox
*Brigham Young University*

# Well-Being and Physiological Reactivity to Stress

Sheilagh Fox

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

Patrick R. Steffen, Chair
Scott R. Braithwaite
Melissa K. Jones

Department of Psychology

Brigham Young University

ABSTRACT

Well-Being and Physiological Reactivity to Stress

Sheilagh Fox
Department of Psychology, BYU
Master of Science

Because of the impact of stress on health, it is important to understand the variables that underlie cardiovascular reactivity to stress because it may lead to more focused targets of intervention for helping people to reduce or otherwise better manage their stress. The purpose of the present study was to answer the following questions: does lack of eudaimonic well-being (a combination of psychological and social well-being) predict increased cardiovascular reactivity to stress in a clinically distressed population? And does increased eudaimonic well-being protect against increased cardiovascular reactivity to stress when hedonic well-being (a combination of positive affect and life satisfaction) is low and depression and stress are high? If so, then it may be possible to reduce the effects of stress on health even if depression and stress are present.

One hundred twenty-nine college students (ages 18-29) who were clinically distressed were administered a questionnaire that included questions about demographic variables and measures of hedonic and eudaimonic well-being, depression, and general perceived stress. After answering the questionnaire, a baseline reading of cardiovascular activity was taken. After the baseline reading, participants were subjected to the Trier Social Stress Test (TSST), an interpersonal stressor that consists of an anticipation period, a speech, and a math task. Measurements of cardiovascular activity were taken throughout the TSST. I predicted that lower levels of eudaimonic and hedonic well-being, mental health, and higher amounts of general perceived stress would predict increased cardiovascular reactivity to the TSST as measured by systolic blood pressure, diastolic blood pressure, and heart rate. Then, should the prior hypothesis be true, I predicted that higher eudaimonic well-being will suppress the effect of lower hedonic will-being, lower mental health, and higher general perceived stress on cardiovascular activity to acute stress.

Results of the study found no effect of eudaimonic well-being, hedonic well-being, depression, and general perceived stress on cardiovascular reactivity during the TSST. The results suggest that there is no relationship between well-being, depression, and general perceived stress and cardiovascular reactivity to stress in a young college student population.

Keywords: eudaimonic well-being, hedonic well-being, depression, general perceived stress, acute stress, cardiovascular reactivity

ACKNOWLEDGEMENTS

First, I express my gratitude to the chair of my committee, Dr. Patrick Steffen, for his continuous support of my academic interests and for the research opportunities he has provided me. I also thank Dr. Scott Braithwaite and Dr. Melissa Jones for their assistance and encouragement with this project.

Second, I am thankful for my peers in the clinical psychology program. In particular, I am grateful for the friendship of Brodrick Brown, Eric Ghelfi, and Dr. Louise Wheeler, whose support and encouragement I depended on during the completion of this project. I could not ask for better friends and colleagues.

Finally, I am indebted to many friends and family members for their unfailing support. If I were to list all my thoughts and feelings on this matter, the acknowledgements would be the longest section of this document. I will keep it short by thanking everyone collectively. Thank you!

TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF APPENDICES

# Well-Being and Physiological Reactivity to Stress

There is no consensus on the definition of stress. In fact, many researchers "simply define *stress* as circumstances that most people would find stressful" (Segerstrom & Miller, 2004). Despite this lack of agreement, however, it is common to explain the existence of human and animal stress within an evolutionary psychology framework: organisms that respond to life-threatening situations with increased physiological arousal have increased chances for survival because the arousal enables them to better fight, run away from, or otherwise deal with threatening circumstances. Thus, humans react to threatening situations with heightened physiological arousal, and, though these adaptations were useful in the past, they are counterproductive in our modern lives (Segerstrom & Miller, 2004) and can lead to many future health problems through known mechanisms (Sapolsky, 2004). Notably, cardiovascular reactivity to acute stress has been shown to be an important predictor of future cardiovascular health status (Carroll et al., 2012; Chida & Steptoe, 2010), as is the ability to recover after the stressor (Chida & Hamer, 2008). Given these tangible and undesirable health outcomes, physiological reactivity to stress provides a useful operational definition for stress itself.

Many Americans – approximately 40% of people who smoke, 41% of people who gamble, 35% of people who shop, and 27% of people who drink alcohol (American Psychological Association, 2008) – believe that engaging in these unhealthy methods is an effective way to cope with stress. This suggests that many people find it difficult to deal with stress in healthier ways. Because of the impact of stress on health, it is important to understand the variables that underlie cardiovascular reactivity to stress because it may lead to more focused targets of intervention for helping people to reduce or otherwise better manage their stress.

Perhaps one crucial aspect of understanding cardiovascular reactivity to stress is understanding the relationship between how people react to acute stress and general well-being. There is evidence that people who are in psychotherapy or who report distress tend to demonstrate increased cardiovascular reactivity to stress (Steffen, Fidalgo, Schmuck, Tsui & Brown, 2014). However, as outlined in the next section, well-being comes in several flavors. In the present study, I will attempt to investigate the differential impact of two types of well-being on cardiovascular reactivity to stress in a distressed population.

## Defining Well-Being

Defining well-being as it pertains to mental health is a surprisingly difficult task. Despite being a top priority and fundamental value of mental health clinicians and researchers (American Association for Marriage and Family Therapy, 2012; American Counseling Association, 2014; American National Association of Social Work, 1996; American Psychiatric Association, 2010; American Psychological Association, 2002), well-being is a nebulous concept that is rarely explicitly defined. Indeed, as Epicurus and Aristotle had profoundly different opinions on what constituted the good life, so do psychologists and other mental health professionals in modern times. In psychological research, differing views of well-being are implicit in what researchers choose to study and, therefore, are manifested in what they choose to measure. Thus, it is useful to examine several different measures of well-being to illustrate some of the more modern views of well-being.

**Conceptualizations and measures of well-being.** Different measures of well-being reflect some diversity among psychologists about what "the good life" entails. One of the first scales to measure well-being was the Bradburn Scale of Psychological Well-Being (1969), which consisted of 10 questions measuring the balance between positive and negative affect in the

previous few weeks (e.g., “Did you feel particularly excited or interested in something?”, “Did you feel pleased about having accomplished something?”, “Did you feel bored?”, “Did you feel upset because someone criticized you?”). In other words, scales such as Bradburn’s strongly emphasized affect (Ryff, 1989b). Many conceptualizations of well-being continued to emphasize affect with many also taking into account life satisfaction (Bryant & Veroff, 1982; Diener, Suh, Lucas, & Smith, 1999; Ryff, 1989b; Stock, Okun, & Benin, 1986). However, other conceptions of well-being have been proposed, particularly within the positive psychology movement.

***Psychological well-being.*** Ryff was one of the first to articulate some of the alternatives to conventional assumptions of well-being, criticizing hedonic conceptions as having an insufficient theoretical basis for assuming that well-being is the same as positive affect or life satisfaction (Ryff, 1989b). Drawing theoretically from the Aristotelian concept of eudaimonia (“the feelings accompanying behavior in the direction of, and consistent with, one’s true potentials”; Waterman, 1984, p. 16) as well as from the work of Maslow (1968), Rogers (1961), Jung (1933), Allport (1961), Erikson (1959), Buhler (1935; Buhler & Massarick, 1968), Neugarten (1968; 1973), and Jahoda (1958), she created an assessment to assess what she believed to be the theories’ common points of theoretical convergence: Positive Relations with Others, Personal Growth, Purpose in Life, Environmental Mastery, Self-Acceptance, and Autonomy (Ryff, 1989a; Ryff, 1989b). She defined Positive Relationships as “warm, trusting interpersonal relations”; Personal Growth as continual development; Purpose in Life as “goals, intentions, and a sense of directedness”; Environmental Mastery as competent, active participation in and influence on their psychological environment; Self-Acceptance as holding a “positive attitude toward oneself and one’s life”; and Autonomy as resistance to or independence from external standards for personal self-evaluation (Ryff, 1989a).

She developed a scale based on these domains to operationalize her new framework for well-being (Ryff, 1989b). It had 20 questions for each of the six domains, each of which was demonstrated to be reliable. The initial evidence for the facture structure of psychological well-being was limited because it was based on a principal components analysis with a varimax solution, meaning that all variance (including error variance) was accounted for in the factors and the three extracted components were orthogonal (uncorrelated) even though aspects of well-being were expected to be correlated. Several years later, however, a confirmatory factor analysis provided additional evidence of validity. The confirmatory factor analysis was done using a short version (3 items for each proposed dimension) of the original scale and it indicated that the best-fitting model for the measure was a six-factor model corresponding to the proposed dimensions plus an overall superfactor with an adjusted-goodness-of-fit index (AGFI = .89; Ryff & Keyes, 1995). Additionally, her model of psychological well-being showed good discriminant validity with subjective well-being. When a confirmatory factor analysis was applied to subscales for all aspects of psychological well-being as well as items designed to get at subjective well-being (which was conceptualized as presence of positive affect, absence of negative affect, and life satisfaction). The psychological well-being and subjective well-being latent factors were highly correlated (.84), suggesting a strong relationship between the different types of well-being, and the model yielded high goodness-of-fit indices (AGFI = .94, RMSEA = .07, CFI = .95; Keyes, Shmotkin, & Ryff, 2002).

***Eudaimonic well-being.*** Keyes elaborated upon Ryff's model, arguing that positive functioning should encompass more than private psychological functioning and extend to social well-being (Keyes, 2002). He proposed five dimensions of social well-being as being important to individual mental health: Social Integration, Social Acceptance, Social Contribution, Social

Actualization, and Social Coherence (Keyes, 1998). He defined Social Integration as self-evaluation of "one's relationship to society and community", Social Acceptance as "construal of society through the character and qualities of other people as a generalized category", Social Contribution as "evaluation of one's social value", Social Actualization as the "evaluation of the potential and trajectory of society", and Social Coherence as "perception of the quality, organization, and operation of the social world... includ[ing] a concern for knowing about the world" (Keyes, 1998). A confirmatory analysis showed that a five-factor model provided the best fit as compared with all other possible factor structures (in one sample, AGFI = .92 and in another AGFI = .84; Keyes, 1998).

Keyes went on to synthesize emotional well-being (a concept equivalent to what Ryff defined as hedonic well-being), Ryff's conceptualization of psychological well-being, and his own concept of social well-being into a broader model of mental health status (the latter two, psychological and social well-being, constituting eudaimonic well-being; Keyes, 2002).

**The nature of well-being in relation to mental illness.** Keyes theorized that, though negatively correlated, mental health and mental illness were not opposite ends of the same spectrum; rather, mental health is a syndrome of mental health symptoms in its own right. Additionally, he invented terminology to describe the presence and absence of mental health to avoid conflating absence of mental health with mental illness:

> The mental health continuum consists of complete and incomplete mental health. Adults with complete mental health are *flourishing* in life with high levels of well-being. To be flourishing, then, is to be filled with positive emotion and to be functioning well psychologically and socially. Adults with incomplete mental health may be conceived of as emptiness and stagnation, constituting a life of quiet despair that parallels accounts of

> individuals who describe themselves and life as “hollow,” “empty,” “a shell,” and “a void”. (Keyes, 2002, p. 210)

Keyes’ tripartite conceptualization of well-being showed clear evidence of divergent validity with mental illness, which was operationally defined as having depressive symptoms. In a randomly selected sample of 3032 non-institutionalized, English-speaking adults in the 48 contiguous states, Keyes found that adults who were languishing but did not meet diagnosis for depression had an average of .13 symptoms of depression (out of a possible total of 9; Keyes, 2002). This low average provided considerable evidence that mental health and mental illness are categorically and not merely quantitatively different because five of the nine symptoms need to present for a major depressive disorder diagnosis to be warranted.

Additionally, he found that non-concurrent languishing or depression had similar prevalences and both resulted in significant psychosocial impairment. Psychosocial impairment was defined as subjective evaluation of emotional/mental health, self-reported impairment in doing basic activities (such as bathing/dressing oneself, carrying groceries, walking more than a mile, walking one block, and vigorous physical activity), and number of workdays lost or cut back in the last 30 days due to mental health or a combination of physical and mental health. Concurrent languishing and depression resulted in the worst psychosocial impairment.

Another reason why Keyes’ delineation between mental health and mental illness may be important is due to the suppressing influence of mental health on mental illness. In one study, Keyes, Dhingra, and Simoes (2010) investigated whether high levels of mental health were protective against the development of mental illness later. They compared the mental health and mental illness of 1723 people (out of an original 3032 participants) at two time points ten years apart. They found that adults who were languishing at both time points and adults who declined

from moderate or flourishing to languishing were 6.6 and 8.2 times as likely to have a mental illness at the later time point compared to adults who stayed flourishing, respectively. Additionally, they found that adults who stayed at moderate mental health or adults who declined from flourishing to moderate mental health were 4.4 times and 3.7 times as likely to have a mental illness at the later time point as those who stayed flourishing, respectively. These results suggest that flourishing mental health is protective against mental illness. Furthermore, they suggest that mental health should be promoted and protected as much as possible because a change to languishing from a state of more positive mental health is associated with a very high likelihood of future mental illness. Thus, they made a convincing case that not only is mental illness different from absence of mental health, but that absence of mental health is just as problematic as presence of mental illness.

## Relationships Between Well-Being and Physical Health

Both Ryff and Keyes went on to investigate the impact of psychological well-being on physical health. This was a logical next step, as their theorizing originally grew out of an interest in understanding aging (see Ryff, 1989a), which is often characterized by health problems. Ultimately, they were both interested in showing how their theories were important from a biological perspective as well as a psychological or psychosocial perspective.

**Psychological well-being.** Ryff and colleagues have investigated the relationship between her construct of psychological well-being and various aspects of physical health for over a decade. However, few of these studies examined cardiovascular health in connection with psychological well-being, and none studied cardiovascular reactivity to stress.

***Studies that examined cardiovascular health indicators.*** In one of these few studies, Ryff, Singer, and Love (2004) examined the relationship between several facets of psychological

well-being and various indicators of cardiovascular health in a sample of 135 older women (61-75 years). The cardiovascular indicators they used included levels of HDL cholesterol, weight, waist-hip ratio, glycosylated hemoglobin levels, inflammatory cytokine levels, SBP, and DBP. They found evidence that high levels of Personal Growth are associated with higher HDL cholesterol levels ("good cholesterol") and lower levels of inflammatory cytokines (which are linked to the presence of atherosclerosis as well as insulin resistance, which in turn increases the likelihood of obesity; Black, 2003; Schuett, Luchtefield, Grothusen, Grote, Schieffer, 2009). Purpose in Life was associated with higher HDL cholesterol; Positive Relations was associated with lower weight, waist-hip ratio, and lower levels of glycosylated hemoglobin (increased glycosylated hemoglobin increases the viscosity of blood, leading to inflammation; Saleh, 2015); and Environmental Mastery and Self-Acceptance were associated with lower levels of glycosylated hemoglobin (Ryff et al., 2004). However, they did not find any relationship between SBP or DBP and the subscales of psychological well-being (Ryff et al., 2006).

They also tested aspects of "ill-being" and their associations with biomarkers. They found that resting SBP was positively correlated with negative affect, trait anxiety, and anger; elevated glycosylated hemoglobin was positively correlated with trait anxiety; and elevated glycosylated hemoglobin was positively correlated with anger (Ryff et al., 2006). DBP was not found to have any relationship with markers of ill-being.

In another study that was pertinent to cardiovascular health (but did not include measures of SBP, DBP, and HR), Tsenkova, Love, Singer, & Ryff (2007) investigated the relationship between glycosylated hemoglobin and various aspects of psychological well-being, hedonic well-being, and demographic factors. They compared 91 women with no history of diet or pharmacologically controlled diabetes and healthy glycosylated hemoglobin levels at an initial

time point to a time point approximately two years later to see what variables predicted an increase in glycosylated hemoglobin. The best predictors of increased glycosylated hemoglobin were pretax household income and positive affect.

They also found that Purpose in Life and Personal Growth moderated the relationship between income and glycosylated hemoglobin, with low levels appearing to intensify the effects of low income on increases in glycosylated hemoglobin. Though this is only one study, it does raise an interesting possibility: if psychological well-being (or any of its facets) were found to reliably moderate the effects of stressful circumstances on any aspects of health, it could be beneficial to target psychological well-being as part of a health intervention.

***Studies that examined non-cardiovascular health indicators.*** Many more studies have examined the connection between psychological well-being and other, non-cardiovascular indicators of health. For example, Ryff et al. (2004) found evidence in their sample of 135 older women (61-75 years) that participants with high levels of Personal Growth tend to have lower levels of salivary cortisol (a stress hormone) throughout the day. However, no significant effects were found for urinary cortisol (Ryff et al., 2006). They also found that Positive Relationships, Purpose in Life, and Environmental Mastery were associated with improved aspects of sleep (Ryff, Singer, & Love, 2004).

In another study, Friedman et al. (2005) studied the relationships between the Positive Relationships factor of psychological well-being, quality of sleep, and a type of inflammatory cytokine in this same sample of 135 women. They found evidence that quality of sleep and positive relations both predicted the amount of inflammatory cytokines in the blood. Additionally, they found that high levels of Positive Relationships diminished the effect of low sleep and vice versa.

Boyle, Barnes, Buchman, and Bennett (2009) studied older adults recruited from continuous care retirement communities, subsidized housing facilities for seniors, and in the broader community (e.g., from church organizations). They found that in a group of 1238 older persons without dementia that people who died within five years had significantly lower scores for the well-being domain of Purpose in Life than people who lived.

In a sample of 970 people recruited from senior housing facilities who did not have dementia, Boyle, Buchman, and Bennett (2010) found that higher Purpose in Life scores were associated with less accumulation of disabilities impacting ability to do basic activities of daily living (e.g., feeding, bathing), instrumental activities of daily living (e.g. meal preparation, money management), and tasks related to mobility (e.g., walking half a mile, walking up and down a flight of stairs) over a period of up to 8 years. Participants were assessed, on average, 4.6 times approximately once a year.

In a sample of 951 people recruited from senior housing facilities and continuous care retirement communities who did not have dementia at baseline, Boyle, Buchman, Barnes, and Bennett (2010) found that higher Purpose in Life scores were associated with less onset of Alzheimer's disease over up to seven years of follow-up (with a mean of approximately 4-4.3 years of follow-up).

More recently, Schaefer et al. (2013) found that Purpose in Life was negatively correlated with the time it took people to recover from an emotionally negative stimulus (such as an unpleasant picture or sound) as measured by eyeblink reflex magnitude. Eyeblink reflex magnitude essentially monitors activity in orbicularis oculi, the muscle responsible for the opening and closing of the eyelid; activity in the muscle was assumed to increase when an unpleasant stimulus was present based off previous research.

Finally, Ryff, Radler, and Friedman (2015) studied the long-term effects of psychological well-being on health outcomes in a large sample over two time points ten years apart. 4963 out of an original 7108 participants were retained, a 75% rate once mortality was adjusted for. Notably, they found that individuals' levels of psychological well-being tended to remain similar over time – less than 10% of participants had any reliable change in any of the domains of well-being between the two time points. They found that individuals with lower psychological well-being had significantly larger increases in chronic health conditions and decreases in ability to do instrumental activities of daily living as well as subjective perception of health.

**Eudaimonic well-being.** In one study, Keyes (2004) investigated the association between flourishing mental health and cardiovascular disease. Additionally, he investigated whether or not the three components of well-being (emotional, psychological, and social) could independently predict incidence of cardiovascular disease. In a randomly selected sample of 3032 adults from the contiguous 48 states, his results suggested that when demographic variables such as sex and age are controlled for, people who are both mentally healthy and do not have depression have the lowest rates of cardiovascular disease. People with depression only were 2.1 [CI 1.3-3.3] times more likely than a flourishing person to have CVD while people with both depression and languishing mental health were 2.9 [CI 1.3-3.3] times more likely. People who were languishing but did not have depression did not detect a statistically significant difference ($p < .07$). These results provided inconclusive evidence of the impact of languishing on cardiovascular health independently of mental illness. Given that cardiovascular reactivity to stress is an important predictor of future cardiovascular health (Carroll et al., 2012; Chida & Hamer, 2008; Chida & Steptoe, 2010), this study suggests that studying the relationship between eudaimonic well-being and cardiovascular activity could be a fruitful research endeavor.

**Rationale and Hypotheses**

Previous studies have found associations between aspects of eudaimonic well-being (psychological well-being and social well-being) and a variety of health outcomes. However, research investigating the relationship between eudaimonic well-being and cardiovascular physiological responses to stress is non-existent. Thus, the purpose of the present study is to answer the following questions: does lack of eudaimonic well-being predict increased cardiovascular reactivity to stress in a clinically distressed population? And does increased eudaimonic well-being protect against increased cardiovascular reactivity to stress when hedonic well-being is low and depression and stress are high? Addressing these questions could contribute to the existing clinical literature and general discussion. If high eudaimonic well-being protects against increased cardiovascular reactivity to stress even in the context of low hedonic well-being, it would suggest that many health benefits could be obtained without necessarily reducing affective symptomatology (lack of emotional well-being).

The hypotheses of this study are as follows:

*Hypothesis 1: Lower levels of well-being, mental health, and higher amounts of general perceived stress will predict increased cardiovascular reactivity to acute stress.*

a. Lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress (before an acute stressor) will predict increased SBP after an acute stressor.
b. Lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress (before an acute stressor) will predict increased DBP after an acute stressor.

c. Lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress (before an acute stressor) will predict increased HR after an acute stressor.

*Hypothesis 2: If the above hypotheses are true, then higher eudaimonic well-being will suppress the effect of lower hedonic will-being, lower mental health, and higher general perceived stress on cardiovascular activity to acute stress.*

a. Higher eudaimonic well-being will suppress the effect of lower hedonic will-being, higher depression, and higher general perceived stress on SBP after an acute stressor.
b. Higher eudaimonic well-being will suppress the effect of lower hedonic will-being, higher depression, and higher general perceived stress on DBP after an acute stressor.
c. Higher eudaimonic well-being will suppress the effect of lower hedonic will-being, higher depression, and higher general perceived stress on HR after an acute stressor.

## Methods

### Participants

The 129 participants in the study were students at Brigham Young University receiving therapy at Counseling and Psychological Services. All the participants had recently completed the intake paperwork and only those who agreed to be contacted about research opportunities were recruited. Eighty-nine (63%) of the participants were female and 40 (37%) were male. The average age was 21.0 years with a standard deviation of 2.6 years, and the ages ranged from 18 to 29 years. As college students are young and less likely to have cardiovascular problems than older adults, using a college student sample increased the likelihood that any effect found would reflect a broadly generalizable relationship between eudaimonic well-being and cardiovascular reactivity to stress. Only people with an OQ-45 score that indicated a clinically significant level

of distress (64 or higher; Beckstead et al., 2003) were allowed to participate in the study. Using a distressed population was thought to increase the likelihood that people with low hedonic well-being (increased negative affect and decreased life satisfaction) would be present in the sample. Additionally, participants were excluded from participating if they had been diagnosed with high blood pressure or other heart-related conditions, if they were taking medication known to affect blood pressure, or if they had any previous biofeedback experience.

**Measures**

**Mental Health Continuum Scale Short Form (MHC-SF).** The MHC-SF (Keyes, 2009) is the short form of Keyes' original Mental Health Continuum scale. The original scale was 40 questions, with 7 items measuring emotional (or hedonic) well-being, 18 measuring psychological well-being (3 each for each of Ryff's 6 domains), and 15 measuring social well-being (3 each for each of Keyes' 5 domains). The short form consists of 14 items: 3 for hedonic well-being, 6 for psychological well-being (one from each of Ryff's dimensions), and 5 for social well-being (one from each of Keyes' dimensions). The MHC-SF has good internal consistency (greater than .80; Keyes, 2009). The factor structure has been shown to be tripartite in several languages and cultures in many different confirmatory factor analyses (Gallagher, Lopez, & Preacher, 2009; Joshanloo, Rostami, & Nosratabadi, 2006; Joshanloo, Wissing, Khumalo, & Lamers, 2013; Karaś, Cieciuch, & Keyes, 2014; Lamers, Westerhof, Bohlmeijer, ten Klooster, & Keyes, 2011; Rafiey et al., 2017) and exploratory structural equation modeling analyses (Joshanloo, 2016a; Joshanloo, 2016b; Joshanloo, Jose, Kielpikowski, 2017; Joshanloo & Lamers, 2016).

**Brief Inventory of Perceived Stress (BIPS).** The BIPS (Lehman, Burns, Gagen & Mohr, 2012) is a measure of perceived stress. It contains 9 questions measured on a 5-point

Likert scale. It displayed an internal consistency coefficient of .869 but has very limited evidence of a factor structure consistent with its subscales (Lehman et al., 2012). As intended, it showed good convergent validity the perceived stress scale, which has been interpreted to measure a sense of unpredictability, uncontrollability, and overloadedness and confidence in ability to cope positively with negative events.

**Beck Depression Inventory (BDI-II).** The BDI-II (Beck, 1996) is a commonly used measure of depression symptoms. It consists of 21 questions measured on a 4-point Likert scale. In this study, the question about suicide was omitted due to the OQ-45 already asking a question about suicide. It has internal consistency coefficients ranging from .73 to .96 as well as test-retest reliability coefficients between .92-.93, with an average 7 day interval between administrations (Wang & Gorenstein, 2013). In general, it shows a 2 factor structure consistent with Beck's proposed cognitive-affective and somatic-vegetative factors, though many studies have shown a 3 factor structure and a few have shown a 4 factor structure (Wang & Gorenstein, 2013). It shows convergent validity with several anxiety scales and divergent validity with scales measuring substance use, chronic pain and, problematically, suicidal ideation (Wang & Gorenstein, 2013).

**Outcome Questionnaire-45 (OQ-45).** The OQ-45 (Lambert et al., 2004) is an instrument designed to measure the progress of individuals in psychotherapy. In this study, we used the OQ-45 total to screen out potential participants who were not clinically distressed. It was not used in the analysis. The OQ-45 has 45 items divided into three subscales: symptom distress, interpersonal, and social role functioning. It uses a 5-point Likert scale. It a reliable measure with internal consistency coefficients of .92, .74, and .70 test-retest reliabilities of .78, .80. and .82 for each of the subscales (symptom distress, interpersonal, and social role

functioning, respectively). However, confirmatory analysis of its factors had yielded mixed results (Lambert et al., 2013). It has significant correlations with measures of depression (Beck Depression Inventory, Zung Self-Rating Depression Scale), anxiety (State-Trait Anxiety Inventory, Zung Self-Rating Anxiety Scale, Taylor Manifest Anxiety Scale) and interpersonal problems (Inventory of Interpersonal Problems, Social Adjustment Scale), suggesting good convergent validity (Lambert et al., 2013).

The aforementioned OQ-45 cut-off score of 64 to indicate a clinically significant level of distress was derived using the Jacobson & Truax method (1991) by Beckstead et al. (2003).

**Positive and Negative Affect Scale (PANAS).** The PANAS (Watson, Clark, & Tellegen, 1988) is a measure of positive and negative affect. They are relevant to the current study because they were frequently administered throughout the protocol and created short breaks between the questionnaire/hookup of equipment, baseline measurements, the TSST, and the recovery period. However, they were not statistically analyzed as part of the present study.

**Trier Social Stress Test (TSST).** The TSST (Kirschbaum, Pirke, & Hellhammer, 1993) is a social stressor that is considered the gold standard protocol for studying physiological reactivity to stress (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014; Steffen et al., 2014) because the TSST has been shown to reliably increase HPA axis activity (Allen et al., 2014). This is particularly true for salivary cortisol, which reliably increases 2- to 4-fold in concentration (Kirschbaum, Pirk, & Hellhammer, 1993). Additionally, there is limited evidence that suggests the TSST consistently increases cardiovascular activity, particularly HR and SBP (Allen et al., 2014, Buske-Kirschbaum, Geiben, Höllig, Morchhäuser, & Hellhammer, 2002; Campisi, Bravo, Cole, & Gobeil, 2012; Gerra et al., 2001; Jezova, Makatsori, Duncko, Moncek & Jakubek, 2004; Polheber & Matchock, 2014; Rimmele et al., 2009; Steffen et al., 2014; Yamawaka et al., 2009).

Additionally, several studies have found mixed results concerning whether the TSST affects DBP (Campisi, Bravo, Cole, & Gobeil, 2012; Gerra et al., 2001).

Our TSST protocol consisted of a 5-minute anticipation period where participants were informed they were to give a speech to an imaginary employer about being an ideal job candidate, a 5-minute speech, and a 5-minute arithmetic task consisting of serially subtracting the number 17 from 2023 as quickly and accurately as possible. If a mistake was made on the arithmetic task, they were asked to start over from 2023.

**Procedure**

The participants were recruited from Brigham Young University Counseling and Psychological Services. Clients who had recently completed the intake paperwork for psychotherapy who agreed to be contacted about research opportunities received a mass email inviting them to contact our lab. Participants who responded to invitations to participate in the study were sent a screening questionnaire (see Appendix A) that contained the OQ-45 and questions about whether they had been diagnosed with high blood pressure or other heart-related conditions, if they were taking medication known to affect blood pressure, or if they had any previous biofeedback experience. Those who were eligible were then invited to sign up to come into the lab via a personal email.

Eligible participants who signed up came into the lab signed a consent form immediately upon their arrival to the lab. Following the signing of the consent form, they filled out a questionnaire that asked them about their gender, age, height, weight, years of education, finances, ethnicity, race, current relationship status, religious affiliation, and health behaviors. The questionnaire included the MHC-SF, BDI-II, and BIPS.

After the questionnaire, one of the research assistants placed a blood pressure cuff on the left arm (in some cases on the right arm) to measure SBP, DBP, and HR. Additionally, the research assistant placed electrodes on the left ankle and right wrist (if a participant was wearing tights or a boot that was difficult to remove, the left wrist substituted for the left ankle) to take an electrocardiogram, electrodes on the second and third finger on the non-dominant hand to measure electrodermal response, and a respiration belt around the waist to measure breathing activity. The participant then filled out the first PANAS.

After filling out the first PANAS, the participants either watched a 15-minute nature imagery video or were given brief training in diaphragmatic breathing followed by 15 minutes of diaphragmatic breathing depending on the group they had randomly been assigned to for the original study. (For the purpose of the current study, the variability between the two groups is assumed to be negligible; of the participants that completed the 6-session original study [the procedure described here outlines the first session] there was no significant difference between participants who had the biofeedback intervention versus those who watched the imagery video on SBP, DBP, and HR during the TSST after 5 structured biofeedback practice sessions or imagery videos; see Wheeler, 2016). SBP, DBP, and HR were recorded at minute 10, 12, and 14 to get a baseline reading before the TSST. After 15 minutes of watching a nature video or practicing diaphragmatic breathing, the participant filled out the second PANAS.

After the second PANAS, the TSST was administered. SBP, DBP, and HR were measured twice during the speech prep phase at minutes 2 and 4, twice during the speech phase at minutes 2 and 4, and two times during the math task phase at minutes 2 and 4. After the TSST, the participant filled out the third PANAS.

After the TSST, there was a 10-minute rest period where the participant relaxed. SBP, DBP, and HR were measured at minutes 1, 3, 7, and 9. After the rest period, the participant filled out the fourth PANAS. The participants were paid five dollars and the research assistants signed them up for their next visit.

## Results

### Data Analysis Plan

To address whether low hedonic well-being and low eudaimonic well-being predicts increased SBP, DBP, and HR during a stress task, I used a multiple regression approach. In the regression equations, I included age, gender, body mass index (BMI), depression, perceived stress, and baseline SBP, DBP, or HR. This made it possible to see the impact of hedonic and eudaimonic well-being when age, gender, BMI, depression, perceived stress, and baseline SBP, DBP, or HR were controlled for. If there were significant relationships between cardiovascular reactivity and eudaimonic well-being as well as cardiovascular reactivity and hedonic well-being, depression, or perceived stress, I was going to test whether eudaimonic well-being is a moderator that lessens the impact of low hedonic well-being, depression, and perceived stress on cardiovascular reactivity to stress. All data were analyzed in Stata 15.1.

### Data Cleaning and Screening

First, I screened for keying errors and checked for missing data. One participant's weight was missing, so it was estimated according to a regression equation based on the sample taking into account height and gender. Participants who only had one blood pressure and HR measurement taken during a particular event (i.e., baseline, speech, or math task) simply had the known value represent the measurements taken during that event instead of the averaged measurements. This problem happened with 6 participants. There was no other missing data.

Second, I fenced in all univariate outliers to the median plus or minus two interquartile ranges. The median and interquartile ranges were used instead of the mean and standard deviations because the median and interquartile rangers are more robust to outliers. This was done to prevent any outliers from inflating the likelihood of type I errors. BMI had three measurements fenced to the upper limit, baseline SBP had 3 measurements fenced to the upper limit, baseline HR had two measurements fenced to the upper limit, speech DBP had one measurement fenced to the upper limit, speech HR had four measurements fenced to the upper limit, the math task HR had two measurements fenced to the upper limit, and the BIPS had one measurement fenced to the lower limit. The values for SBP, DBP, and HR for the speech and math tasks were then averaged to create an average SBP, DBP, and HR. The descriptive statistics for the key study variables after fencing in univariate outliers are presented in Table 1.

Table 1
*Descriptive Statistics For All Variables*

| Variable | M | SD. | Min. | Max. |
|---|---|---|---|---|
| Age (years) | 21 | 2.6 | 18 | 29 |
| BMI ($kg/m^2$) | 23 | 3.2 | 16 | 31 |
| Baseline SBP (mmHg) | 106 | 8.0 | 89 | 126 |
| Baseline DBP (mmHg) | 64 | 5.7 | 52 | 79 |
| Baseline HR (beats/min) | 69 | 10 | 43 | 96 |
| Trier SBP (mmHg) | 124 | 12 | 97 | 152 |
| Trier DBP (mmHg) | 77 | 85 | 57 | 95 |
| Trier HR (beats/min) | 80 | 12 | 53 | 116 |
| Perceived Stress | 24 | 6.2 | 7 | 35 |
| Depression | 16 | 10 | 0 | 44 |
| Hedonic Well-being | 10 | 3.3 | 2 | 15 |
| Eudaimonic Well-being | 31 | 12 | 4 | 55 |

As the analysis to be used was multiple regression, I screened the data to make sure it met the requisite assumptions. Observations are assumed to be independent as there is no reason why any of the observations would influence any of the others. A visual inspection of scatterplots did not show any obviously non-linear relationships or homoscedasticity between any of the independent and dependent variables (e.g., Trier HR did not have any visually observable non-linear relationship or heterogeneity of variance with baseline HR, BDI, BIPS, MHC hedonic well-being, or MHC eudaimonic well-being). I checked for multivariate outliers using the blocked adaptive computationally efficient outlier nominators function (BACON; Billor, Hadi, &

Velleman, 2000) and found no BACON outliers at the 15th percentile or lower of the chi-squared distribution. Finally, multicollinearity was evaluated. The mean variance inflation factor was 2.47, with no factor higher than 3.62. On this basis, I determined that multicollinearity would not be a major issue (see Table 2). Thus, I determined that it was appropriate to proceed with multiple regression.

Table 2
*Descriptive Statistics For All Variables*

| Variable | VIF |
|---|---|
| Age (years) | 1.12 |
| BMI ($kg/m^2$) | 1.21 |
| Baseline SBP (mmHg) | 2.34 |
| Baseline DBP (mmHg) | 1.91 |
| Baseline HR (beats/min) | 2.56 |
| Trier SBP (mmHg) | 3.62 |
| Trier DBP (mmHg) | 2.54 |
| Trier HR (beats/min) | 2.91 |
| Perceived Stress | 1.85 |
| Depression | 3.04 |
| Hedonic Well-being | 3.10 |
| Eudaimonic Well-being | 3.42 |
| Mean VIF | 2.47 |

**Planned Analysis**

First, I had baseline SBP, age, sex, BMI, depression, perceived stress, hedonic well-being, and eudaimonic well-being predict Trier SBP (see Table 3). Only baseline SBP and gender significantly predicted Trier SBP. Contrary to hypothesis 1a (lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress [before an acute stressor] will predict increased SBP after an acute stressor), hedonic well-being, eudaimonic well-being, depression, and general perceived stress did not significantly predict SBP during an acute stressor.

Table 3
*Regression For Trier SBP*

| Variable | Coefficient | SE | t | P-Value | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| | | | | | Upper | Lower |
| Baseline SBP | 0.822 | 0.118 | 6.97 | 0.000* | 0.588 | 1.056 |
| Age | -0.143 | 0.337 | -0.43 | 0.671 | -0.810 | 0.524 |
| Female | -4.456 | 2.091 | -2.13 | 0.035* | -8.596 | -0.316 |
| BMI ($kg/m^2$) | 0.035 | 0.280 | 0.12 | 0.901 | -0.519 | 0.588 |
| Stress | 0.006 | 0.136 | 0.04 | 0.967 | -0.265 | 0.276 |
| Depression | -0.007 | 0.180 | -0.04 | 0.97 | -0.364 | 0.350 |
| Hedonic | -0.330 | 0.430 | -0.77 | 0.444 | -1.182 | 0.521 |
| Eudaimonic | 0.223 | 0.128 | 1.74 | 0.084 | -0.0303 | 0.476 |
| Constant | 38.490 | 15.607 | 2.47 | 0.015* | 7.586 | 69.393 |

*Note.* * indicates significance at $p < .05$

Second, I had baseline DBP, age, sex, BMI, depression, perceived stress, hedonic well-being, and eudaimonic well-being predict Trier DBP (see Table 4). Only baseline DBP

significantly predicted Trier DBP. Contrary to hypothesis 1b (lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress [before an acute stressor] will predict increased DBP after an acute stressor), hedonic well-being, eudaimonic well-being, depression, and general perceived stress did not significantly predict DBP during an acute stressor.

Table 4
*Regression For Trier DBP*

| Variable | Coefficient | SE | t | P-Value | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| | | | | | Upper | Lower |
| Baseline DBP | 0.781 | 0.118 | 6.630 | 0.000* | 0.548 | 1.015 |
| Age | 0.198 | 0.266 | 0.740 | 0.459 | -0.329 | 0.724 |
| Female | -2.887 | 1.469 | -1.960 | 0.052 | -5.796 | 0.022 |
| BMI ($kg/m^2$) | -0.193 | 0.213 | -0.900 | 0.368 | -0.615 | 0.229 |
| Stress | -0.025 | 0.107 | -0.230 | 0.817 | -0.237 | 0.187 |
| Depression | 0.048 | 0.143 | 0.330 | 0.739 | -0.236 | 0.332 |
| Hedonic | -0.126 | 0.338 | -0.370 | 0.710 | -0.795 | 0.543 |
| Eudaimonic | 0.089 | 0.101 | 0.890 | 0.378 | -0.110 | 0.288 |
| Constant | 27.696 | 10.585 | 2.620 | 0.010* | 6.737 | 48.656 |

*Note.* * indicates significance at $p < .05$

Third, I had baseline HR, age, sex, BMI, depression, perceived stress, hedonic well-being, and eudaimonic well-being predict Tier HR (see Table 5). Only baseline HR significantly predicted Trier HR. Contrary to hypothesis 1c (lower hedonic well-being, lower eudaimonic well-being, higher depression, higher general perceived stress [before an acute stressor] will predict increased HR after an acute stressor), hedonic well-being, eudaimonic well-being,

depression, and general perceived stress did not significantly predict DBP during an acute stressor.

Table 5
*Regression For Trier HR*

| Variable | Coefficient | SE | t | P-Value | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| | | | | | Upper | Lower |
| Baseline HR | 0.904 | 0.080 | 11.280 | 0.000* | 0.745 | 1.062 |
| Age | -0.430 | 0.323 | -1.330 | 0.186 | -1.070 | 0.210 |
| Female | -1.505 | 1.787 | -0.840 | 0.401 | -5.044 | 2.034 |
| BMI ($kg/m^2$) | 0.115 | 0.260 | 0.440 | 0.659 | -0.400 | 0.631 |
| Stress | 0.022 | 0.131 | 0.170 | 0.869 | -0.237 | 0.281 |
| Depression | -0.134 | 0.172 | -0.780 | 0.439 | -0.475 | 0.208 |
| Hedonic | -0.101 | 0.413 | -0.240 | 0.807 | -0.919 | 0.717 |
| Eudaimonic | 0.061 | 0.123 | 0.500 | 0.621 | -0.183 | 0.305 |
| Constant | 27.561 | 11.362 | 2.430 | 0.017* | 5.063 | 50.059 |

*Note.* * indicates significance at $p < .05$

Finally, it was not possible to test for the moderating ability of eudaimonic well-being because hedonic well-being, eudaimonic well-being, depression, and perceived stress were not statistically significant predictors of SBP, DBP, and HR. Thus, the analysis did not address hypothesis 2a, 2b, and 2c.

**Exploratory Analysis**

To determine if it would be appropriate to create a correlation matrix, univariate normality of the variables had to be established because only bivariate normality was examined to test whether the assumptions for multiple regression were met. A visual inspection of

histograms found that age appeared to have a distinct right skew, depression scores a mild right skew, hedonic well-being scores a mild left skew due to a ceiling effect, and eudaimonic well-being scores a mild right skew. Using the D'Agostino skewness-kurtosis test with Royston correction (D'Agostino, Belanger, & D'Agostino, 1990; Royston, 1991), which tests for univariate normality taking into account both skewness and kurtosis, I found that the BDI score, and the hedonic well-being and eudaimonic well-being scores of the MHC-SF are unlikely to be normally distributed at a significance level of .05 (see Table 6).

Table 6
*Test For Univariate Normality*

| Variable | Adj. $X^2(2)$ | P-Value |
|---|---|---|
| Age (years) | 11.83 | 0.0027* |
| BMI ($kg/m^2$) | 4.09 | 0.1297 |
| Baseline SBP (mm/Hg) | 4.57 | 0.1018 |
| Baseline DBP (mm/Hg) | 2.34 | 0.31 |
| Baseline HR (beats/min) | 1.32 | 0.5161 |
| Trier SBP (mm/Hg) | 2.73 | 0.2554 |
| Trier DBP (mm/Hg) | 3.66 | 0.1601 |
| Trier HR (beats/min) | 2.96 | 0.2272 |
| Stress | 4.35 | 0.1135 |
| Depression | 6.74 | 0.0344* |
| Hedonic | 6.29 | 0.043* |
| Eudaimonic | 6.6 | 0.0369* |

*Note.* * indicates significance at $p < .05$

Age had a skewness of .818 and kurtosis of 3.416, BDI score had a skewness of .466 and kurtosis of 2.43, the MHC hedonic well-being scale score had a skewness of -.341 and kurtosis of 2.34, and the MHC eudaimonic well-being scale score had a skewness of .065 and kurtosis of 2.23. Because Pearson's correlation is not particularly robust to violations of normality, Spearman's rank correlations were calculated for all the variables to screen for potential associations. Transformations were avoided to reduce potential issues of interpretability. Interestingly, I found that BMI was significantly correlated with eudaimonic well-being (-.23), stress with baseline DBP (.18), depression with baseline HR (.19), eudaimonic well-being with baseline HR (-.19). No other significant relationships were found between physiological measures and psychological constructs.

Unsurprisingly, I found that many physical and physiological measurements were intercorrelated (see Table 7).

Table 7
*Spearman's Rank Correlation Matrix For All Variables*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Age (years) | 1 | | | | | | | | | | | |
| 2 | BMI ($kg/m^2$) | .20* | 1 | | | | | | | | | | |
| 3 | Baseline SBP (mm/Hg) | .12 | .18* | 1 | | | | | | | | | |
| 4 | Baseline DBP (mm/Hg) | .12 | .03 | .58* | 1 | | | | | | | | |
| 5 | Baseline HR (beats/min) | .05 | .15 | .11 | 0.16 | 1 | | | | | | | |
| 6 | Trier SBP (mm/Hg) | .07 | .04 | .62* | 0.37* | 0.04 | 1 | | | | | | |
| 7 | Trier DBP (mm/Hg) | .12 | -.06 | .46* | 0.51* | 0.06 | 0.73* | 1 | | | | | |
| 8 | Trier HR (beats/min) | -.04 | .07 | .20* | 0.16 | 0.69* | 0.38* | 0.28* | 1 | | | | |
| 9 | Stress | .03 | .03 | -.05 | 0.18* | 0.16 | -0.11 | 0.06 | 0.06 | 1 | | | |
| 10 | Depression | .10 | .10 | -.05 | 0.12 | 0.19* | -0.15 | 0.00 | 0.06 | 0.66* | 1 | | |
| 11 | Hedonic Well-Being | -.09 | -.17 | .00 | -0.14 | -0.15 | 0.12 | -0.01 | -0.06 | -0.50* | -0.75* | 1 | |
| 12 | Eudaimonic Well-Being | -.08 | -.23* | .04 | -0.12 | -0.19* | 0.17 | 0.02 | -0.07 | -0.48* | -0.74* | 0.82* | 1 |

*Note.* * indicates significance at $p < .05$

## Discussion

Eudaimonic well-being was not found to have any association with cardiovascular reactivity to stress in the planned regression analyses. In the SBP regression analysis, only baseline SBP and gender were significant predictors of Trier SBP. This is to be expected because, beyond SBP being obviously likely to correlate between different people at the same time periods, gender is known to influence cardiovascular activity (Umetani, Singer, McCraty, & Atkinson, 1998; Wiinberg et al., 1995). In the DBP and HR equations, only the baseline values for DBP and HR (respectively) were significant predictors. As eudaimonic well-being and hedonic well-being both did not predict any cardiovascular stress responses, there was no moderation to test for. Thus, the present study provides no evidence of a relationship between eudaimonic well-being and cardiovascular physiological responses to stress or the ability of high eudaimonic well-being to moderate the impact of low hedonic well-being, high levels of stress, or low levels of depression in a clinically distressed population.

In the exploratory analysis, BMI was significantly negatively correlated with eudaimonic well-being, stress positively correlated with baseline DBP, depression positively correlated with baseline HR, and eudaimonic well-being positively correlated with baseline HR. However, given that there were 32 correlations between physiological measures and psychological constructs, 1.6 type I errors should be expected. Furthermore, there is only a 19.4% chance that none of the 32 correlations would exhibit a type I error. Thus, no conclusions should be drawn from this exploratory analysis. Though largely unrelated to the content of the present study, the most interesting and unexpected of the correlations is the negative correlation between BMI – a control variable in the present study – and eudaimonic well-being. If a strong association between BMI and eudaimonic well-being was replicated, it could be an interesting avenue for

future research concerning psychosocial factors associated with overweight or obesity. Though eudaimonic well-being has been examined as a variable influencing adherence to exercise protocols, no studies investigating a connection between eudaimonic well-being (or Ryff's psychological well-being) and overweight or obesity have been conducted.

**Limitations and Recommendations for Future Research**

There are a number of limitations that could have impacted the validity of this study. Firstly, there is mixed evidence concerning the impact of the TSST on DBP (Campisi, Bravo, Cole, & Gobeil, 2012); there is more support for it increasing HR (Buske-Kirschbaum, Geiben, Höllig, Morchhäuser, & Hellhammer, 2002; Jezova, Makatsori, Duncko, Moncek & Jakubek, 2004; Polheber & Matchock, 2014; Rimmele et al., 2009; Steffen et al., 2014; Yamawaka et al., 2009), SBP (Campisi, Bravo, Cole, & Gobeil, 2012; Gerra et al., 2001), and HPA axis activity (Allen et al., 2014). Additional research is needed to assess the impact of the TSST on cardiovascular indicators of stress. Though Allen et al. (2014) did a thorough review on many aspects of the TSST, it would be beneficial to do a meta-analytic study to determine more precisely the impact of the TSST on HR, SBP, DBP, heart rate variability, and cortisol levels.

Additionally, the majority of the protocols were administered by undergraduate research assistants without any kind of fidelity check. It is possible that the experimental manipulation failed to induce a significant amount of psychosocial stress in many of the participants due to some research assistants failing to be sufficiently neutral (i.e., acting too friendly or having an affect that is too positive). Future investigations using the TSST should include a fidelity check to ensure that the manipulation was properly carried out and, potentially, to control for the effectiveness of the manipulation.

Statistically speaking, though the BIPS and the BDI-II have both displayed good internal consistency in the past, they have shown mixed evidence of their factor structures (Lehman et al., 2012; Wang & Gorenstein, 2013). The BDI-II in particular has known validity issues, including difficulty discriminating between depression and anxiety symptoms and detecting suicidal ideation, a common symptom of depression. Thus, it is possible that there are reliability and validity issues with the use of these measures in the present sample. Also, though it was adequately powered to find a moderate or large effect, the study was underpowered to find a small effect. Using G*Power 3.1, I calculated that to find an effect size of $f^2$=.02 with $\alpha$=.05 and 1- $\beta$= .8 in a multiple regression with 7 predictors, a sample of 395 people be needed.

Additionally, the sample was composed primarily of young people. Most of the studies mentioned in the literature review that detected relationships between eudaimonic well-being and health outcomes were performed in older populations (Boyle, Barnes, Buchman, & Bennett, 2009; Boyle, Buchman, Barnes, & Bennett, 2010; Boyle, Buchman, & Bennett, 2010; Friedman et al., 2005; Keyes, 2004; Keyes, Dhingra, & Simoes, 2010; Ryff et al., 2006; Ryff, Radler, & Friedman, 2015; Ryff, Singer, & Love, 2004; Schaefer et al., 2013; Tsenkova, Love, Singer, & Ryff;). This is highly salient because younger people tend to have fewer health issues than older people, including cardiovascular health problems that would be indicated by SBP, DBP, and HR. Additionally, potential participants were excluded from participating if they had been previously diagnosed with high blood pressure or other heart-related conditions or if they were taking medication known to affect blood pressure. Thus, there is a critical external validity issue that prevents the null results of this study from being generalizable to the general population. The results of the present study may well have turned out differently had an older, less healthy sample been used. Future research investigating indicators of cardiovascular health and

eudaimonic well-being should actively include older individuals and not exclude individuals known to have cardiovascular health problems.

Another potential issue is that the questionnaire answers provided by participants may have been systematically influenced by cultural factors. The study took place at Brigham Young University, a university where the vast majority of the student population are practicing members of the Church of Jesus Christ of Latter-day Saints (LDS). Of particular salience is the possibility that participants may have been reluctant to give any responses which indicated poor well-being due to internalized cultural beliefs about happiness necessarily being the result of personal righteousness and, therefore, unhappiness being the result of personal unrighteousness. Nothing is known about the reliability and the validity of the measures in a predominantly LDS population. Thus, future investigations of well-being should study more diverse populations to reduce the possibility of culture-specific factors influencing results when self-report measures are used.

A final recommendation for studying well-being, particularly eudaimonic well-being, in connection with health-related variables (or anything else) is to feature or, at the very least, include a qualitative component in a mixed-methods approach. It is ironic to investigate a eudaimonia, a construct that encompasses such phenomenologically rich dimensions as purpose in life and personal growth, without attempting to understand the lived experience and personal meanings of the individuals being studied. It is very possible that purpose in life and personal growth are highly idiosyncratic and strongly dependent on the demographics, values, abilities, and personalities of individuals. In short, all purposes in life and all patterns of personal growth (or lack thereof) may not be equal, and it may be a mistake to methodologically treat them as such.

## Conclusion

Though the present study did not find significant results and has serious limitations, it is only the second study that has attempted to link eudaimonic well-being with cardiovascular indicators of health. Because of the limitations of the dataset, it is not known whether eudaimonic well-being affects cardiovascular reactivity to stress or if increased eudaimonic well-being protects against increased cardiovascular reactivity to stress when hedonic well-being is low and depression and stress are high in the most relevant populations. Thus, it is still not known whether health benefits could be obtained without necessarily reducing affective symptomatology (lack of emotional well-being). Further research is needed to evaluate whether its null findings generalize to broader and more relevant segments of the population.

References

Allen, A.P., Kennedy, P.J., Cryan, J.F., Dinan, T.G., & Clarke, G. (2014). Biological and psychological markers of stress in humans: Focus on the Trier Social Stress Test. *Neuroscience and Biobehavioral Reviews, 38*, 94-124.

Allport, G.W. (1961). *Pattern and growth in personality.* New York, NY: Holt, Rinehart, & Winston.

American Association for Marriage and Family Therapy (2012, July 1). *AAMFT code of ethics.* Retrieved from https://www.aamft.org/imis15/Documents/AAMFT%20Code_11_2012_Secured.pdf

American Counseling Association (2014). *ACA code of ethics*. Alexandria, VA: Author.

American Psychiatric Association (2010). *The principles of medical ethics with annotations especially applicable to psychiatry.* Arlington, VA: Author.

American Psychological Association (2002). Ethical principles of psychologists and code of conduct. *American Psychologist*, 57, 1060-1073.

Beck, A., Steer, R., & Brown, G. (1996). *Manual for Beck Depression Inventory-II* (2nd ed.). San Antonio, TX: Psychological Corporation.

Beckstead, D. J., Hatch, A. L., Lambert, M. J., Eggett, D. L., Goates, M. K., & Vermeersch, D.A. (2003). Clinical significance of the Outcome Questionnaire (OQ-45.2). *The Behavior Analyst Today, 4*(1), 86-97.

Billor, N., Hadi, A.S., & Velleman, P.F. (2000). BACON: Blocked adaptive computationally efficient outlier nominators. *Computational Statistics & Data Analysis, 34*, 279-298.

Black, P.H. (2003). The inflammatory response is an integral part of the stress response: Implications for artherosclerosis, insulin resistance, type II diabetes, and metabolic syndrome X. *Brain, Behavior, and Immunity, 17*(5), 350-364.

Boyle, P.A., Barnes, L.L., Buchman, A.S., & Bennett, D.A. (2009). Purpose in life is associated with mortality among community-dwelling older persons. *Psychosomatic Medicine, 71*(5), 574-579.

Boyle, P.A., Buchman, A.S., Barnes, L.L., & Bennett, D.A. (2010). Effect of a purpose in life on risk of incident Alzheimer disease and mild cognitive impairment in community-dwelling older persons. *Archives of General Psychiatry, 67*(3), 304-310.

Boyle, P. A., Buchman, A. S., & Bennett, D. A. (2010). Purpose in life is associated with a reduced risk of incident disability among community-dwelling older persons. *The American Journal of Geriatric Psychiatry, 18*(12), 1093–1102.

Bradburn, N.M. (1969). *The structure of psychological well-being.* Chicago: Aldine.

Bryant, F. B., & Veroff, J. (1982). The structure of psychological wellbeing: A sociohistorical analysis. *Journal of Personality and Social Psychology, 43,* 653-673.

Buhler, C. (1935). The curve of life as studied in biographies. *Journal of Applied Psychology, 19,* 405-409.

Buhler, C., & Massarik, F. (Eds.). (1968). *The course of human life.* New York, NY: Springer.

Buske-Kirschbaum, A., Geiben, A., Höllig, H., Morschhäuser, E., & Hellhammer, D. (2002). Altered responsiveness of the hypothalamus-pituitary-adrenal axis and the sympathetic adrenomedullary system to stress in patients with atopic dermatitis. *The Journal of Clinical Endocrinology and Metabolism, 87*(9), 4245-4251.

Campisi, J., Bravo, Y., Cole, J., & Gobeil, K. (2012). Acute psychosocial stress differentially influences salivary endocrine and immune measures in undergraduate students. *Physiology and Behavior, 107*, 317-321.

Carroll, D., Ginty, A.T., Der, G., Hunt, K., Benzeval, M., & Phillips, A.C. (2012). Increased blood pressure reactions to acute mental stress are associated with 16-year cardiovascular disease mortality. *Psychophysiology, 49,* 1444-1448.

Chida, Y. & Hamer, M. (2008). Chronic psychosocial factors and acute physiological responses to laboratory-induced stress in healthy populations: A quantitative review of 30 years of investigations. *Psychological Bulletin, 134*(6), 829-885.

Chida, Y. & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status. *Hypertension, 55,* 1026-1032.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior 24*(4), 385-396.

D'Agostino, R. B., Belanger, A.J., and D'Agostino, R.B. (1990). A suggestion for using powerful and informative tests of normality. *American Statistician, 44*, 316-321.

Diener, E., Suh, E.M., Lucas, R.E., & Smith, H.L. (1999). Subjective well-being: Three decades of progress. *Psychological Bulletin, 125*(2), 276-302.

Erikson, E. (1959). Identity and the life cycle. *Psychological Issues, 1,* 18-164.

Friedman, E.M., Hayney, M.S., Love, G.D., Urry, H.L., Rosenkranz, M.A., Davidson, R.J., ... Ryff, C.D. (2005). Social relationships, sleep quality, and interleukin-6 in aging women. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 102*(51), 18757-18762.

Gallagher, M.W., Lopez, S.J., & Preacher, K.J. (2009). The hierarchical structure of well-being. *Journal of Personality, 77*(4), 1025-1050.

Gerra, G., Zaimovic, A., Mascetti, G.G., Gardini, S., Zambelli, U., Timpano, M., ... Brambilla, F. (2001). Neuroendocrine responses to experimentally-induced psychological stress in healthy humans. *Psychoneuroendocrinology, 26*, 91-107.

Jacobson, N.S., & Truax, P. (1991). Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology, 59*(1), 12-19.

Jahoda, M. (1958). *Current concepts of positive mental health.* New York, NY: Basic Books.

Jezova, D., Makatsori, A., Duncko, R., Moncek, F., & Jakubek, M. (2004). High trait anxiety in healthy subjects is associated with low neuroendocrine activity during psychosocial stress. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 28*, 1331-1336.

Joshanloo, M. (2016a). A new look at the factor structure of the MHC-SF in Iran and the United States using exploratory structural equation modeling. *Journal of Clinical Psychology, 72*(7), 701-713.

Joshanloo, M. (2016b). Revisiting the empirical distinction between hedonic and eudaimonic aspects of well-being using exploratory structural equation modeling. *Journal of Happiness Studies, 17*(5), 2023-2036.

Joshanloo, M., Jose, P.E., & Kielpikowski, M. (2017). The value of exploratory structural equation modeling in identifying factor overlap in the Mental Health Continuum – Short Form (MHC-SF): A study with a New Zealand sample. *Journal of Happiness Studies, 18*(4), 1061-1074.

Joshanloo, M., & Lamers, S.M.A. (2016). Reinvestigation of the factor structure of the MHC-SF in the Netherlands: Contributions of exploratory structural equation modeling. *Personality and Individual Differences, 97,* 8-12.

Joshanloo, M., Rostami, R., & Nosratabadi, 2006. Examining the factor structure of the Keyes' comprehensive scale of well-being. *Journal of Iranian Psychologists, 3*(9), 35-51.

Joshanloo, M., Wissing, M.P., Khumalo, I. P., & Lamers, S. (2013). Measurement invariance of the Mental Health Continuum-Short Form (MHC-SF) across three cultural groups. *Personality and Individual Differences, 55*(7), 755–759.

Jung, C.G. (1933). *Modern man in search of a soul* (W.S Dell & C.F. Baynes, Trans.). New York, NY: Harcourt, Brace, & World.

Karaś, D., Cieciuch, J., & Keyes, C. L. (2014). The Polish adaptation of the Mental Health Continuum-Short Form (MHC-SF). *Personality and Individual Differences, 69,* 104–109.

Keyes, C.L.M. (1998). Social well-being. *Social Psychology Quarterly, 61*(2), 121-140.

Keyes, C.L.M. (2002). The mental health continuum: From languishing to flourishing in life. *Journal of Health and Social Behavior, 43*(2), 207-222.

Keyes, C.L.M. (2004). The nexus of cardiovascular disease and depression revisited: The complete mental health perspective and the moderating role of age and gender. *Aging & Mental Health, 8*(3), 266-274.

Keyes, C.L.M. (2005). Chronic physical conditions and aging: Is mental health a potential protective factor? *Ageing International, 30*(1), 88-104.

Keyes, C.L.M. (2007). Promoting and protecting mental health as flourishing: A complementary strategy for improving national mental health. *American Psychologist, 62*(2), 95-108.

Keyes, C.L.M. (2009). *Brief description of the Mental Health Continuum short form (MHC-SF)*. Available from https://www.aacu.org/sites/default/files/MHC-SFEnglish.pdf

Keyes, C.L.M., Dhingra, S.S., & Simoes, E.J. (2010). Change in level of positive mental health as a predictor of future risk of mental illness. *American Journal of Public Health, 100*(12), 2366-2371.

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.

Kirschbaum, C., Pirke, K.M., & Hellhammer, D.H. (1993). The `Trier Social Stress Test'- A tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology, 28,* 76-81.

Lambert, M.J., Kahler, M., Harmon, C., Burlingame, G.M., Shimokawa, K., & White, M.M. (2013). *Administration and scoring manual: Outcome Questionnaire 45.2*. Salt Lake City, UT: OQ Measures LLC.

Lambert, M. J., Morton, J. J., Hatfield, D., Harmon, C., Hamilton, S., Reid, R. C., ... Burlingame, G.M. (2004). *Administration and scoring manual for the OQ-45.2*. Orem, UT: American Professional Credentialing Services.

Lamers, S., Westerhof, G. J., Bohlmeijer, E. T., ten Klooster, P.M., & Keyes, C. L. (2011). Evaluating the psychometric properties of the Mental Health Continuum-Short Form (MHC-SF). *Journal of Clinical Psychology, 67*(1), 99–110.

Lehman, K.A., Burns, M.N., Gagen, E.C., & Mohr, D.C. (2012). Development of the Brief Inventory of Perceived Stress. *Journal of Clinical Psychology, 68*(6), 631-644.

Maslow, A.H. (1968). *Toward a psychology of being* (2nd ed.). New York, NY: Van Nostrand Reinhold.

National Association of Social Workers (1996). *Code of ethics of the National Association of Social Workers*. Washington, DC: Author.

Neugarten, B.L. (1968). The awareness of middle age. In B.L. Neugarten (Ed.), *Middle age and aging* (pp. 93-98). Chicago: University of Chicago Press.

Neugarten, B.L., (1973). Personality change in late life: A developmental perspective. In C. Eisdorfer & M.P. Lawton (Eds.), *The psychology of adult development and aging* (pp. 311-335). Washington, DC: American Psychological Association.

Polheber, J.P, & Matchock, R.L. (2014). The presence of a dog attenuates cortisol and HR in the Trier Social Stress Test compared to human friends. *Journal of Behavioral Medicine, 37*, 860-867.

Rafiey, H., Alipour, F., LeBeau, R., Rarani, M.A., Salimi, Y., & Ahmadi, S. (2017). Evaluating the psychometric properties of the Mental Health Continuum – Short Form (MHC-SF) in Iranian earthquake survivors. *International Journal of Mental Health, 46*(3), 243-251.

Rimmele, U., Seiler, S., Marti, B., Wirtz, P.H., Ehlert, U., & Heinrichs, M. (2009). The level of physical activity affects adrenal and cardiovascular reactivity to psychosocial stress. *Psychoneuroendocrinology, 34*, 190-198.

Rogers, C.R. (1961). *On becoming a person.* Boston, MA: Houghton Mifflin.

Royston, P. (1991). sg3.5: Comment on sg3.4 and an improved D'Agostino test. *Stata Technical Bulletin 3*, 23-24.

Ryff, C.D. (1989a). Beyond Ponce de Leon and life satisfaction: New directions in quest of successful aging. *International Journal of Behavioral Development, 12*(1), 35-55.

Ryff, C.D. (1989b). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology, 57*(6), 1069-1081.

Ryff, C.D. (2013). Eudaimonic well-being and health: Mapping consequences of self-realization. In A.S. Waterman (Ed.), *The best within us: Positive psychology perspectives on eudaimonia.* Washington, DC: American Psychological Association.

Ryff, C.D., & Keyes, C.L. (1995). The structure of psychological well-being revisited. *The Journal of Personality and Social Psychology, 69*(4), 719-727.

Ryff, C.D., Love, G.D., Urry, H.L., Muller, D., Rosenkranz, M.A., Friedman, E.M., ... Singer, B. (2006). Psychological well-being and ill-being: Do they have distinct or mirrored biological correlates? *Psychotherapy and Psychosomatics, 75*(2), 85-95.

Ryff, C.D., Radler, B.T., & Friedman, E.M. (2015). Persistent psychological well-being predicts improved self-rated health over 9-10 years: Longitudinal evidence from MIDUS. *Health Psychology Open, 2*(2), 1-11.

Ryff, C.D., Singer, B.H., & Love, G.D. (2004). Positive health: Connecting well being with biology. *Philosophical Transactions of the Royal Society B: Biological Sciences, 359*(1449), 1383-1394.

Saleh, J. (2015). Glycated hemoglobin and its spinoffs: Cardiovascular disease markers or risk factors? *World Journal of Cardiology, 7*(8), 449-453.

Sapolsky, R.M. (2004). *Why zebras don't get ulcers.* New York, NY: W.H. Freeman.

Schaefer, S.M., Boylan, J.M., van Reekum, C.M., Lapate, R.C., Norris, C.J., Ryff, C.D., & Davidson, R.J. (2013). Purpose in life predicts better emotional recovery from negative stimuli. *PLoS ONE, 8*(11), e80329. doi:10.1371/journal/pone.0080329.

Schubert, C. (2007). Psychological well-being and ill-being and their biological correlates: Additional findings from an integrative single-case study. *Psychotherapy and Psychosomatics, 76*, 252-253.

Schuett, H., Luchtefield, M., Grothusen, C., Grote, K., & Schieffer, B. (2009). How much is too much? Interleukin-6 and its signaling in atherosclerosis. *Thrombosis and Haemostasis, 102*(2), 215-222.

Segerstrom, S.C., & Miller, G.E. (2004). Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry. *Psychological Bulletin, 130*(4), 601-630.

Spielberger, C. D., Gorusch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists.

Steffen, P.R., Fidalgo, L., Schmuck, D., Tsui, Y., & Brown, T. (2014). Psychotherapy participants show increased physiological responsiveness to a lab stressor relative to matched. *Frontiers in Psychology, 5*, 1-5.

Stock, W. A., Okun, M. A., & Benin, M. (1986). Structure of subjective well-being among the elderly. *Psychology and Aging, 1*(2), 91-102.

Tsenkova, V.K., Love, G.D., Singer, B.H., & Ryff, C.D. (2007). Socioeconomic status and psychological well-being predict cross-time change in glycosylated hemoglobin in older women without diabetes. *Psychosomatic Medicine, 69*(8), 777-784.

Umetani, K., Singer, D.H., McCraty, R. & Atkinson, M. (1998). Twenty-four hour time domain heart rate variability and heart rate: Relations to age and gender over nine decades. *Journal of the American College of Cardiology, 31*(3), 593-601.

Wang, Y-P., & Gorenstein, C. (2013). Psychometric properties of the Beck Depression Inventory-II: A comprehensive review. *Revista Brasileira de Psiquiatria, 35*(4), 416-431.

Waterman, A.S. (1984). *The psychology of individualism.* New York, NY: Praeger.

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Wheeler, L.F. (2016). *Stress and psychotherapy outcome: Implementation of a heart rate variability biofeedback intervention to improve psychotherapy outcome* (Unpublished doctoral dissertation). Brigham Young University, Provo, UT.

Wiinberg, N., Høegholm, A., Christensen, H.R., Bang, L.E., Mikkelsen, K.L., Nielsen, P.E., ... Bentzon, M.W. (1995). 24-h ambulatory blood pressure in 352 normal Danish subjects, related to age and gender. *American Journal of Hypertension, 8*(10), 978-986.

Yamawaka, K., Matsunaga, A., Isowa, T., Kimura, K., Kasugai, K., Yoneda, M., ... Hideki, O. (2009). Transient responses of inflammatory cytokines in acute stress. *Biological Psychology, 82*(2009), 25-32.

# Appendix A

## Screening Questionnaire

Participant number:

Date of birth:

Are you 18-29 years of age?

Yes/No

BYU student ID number (e.g., 56-081-8585)

Date (month/day/year)

Have you ever received stress management/biofeedback services from the counseling center?

Yes/No

Have you been diagnosed with any heart disease?

Yes/No

If you answered yes to the previous question, please specify what you were diagnosed with?

Are you currently taking medications that impact your blood pressure?

Yes/No

Do you agree on being contacted through email by our research team? (i.e., appointments and practice reminders)

Please answer your email address if you answered “yes” to the previous question:

Do you agree on being contacted through text messages by our research team? (i.e., appointments and practice reminders)

Please answer your phone number if you answered “yes” to the previous question:

These questions were followed by the Outcome Questionnaire 45.2.