EXAMINING THE ROLE OF STRESS REACTIVTY AND EMOTION REGULATION ABILITY IN BEHAVIORAL AND PHYSICAL HEALTH

by

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A dissertation submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
Health Psychology

Charlotte

2018

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ABSTRACT

SARA JOAN SAGUI-HENSON. Examining the role of stress reactivity and emotion regulation ability in behavioral and physical health. (Under the direction of DR. SARA M. LEVENS)

Obesity is a serious and costly societal issue that, combined with other biobehavioral risk factors, contributes to chronic cardiometabolic illnesses. Stress reactivity is posited as a causal mechanism in the development of obesity and cardiometabolic diseases, with maladaptive outcomes associated with both high and low stress reactions. Emotion regulation ability (ERA) represents an entry point for individuals to alter their stress response, leading to reduced risk for illness. This program of research sought to understand the ways in which stress reactivity and ERA interact to influence behavioral and physical health. Study One explored the interaction between perceived stress reactivity and ERA in predicting obesity-related health outcomes. Results revealed that only those reporting higher perceived reactivity benefited from the ability to down-regulate negative emotions, as indicated by lower body mass index and Type 2 diabetes incidence. To further explore ERA in a health-context, Study Two developed a novel ERA task that assesses the up- and down-regulation of negative emotions toward obesity-related health stimuli. Study Three used this task to test whether health-focused ERA modulates the influence of perceived and physiological stress reactivity on biobehavioral health. Analyses revealed that perceived stress reactivity and ERA interacted to predict sleep quality and blood pressure. This program of research highlights the ways in which psychological, emotional, and biobehavioral health interactions can inform patient-centered and individualized approaches to medicine.

DEDICATION

My deepest appreciation goes to my parents, Bob and Liz Sagui, who always invested in my growth as a person. By supporting me through my many academic and non-academic endeavors, they instilled in me a love of learning, a curious mind, and a drive to succeed at something I'm passionate about. I would also like to thank my younger brother, Chris Sagui, who was and is my first best friend in life. He always knew I was going to become a doctor and he helped me cope throughout graduate school with countless games of Yahtzee and endless humor. I would not be here without my family's emotional, psychological, and financial support and I am most grateful for their friendship. I would like to send appreciation to my friends who listened to me and encouraged me over the last five years, including Nicole Hilaire and Hannah Peach. I would also like to thank my extended Sagui and Swank families, and my beloved four-legged supporters, Toby, Duke, Daisy, and Oreo. Finally, I would like to express immeasurable gratitude to my husband, Kenny, for being my biggest advocate. His kindness, love, patience, laughter, and friendship help me navigate through life with a smile. This career has many ups and downs and sacrifices; having him with me to celebrate my wins and help me up after my losses gave me the strength to persist. Kenny is my partner, my best friend, my stress manager, my emotion regulator, and my sunflower. I dedicate my Ph.D. to him.

ACKNOWLEDGEMENTS

I would like to acknowledge my advisor, Dr. Sara Levens, for her endless support and encouragement throughout my five years in graduate school. Early in my tenure, she adopted me as her student and has fostered my development as an independent researcher with enthusiasm, compassion, and understanding. Her positivity and commitment to her students are unparalleled and I am thrilled to consider her my colleague and friend. I would like to thank Dr. Tierney Lorenz who joined my team of mentors only one year ago but who has contributed to my development in ways suggestive of a much longer working relationship. I admire her professionalism and clarity, her willingness to invest in students, and her honesty. It has been a privilege to receive training from her. I would like to thank my committee members, including Dr. Jeanette Bennett for helping me grow into a rigorous scientist, Dr. Chuck Reeve for his contributions to my development as a teacher and my applied statistical skills, and Dr. Mike Turner for his encouragement and invaluable feedback during this process. I would also like to acknowledge the dedicated women who came before me and paved the path for me to receive equal rights to education and achieve my doctorate; I stand on their shoulders. Finally, I would like to thank Dr. Virginia Gil-Rivas and the Health Psychology Ph.D. Program, the UNCC Graduate Assistance Support Program, and the Thomas L. Reynolds Graduate Research Award for their support and financial assistance.

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CHAPTER 1: INTRODUCTION

Chronic disease development and health behavior change remain significant public health issues and challenges in healthy psychology research. Obesity-related health conditions alone are serious and costly societal issues that contribute to the leading causes of preventable death (Centers for Disease Control and Prevention [CDC], 2016b) and place a large economic burden ($147 billion in 2008) on the country's health care system (Centers for Disease Control and Prevention [CDC], 2016a, c). The medical paradigm shift from treating acute infections to managing noncommunicable chronic diseases requires patients to be more active in their health care (Mascie-Taylor & Karim, 2003), yet recent estimates suggest that only 10 – 20% of American adults engage in important healthy behaviors, such as physical activity and fruit and vegetable consumption (CDC, 2015; CDC Morbidity and Mortality Weekly Report, 2015). This gap necessitates a research approach that considers the psychological and emotional mechanisms that can enable individuals to be more active in their health and mitigate risk for chronic illness.

Stress reactivity and emotion regulation represent two important mechanisms that have been separately considered in literature investigating chronic disease development (Carver & Vargas, 2011; DeSteno, Gross, & Kubzansky, 2013); however, much less work has been dedicated to investigating the interaction of these processes. Because both constructs are highly implicated in health and wellness, the present dissertation advances the notion that the combination of these mechanisms should be considered as determinants of behavioral and physical health processes.

Theories of Stress and Health

Contemporary views of stress stem from early research by Richard Lazarus and Susan Folkman, who proposed that psychological stress occurs when a person appraises a situation, experiences negative emotions, and then perceives that situation to be threatening in ways beyond her/his coping abilities (Lazarus, 1966, 1999; Lazarus & Folkman, 1984). According to the psychological appraisal theory (Lazarus & Folkman, 1984), a threatening perception of a stressor gives rise to a multifaceted stress reaction that activates experiential, cognitive, behavioral, and physiological response systems (Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011). Reactivity to stress is posited as a causal mechanism in the promotion of health and/or the development of chronic illnesses (Carver & Vargas, 2011) and primarily influences health through two functional pathways (Carver & Vargas, 2011). The first pathway is through behavioral mechanisms, whereby stress reactivity influences an individual's engagement in unhealthy behaviors (Smith & Leon, 1992). The second is through physiological mechanisms, whereby stress reactions affect biological systems that disrupt homeostasis, leading to poor health (Cacioppo & Berntson, 2011; Sapolsky, 2004).

Individual differences in the way people react to a perceived stressor have implications for the influence of stress on health. Although many studies have demonstrated the detrimental health effects of heighted stress reactivity (e.g., Lovallo, 2015; Steptoe & Wardle, 2005), accumulating evidence suggests that diminished stress reactivity also contributes to poor states of health (e.g., Carroll, Phillips, & Lovallo, 2012; Phillips, Der, Hunt, & Carroll, 2009). Lovallo (2011) argues that stress reactivity has a normative midrange of intensity that is associated with favorable health and reduced disease risk. Furthermore, combining evidence across several investigations, Lovallo (2011) notes that both larger-than-normal and smaller-than-normal stress responses can contribute to behavioral dysregulation and pathophysiological processes, an idea that challenged long-held assumptions about stress and health. This expanded view of the influence of stress reactivity begs the question of how individuals with extreme responses on either side of the distribution might shift their reactivity to the optimal midpoint necessary to mitigate the health impact of stress. Because negative emotions arise from stressful appraisals, emotional coping styles may offer an entry point for individuals to alter their stress response.

Emotion-Focused Coping

Lazarus and Folkman (1984) have described how an individual's chosen coping style has a large impact on the experience of stress and that coping is considered a moderator of the influence of stress perceptions and reactions on behavioral and physical health (Carver & Vargas, 2011). Emotion-focused coping involves changing the way we attend to or interpret a stressful situation with the goal of reducing distressing emotions (Lazarus, 1993). Because emotions can alter stress-related behavior and physiology, regulation of them is critical to decrease the likelihood of pathogenic activation of stress responses and to increase the likelihood that adaptive behavioral responses are chosen (Sapolsky, 2007). One contemporary theory of emotion-focused stress coping is the Stress-Buffering Model of Positive Affect proposed by Pressman and Cohen (2005), which posits that positive emotions build social, psychological and physical resources to ameliorate the pathogenic behavioral and biological influences of stress on health. Although this model considers the benefit of experiencing positive emotions, it does not address the regulation of those emotions, particularly the management of distressing negative emotions that give rise to a stress reaction.

To further examine emotional coping styles in stress processes, theories of emotion regulation must be incorporated. An explanation of how and when emotions are regulated is grounded in two prominent theories proposed by James Gross. The first is the modal model of emotions, which posits that emotions unfold over time as a person attends to an emotion-inducing situation, appraises the situation in light of relevant resources, and formulates an appropriate response (see Gross, 2008, for a review). The second is the process model of emotion regulation, which builds off the modal model to suggest that after generating an emotion, an individual can use various strategies to influence the occurrence, intensity, duration, and/or expression of an emotion by targeting one of the emotion generative stages (i.e., situation, attention, appraisal, response; Gross, 2014). Although both stress reactions and negative emotion generation implicate appraisal processes, the application of emotion regulation theory to psychological stress appraisal theory is just beginning to be broached.

Troy, Wilhelm, Shallcross, and Mauss (2010) conducted one of the first studies to explore an interaction between stress and emotion regulation. They explored cognitive reappraisal ability (CRA), a theoretically distinct construct from self-reported frequency of reappraisal use and found that greater levels of CRA buffered against the detrimental influence of stressful life events on depressive symptoms. Our research lab has extended this finding to stress reactivity and physical health processes and observed an interaction pattern (Sagui & Levens, 2016) that aligned with the curvilinear stress reactivity hypothesis proposed by Lovallo (2011). Results suggested that the ability to down-regulated negative (DRN) emotions using reappraisal—which involves framing a stressful situation in a more positive way to decrease its negative emotional impact—was associated with lower body mass index and incidence of Type 2 diabetes, but only for individuals with higher perceived stress reactivity (Sagui & Levens, 2016). Based on obtained findings, we postulated that higher stress reactive individuals could use DRN reappraisal to lower their response and obtain better health. In contrast, we speculated that individuals with lower stress reactivity might benefit from a greater ability to up-regulate negative (URN) emotions to increase their response.

Stress Reactivity and Emotion Regulation

Aside from these two studies, several disparate lines of research also converge on the idea that studying DRN and URN emotion regulation and stress reactivity together is important for behavioral health promotion and disease risk reduction, making this a promising area of investigation. For example, theories of emotion regulation flexibility urge researchers to consider the context that is eliciting emotion regulation when determining which strategies are most effective in producing favorable mental and physical health (Aldao, Sheppes, & Gross, 2014). However, these theories do not consider the behavioral and physiological adaptiveness of DRN and URN emotion regulation ability (ERA) in the context of stress reactivity.

Similarly, health behavior change is thought to be an emotional process that turns into a cognitive one (Schwarzer, 2011) with the regulation of emotions enabling habitual control over the recurrent actions needed to adopt and sustain behavior change (Schwarzer, 2011). However, prominent health behavior change theories (e.g., Transtheoretical Model of Behavior Change, DiClemente & Prochaska, 1982; Theory of

Planned Behavior, Ajzen, 1991; The Health Action Process Approach, Schwarzer, 2008) largely target cognitive factors (e.g., self-efficacy, perceived control, outcome expectancies) and have yet to incorporate affect-related concepts or emotion regulatory processes (Williams & Evans, 2014). Further, no health behavior change theory currently includes any moderated mediation, which refers not only to why behavior change takes place, but also for whom change takes place in and under what circumstances (Schwarzer, 2011). Because emotion regulation interacts with stress in a unique manner for everyone, ERA has the capacity to function as a moderating variable between stress reactivity and risk factors for disease in a larger mediation model that places disease risk between stress and chronic illness, as found in Sagui and Levens (2016). The first step in utilizing ERA to clarify why and for whom behavioral change and reduced disease risk takes place in is systematically determining the contexts and regulatory strategies under which emotion regulation is associated with adaptive stress reactivity and enhanced behavioral and physical health.

Program of Research

To incorporate stress reactivity into emotion regulation research and identify ERA as a moderating variable in health behavior science, the present program of research seeks to advance understanding of the ways in which stress reactivity and ERA interact to influence behavioral and physical health. In Study One, the interaction between perceived stress reactivity and cognitive reappraisal ability (CRA) is explored in predicting body mass index and Type 2 diabetes incidence. Findings indicate that greater CRA is only beneficial for individuals with higher perceived stress reactivity (Sagui & Levens, 2016). This prompted the development of a framework in which highly stress reactive individuals presumably benefit from having greater positive ERA to lower their reactivity to an optimal level; whereas lower stress reactive individuals presumably benefit from having greater negative ERA to increase their reactivity. To test this framework, a measurement device was needed that could assess both DRN and URN ability in the context of health. Only one device existed for measuring DRN reappraisal ability (Troy et al., 2010), leaving a gap in the field for a more comprehensive measure of positively and negatively framed emotion regulation that was contextualized in a health domain. Further, no ability task had incorporated more than one regulatory strategy.

To address these gaps, Study Two ambitiously sought to develop a novel and innovative measure in the emotion regulation field to assess an individual's ability to implement DRN and URN reappraisal and distraction toward negative and threatening health stimuli. The expansion of ERA framing and the addition of the distraction strategy was not only necessary to test the overarching framework resulting from Study One, but also to broaden the field's view of strategy-frame interactions for decision making and health behavior engagement. The ERA task was developed using a two-phase development process in which a national sample of adults rated health-focused stimuli, then two separate samples completed the ERA task online (Sagui-Henson & Levens, in preparation). Results indicate that the ERA task is robust enough to measure four different types of ERA (DRN and URN reappraisal and distraction ability) and individual differences within those abilities.

After the creation of a measure that would allow a test of the posited framework, the interaction between stress reactivity and health-focused ERA needed to be examined. Therefore, Study Three utilized the ERA task and expanded upon earlier investigations to address two important limitations from Study One. First, because Study One was an initial test in a national community sample, we had to rely on self-report measures for some of our primary constructs (Sagui & Levens, 2016). Specifically, we assessed perceived stress reactivity with a well-validated scale that measures a person's perceptions of her/his responses to stressful situations. To understand if the stress reactivity-ERA interaction is unique to perceptions of stress or if it generalizes to physiological stress responding, a test of both physiological and perceived stress reactivity was needed. Second, Study One assessed self-reported height and weight and Type 2 diabetes incidence. Although these measurements are considered valid (Christian et al., 2013; Margolis et al., 2008), the question of whether stress reactivity and ERA interact to predict objective physical indicators of health had not yet been examined.

Study Three built upon these limitations and assessed the relative influence of physiological stress reactivity compared to perceived reactivity, as well as the interaction with health-focused ERA to predict objective risk factors for disease. By utilizing the ERA task and a social evaluative stress task with concurrent electrocardiography assessments, Study Three sought to measure the influence of cardiovascular stress reactivity, as well as perceived reactivity, on behavioral and physical cardiometabolic risk factors. Specifically, we assessed physical activity and sleep quality, which represent behaviors known to contribute to cardiometabolic diseases (e.g., heart disease, stroke, Type 2 diabetes). Additionally, we assessed abdominal obesity, blood pressure, cholesterol, triglycerides, and glycated hemoglobin as objective physical indicators of cardiometabolic risk by conducting an in-person study and partnering with several faculty and UNCC research labs.

Results from Study Three revealed that only perceived stress reactivity interacted with ERA interacted to predict cardiometabolic risk factors. Specifically, perceived reactivity interacted with DRN and URN reappraisal ability to predict sleep quality. The pattern of results illustrated by two moderated regression models suggested that individuals who perceive themselves to have lower stress reactivity experience higher quality sleep if they possess a greater ability to regulate their emotions to be more positive (higher DRN ability and lower URN ability). Further, perceived stress reactivity interacted with DRN reappraisal ability to predict systolic and diastolic blood pressure in a way that supports the framework posited in this dissertation. Specifically, when a person perceives her or himself to be highly stress reactive, greater DRN ability protects her/him against higher blood pressure, yet DRN ability was maladaptive for blood pressure in individuals with lower perceived reactivity. The findings from Studies One, Two, and Three highlight the importance of considering the effects of different coping strategies on multiple stress-related biobehavioral health outcomes and that interventions promoting stress management need to consider the population and tailor programs around the specific health condition. In this way, applications of the findings from basic science can be used to inform more patient-centered and individualized approaches to medicine.

CHAPTER 2: METHODOLOGICAL APPROACH

The present dissertation takes a multi-methodology approach to examine the role of stress reactivity and emotion regulation ability (ERA) in behavioral and physical health. Each study addresses an existing gap in the literature and builds on the previous investigation to create a coherent program of research. Specifically, the present series of studies broaches 1) the paucity of work investigating stress reactivity and ERA in health research, 2) the lack of a health-focused measure of ERA, and 3) the necessity of examining the interaction between these constructs in predicting behavioral and physical cardiometabolic disease risk. To begin bridging these gaps, this dissertation assesses three overarching constructs: stress reactivity, ERA, and health outcomes. By utilizing different methodological approaches for studying these constructs, a systematic investigation of the topic is built.

Study One

As a first step in testing the interaction between stress reactivity and ERA, an online cross-sectional, correlational study was conducted. This was one of the first studies to program an ERA task (specifically the cognitive reappraisal ability [CRA] task, Troy et al., 2010) on Qualtrics survey software utilizing the video streaming capabilities. Until then, much of emotion regulation research was conducted in-person, making the online administration of the CRA task in Study One a substantial methodological advance in the way emotion research is conducted. The online administration capability also meant that an ERA task could be given to a national community sample via Amazon's innovative participant recruitment platform, Mechanical Turk (MTurk). Therefore, Study One recruited a national sample to complete the CRA task (Troy et al., 2010) and a self-report assessment of stress reactivity (Perceived Stress Reactivity Scale; Schlotz et al., 2011). Two important health outcomes were also assessed that allowed for the construction of a mediation model in which stress reactivity contributed to greater body mass index (BMI), which increased a person's likelihood of being diagnosed with Type 2 diabetes. CRA was then assessed as a moderator in the relation between stress reactivity and BMI.

Results of a moderated mediation analysis indicated that only individuals with higher stress reactivity benefited from having high positive CRA by exhibiting lower BMI and Type 2 diabetes incidence. However, those with low stress reactivity did not benefit from positive CRA and demonstrated the highest BMI and Type 2 diabetes incidence of the entire sample. Prior research had shown that CRA could moderate the impact of stressful life events on mental health outcomes (Troy et al., 2010); however, this was the first research to incorporate stress reactivity and establish that this interaction could influence physical health outcomes. The next step in advancing this investigation was to explicitly test the framework developed from these findings: that highly stress reactive individuals may benefit from greater positive ERA, while lower stress reactive individuals may benefit from greater negative ERA.

Study Two

The CRA Task (Troy et al., 2010) used in Study One provided an initial test of part of the posited framework, but to assess the moderating role of ERA, an expansion of the framing conditions and the application in a health context was needed. Utilizing a two-phase task development procedure (Rottenberg, Ray, & Gross, 2007), a measure of health-focused ERA was developed (Sagui-Henson & Levens, in preparation).

Specifically, in Phase 1, our research team searched for health-focused stimuli from public media outlets and utilized video editing software to transform the media into targeted two-minute film clips depicting vignette-style stories of individuals struggling with obesity-related health conditions. These prospective stimuli were first loaded to a video hosting server, then embedded into Qualtrics. MTurk was again utilized to obtain stimuli rating data from a national community sample. Both quantitative analyses of discrete emotion ratings and an analysis of qualitative codes derived from extensive coding of participant appraisals were used to select the final stimuli, providing an additional opportunity to expand my approach and use a mixed-method analytic strategy.

In Phase 2, the final ERA task was prepared on Qualtrics and administered to two separate samples: a national community sample via MTurk and a local college sample from UNCC. This allowed us to establish proof-of-concept that the measurement of health-focused ERA was possible and determine how ERA functions in different age groups. Results from both samples suggested that the stimuli selected from Phase 1 evoked negative emotions in participants yet were nuanced in their elicitation of both positive and negative appraisals. Overall, the ERA task appears to be robust enough to measure DRN and URN reappraisal and distraction ability and is suitable to utilize for further investigation of stress reactivity and health-focused ERA.

Study Three

To fully understand the ways in which stress reactivity and ERA interact to influence health, the final study used the ERA task and expanded the assessment of stress reactivity to capture cardiovascular responses to stress. This allowed for a comparison of physiological and perceived stress reactivity in influencing health and interacting with

ERA. This study also extended the measurement of health outcomes to include behavioral and physical risk factors for cardiometabolic diseases. By addressing these limitations, Study Three sought to answer remaining questions from prior investigations, thereby building an incremental exploration of stress reactivity, ERA, and health.

Study Three represented a significant expansion of the methodologies used in Studies One and Two. A major strength of those previous projects was that they obtained national community samples as opposed to relying on college student convenience samples. However, the online approach presented unique limitations regarding participants' attentional involvement in the study and restrictions on the types of measures that could be used (i.e., self-report and behavioral measures only). Therefore, Study Three was an in-person multi-part lab study that allowed for the measurement of variables that were not possible to assess online.

Specifically, this research advanced a systematic investigation of the psychological stress and emotion regulatory processes that may reduce the development and/or progression of cardiometabolic disease. Three main objectives were proposed: 1) investigate the curvilinear relation between stress reactivity and behavioral and physical risk factors for cardiometabolic disease, 2) test a conceptual model in which health-focused ERA modulates the influence of stress reactivity to promote reduced cardiometabolic disease risk, and 3) develop a database that includes assessments of psychological, emotional, and biobehavioral health, as well as health beliefs and health-related motivation, which will allow for a larger examination of the way stress and emotions interact to influence health.

Participants were recruited from the UNCC student population, as well as faculty and staff and Charlotte community members. Stringent inclusion and exclusion criteria were utilized to increase the internal validity of the study and isolate the effects of stress reactivity and ERA, a methodological rigor that was not implemented in Study One. Eighty-nine eligible participants who were diverse in age, sex, and race/ethnicity (thereby increasing the external validity beyond that of Study One and Two) first completed Part 1, a 60-minute online survey assessing subjective stress reactivity and behavioral cardiometabolic risk factors, including physical activity and sleep quality. Then, they were scheduled for Part 2, a 2.5 hour in-person lab session where their resting blood pressure was measured, and they completed the health-focused ERA task and a social evaluative stress task. Cardiovascular stress reactivity was measured with continuous electrocardiography before, during, and after the stress task. Additionally, with generous support from two Health Psychology faculty, Drs. Bennett and Lorenz, we collected a finger stick blood sample from each participant to measure high- and low-density lipoprotein cholesterol, triglycerides and glycated hemoglobin (HbA1c).

Finally, participants were scheduled for Part 3, where they underwent a full body composition scan. A partnership with the Health Risk Assessment lab in the Kinesiology Department enabled us to utilize a dual-energy x-ray absorptiometry (DEXA) machine (the gold standard for assessing body fat percentage) to measure abdominal obesity. Coupled with the lipids and HbA1c measurements, these assessments provided objective estimates of physical cardiometabolic risk factors. Results from Study Three revealed that although stress reactivity did not have a curvilinear relation with any cardiometabolic risk factor, perceived stress reactivity interacted with ERA to predict sleep quality and systolic and diastolic blood pressure. Further, a database is being created with a larger sample size that includes assessments of psychological health and coping, emotional health, stress and experiences of trauma, physical and behavioral health, health beliefs and health-related motivation, social support, and demographic characteristics. Future analyses with this database will focus on replicating the preliminary analyses presented in this dissertation and conducting follow-up analyses to explore aspects of preliminary analyses that require clarification. Further, we will utilize the larger database to answer research questions that are beyond the scope of this dissertation that will inform our understanding of how stress, emotions, coping, and health interact.

Taken together, the findings from this program of research substantially contribute to the fields of health psychology and behavioral medicine by highlighting the impact of stress reactivity and emotion regulation on behavioral and physical health. Moreover, future research that builds from these investigations can contribute to stress management and coping interventions that can be recommended to individuals with different patterns of perceived stress reactivity, contributing to a better understanding of patient-centered and individualized approaches to medicine. Further, data collection is ongoing, and a larger database is being created that will contribute to research aimed at reducing the societal impact of obesity-related health conditions.

CHAPTER 3: COGNITIVE REAPPRAISAL ABILITY BUFFERS AGAINST THE INDIRECT EFFECTS OF PERCEIVED STRESS REACTIVITY ON TYPE 2 DIABETES

By Sara J. Sagui, M.A. and Sara M. Levens, Ph.D.

Published October 2016 in the journal *Health Psychology*

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Sagui, S. J., & Levens, S. M. (2016). Cognitive reappraisal ability buffers against the indirect effects of perceived stress reactivity on Type 2 diabetes. *Health Psychology, 35*(10), 1154-1158.
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3.1. ABSTRACT

Objective: Stress contributes to poor health outcomes; importantly, a stress reaction begins with the negative appraisal of a situation. The ability to use cognitive reappraisal, an emotion regulation strategy that involves reinterpreting an initial appraisal to change its emotional impact, could be a protective factor against the health consequences of stress reactivity. The present study investigated (1) if cognitive reappraisal ability acts as a stress-buffer against a body mass index (BMI) indicative of being overweight (≥25 kg/m²) or obese (≥30 kg/m²) and (2) if this buffering effect persists against the indirect influences of perceived stress reactivity (PSR) on type 2 diabetes. *Methods:* One hundred and fifty participants (54% female; mean age = 40.4 years old±12.4 years) completed an online cognitive reappraisal ability (CRA) task, self-report measures of PSR, height, weight, and type 2 diabetes diagnosis on Amazon's Mechanical Turk. *Results:* Results revealed that CRA significantly interacted with PSR to predict BMI, which indirectly predicted type 2 diabetes. Individuals with higher PSR and higher CRA, exhibited BMI within a normal weight range and lower incidence of type 2 diabetes. In contrast, individuals with higher PSR and lower CRA were overweight or obese with a higher incidence of type 2 diabetes. Interestingly, higher CRA was not protective in those who had lower levels of PSR. *Conclusions:* Findings from this study suggest that emotion regulation interventions can be developed to indirectly target type 2 diabetes and similar obesity-related illnesses, and that emotion regulation interventions should be tailored to the individual.

Keywords: emotion regulation; cognitive reappraisal; perceived stress reactivity; body mass index; obesity; type 2 diabetes

3.2. INTRODUCTION

Chronic psychological stress exposure has been reliably linked to increased susceptibility to illness and chronic disease development (e.g., Cohen, Janicki-Deverts, & Miller, 2007). Importantly, people vary in their response to a stressor, with individuals higher in perceived stress reactivity (PSR; i.e., the dispositional tendency to respond to a stressor) having a higher vulnerability for ill health (Cohen & Manuck, 1995; Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011). Physiological markers of health, including being overweight or obese, have been identified as pathways through which psychological stress negatively impacts the development of obesity-related chronic diseases. For example, prolonged heightened stress reactivity has been associated with increased adiposity (Sinha & Jastreboff, 2013; Steptoe & Wardle, 2005; Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011), which in turn increases an individual’s risk for developing type 2 diabetes (Bays, Chapman, & Grandy, 2007). With the prevalence of type 2 diabetes rising, it is important to consider potential buffers against the detrimental impact of stress on the development and progression of this disease.

Critically, a stress reaction begins with the negative appraisal of a situation. According to Lazarus and Folkman’s (1984) psychological appraisal theory, a person’s initial appraisal of a situation, as opposed to the objective event itself, precedes an emotion, which then triggers the physiological and behavioral stress response. Accordingly, an individual’s ability to change this initial appraisal could offer protection against the health consequences of high stress reactivity. Indeed, cognitive reappraisal, an emotion regulation (ER) strategy that involves reinterpreting an appraisal of a situation to change its emotional impact (Gross & John, 2003), has been linked with reduced stress

(Pakenham, 2005) and more adaptive cardiovascular stress responses (Denson et al., 2011; Jamieson et al., 2012). Because the use of reappraisal has the capacity to reduce negative emotions by reframing a negative event in a positive light, an individual's ability to implement reappraisal may represent their capacity to reduce their own stress response. The ability to decrease stress may benefit health through multiple pathways, including more adaptive psychophysiological stress responses (e.g., reduced allostatic load) or reduced engagement in health-compromising behaviors (e.g., poor diet and low physical activity). Thus, high reappraisal ability may offer protection against a body mass index (BMI) indicative of being overweight ($\geq$25 kg/m^2) or obese ($\geq$30 kg/m^2) and the development of type 2 diabetes.

The present study sought to investigate whether cognitive reappraisal ability (CRA) acts as a stress-buffer against BMI indicative of being overweight or obese, and whether this buffering effect persists against type 2 diabetes. We hypothesized that individual differences in CRA to down-regulate negative emotions would moderate the relation between PSR and BMI, such that individuals with higher CRA would be protected from higher BMI despite having higher levels of PSR. Further, we hypothesized that PSR would confer indirect influences on type 2 diabetes via BMI differentially for individuals with higher versus lower CRA.

3.3. METHOD

Participants

Adults in the United States were recruited via the participant recruitment website Amazon Mechanical Turk (Buhrmester, Kwang, & Gosling, 2011). Participants were excluded from analyses if they failed two task manipulation checks or had an outlier BMI value; listwise deletion yielded a final sample size of n = 150. Reported data patterns did not change when the full sample was included. Participants (54% female) were 40.38 years old (SD = 12.42) with a mean BMI of 26.81 kg/m^2 and 9.3% of the sample endorsed a type 2 diabetes diagnosis. Thus, our sample is very similar in rates of type 2 diabetes, but slightly less overweight than other community samples (American Diabetes Association, 2014; NHANES, 2014).

Procedure

Upon selecting the study on MTurk, participants were provided a link to the survey hosted on Qualtrics. Participants provided informed consent using their digital signature and were asked to complete the study in a quiet room free from distractions. Participants first completed a series of counterbalanced questionnaires, followed by the CRA task, then a final set of counterbalanced questionnaires, lasting approximately 45 minutes. Upon completion, participants were compensated with $1.75, a rate consistent with other MTurk studies.

Measures

Demographics. Participants reported their age, gender, racial/ethnic background (78% non-Hispanic White), highest level of education (43.3% completed college), and pre-tax household income (31.3% $25,000-49,999; see supplementary materials for more detail).

Perceived stress reactivity (PSR). PSR was assessed via the 23-item Perceived Stress Reactivity Scale (PSRS; Schlotz et al., 2011). The PSRS has been validated against objective assessments of stress reactivity (Schlotz, Hammerfald, Ehlert, & Gaab, 2011).

Body mass index (BMI). BMI was calculated from self-reported height and weight, which have been shown to be valid (Christian et al., 2013). Individuals who were overweight (≥25 kg/m²) or obese (≥30 kg/m²) were identified as having a high BMI.

Type 2 diabetes. Participants responded to a yes (coded as 1) or no (coded as 0) question asking if a medical doctor had ever diagnosed them with type 2 diabetes. Self-reports of type 2 diabetes diagnosis have been shown to be valid in a community sample (Margolis et al., 2008).

Cognitive reappraisal task. A modified version of an emotion regulation task (Troy, Wilhelm, Shallcross, & Mauss, 2010) was used to assess CRA. For the CRA task, participants viewed four short film clips after which they rated the greatest amount of emotion they experienced to 13 emotion prompts (e.g., sadness, fear, happiness, etc.) using a nine-point Likert scale (1 = *not at all*, 9 = *extremely*). The first clip was an emotionally neutral film depicting nature scenes, followed be three moderately sad film clips 2 minutes in length. All subjects passively watched the first sad film and this rating served as their baseline rating. During the second *or* third film clips (instruction order was counterbalanced), participants were instructed to reappraise the situation in a more positive way to decrease the emotional impact of the film. For additional task details and design aims, see Troy et al. (2010) and the supplementary materials.

Cognitive reappraisal ability and emotional reactivity scores. Post film sadness ratings were used to calculate CRA and emotional reactivity. Sadness ratings were *z*-scored for each film clip so that score differences could be compared across participants. CRA change scores were calculated by subtracting sadness ratings given after the reappraised film clip from sadness ratings given after the baseline sad film. To ensure that CRA scores were not confounded by participants' reactivity to the films, an emotional reactivity change score was calculated by subtracting sadness ratings to the neutral film clip from sadness ratings given after the baseline sad film. Higher scores indicate greater CRA/emotional reactivity.

Reappraisal use. Reappraisal use frequency was measured using the six-item cognitive reappraisal subscale from the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003).

Depressive symptoms. Depressive symptoms were assessed via the Center for Epidemiologic Studies Short Depression Scale (CES-D 10; Radloff, 1977).

Statistical Analysis

Moderated regression, probit regression and path analysis using SPSS (Version 20) tested the hypothesized moderated mediation model. Analyses controlled for age, gender, education, income, emotional reactivity, reappraisal use, and depressive symptoms (Troy et al., 2010). All variables were first transformed to z-scores, then covariates were introduced in step one, PSR and CRA in step two, and the interaction term in step three (Cohen, Cohen, West, & Aiken, 2003). To assess the extension of the stress-buffering effects to type 2 diabetes, three direct and indirect effects were calculated (Cohen et al., 2003). The direct effect of PSR on BMI was estimated as the partial regression coefficient for the impact of PSR on BMI at three levels of CRA (i.e., the simple slopes of the interaction). Probit regression was used to examine the impact of BMI on type 2 diabetes and the probit score was multiplied by each simple slope, yielding the indirect effect of PSR on type 2 diabetes via BMI at each level of CRA (Long, 1997).

3.4. RESULTS

Descriptive statistics and Pearson correlations for all focal variables are presented in Table 1. BMI and type 2 diabetes were positively correlated (Bays et al., 2007). In step one of the moderated regression, the combination of control variables explained 9% of the variance in BMI ($R^2 = .09$, $p = .051$). In step two, the individual predictors did not predict BMI beyond the first model ($\Delta R^2 = .00$, $p > .05$). This indicates that there was no overall main effect for either focal predictor. In step three, however, the interaction term ($b = -.29$, $p < .01$, 95% CI [-.45, -.12]) incrementally predicted BMI ($R^2 = .16$, $\Delta R^2 = .07$, $p < .01$) indicating that together, PSR and CRA have an interactive effect which predicted an additional 7% of the variance in BMI. The simple slopes (see Figure 1; Hayes & Matthes, 2009) revealed an interesting disordinal interaction between PSR and CRA. When an individual has lower CRA, higher PSR intuitively predicts higher BMI ($b = .27$, 95% CI [.19, .35]); however, when CRA is higher, higher PSR predicts *lower* BMI ($b = -.29$, 95% CI [-.38, -.20]). In other words, CRA acts as a buffer against the negative influence of higher PSR. Interestingly, those with lower levels of PSR yet high CRA exhibited the highest BMI, falling in the clinically obese range. This pattern of findings indicates that high CRA is protective against the detrimental impact of *higher* PSR on BMI; however, the ability to cognitively reappraise appears to be harmful when PSR is lower.

Table 1
Descriptive Statistics and Zero-order Correlations Among Focal Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7
1. Emotional Reactivity	.14	1.35	--						
2. Reappraisal Use	29.89	7.45	-.02	(.91)					
3. Depressive Symptoms	8.01	6.82	-.01	-.34*	(.89)				
4. PSR	20.57	10.64	.12	-.35*	.70*	(.93)			
5. CRA	-.02	.94	.32*	.14	-.15	-.14	--		
6. BMI	26.81	7.11	.03	-.05	.07	.02	.03	--	
7. Type 2 Diabetes	.093		.13	-.03	-.01	.03	-.01	.35*	--

Note. $n = 150$. $^{*}p < .001$. PSR = Perceived Stress Reactivity. CRA = Cognitive Reappraisal Ability. BMI = Body Mass Index. Mean of Type 2 Diabetes represents the proportion of individuals who indicated they had been diagnosed with this disease. Internal consistency reliabilities are listed in the diagonal where appropriate.

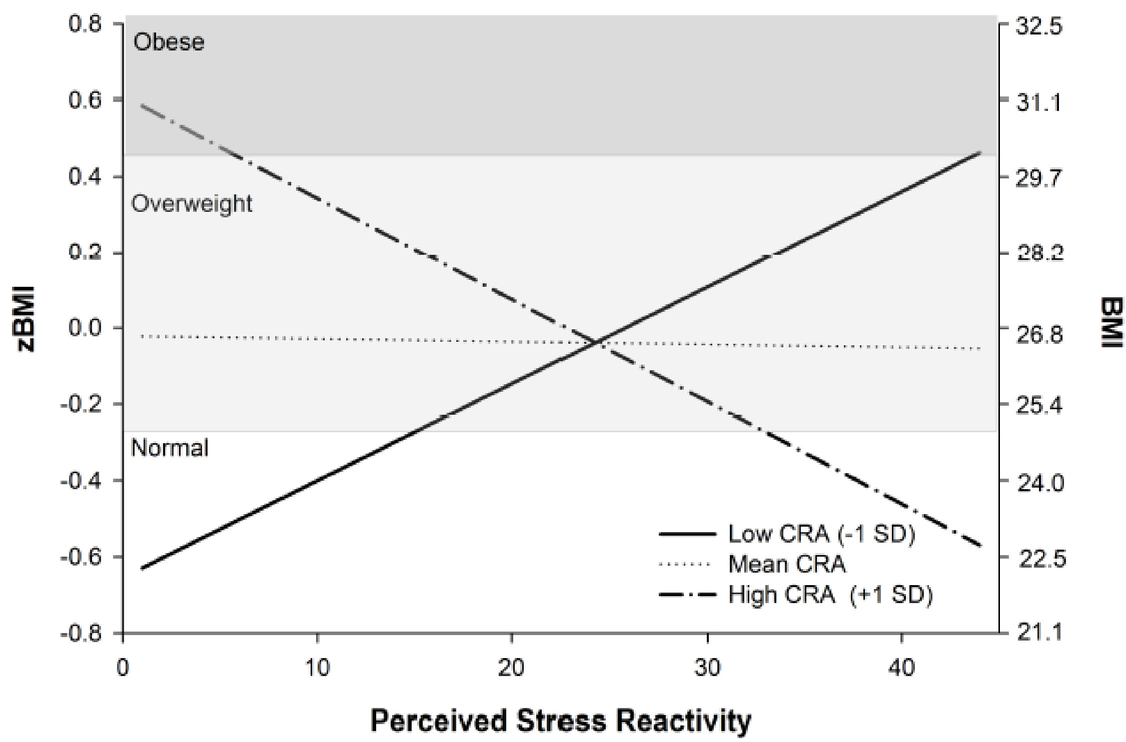

Figure 1. Interactive effect of perceived stress reactivity and cognitive reappraisal ability (CRA) on body mass index (BMI). Analyses controlled for age, gender, education, income, emotional reactivity, reappraisal use, and depressive symptoms. The analyses used the full range of PSR and CRA as continuous variables. For illustrative purposes, CRA levels were graphed using +/- 1 standard deviation from the mean. The simple slopes representing those with low (-1 SD, $b = .27$) and high (+1 SD, $b = -.29$) CRA levels yielded confidence internals that exclude zero and are statistically significant.

Evidence of moderation implied the mediated effects would be moderated as well (i.e., the indirect effect will change at different levels of CRA). The direct effects of PSR on BMI were calculated as the three simple slopes from the moderation. These were multiplied by the probit score from the latter half of the model, which indicated that a 1 SD increase in BMI predicted a .54 SD increase in the probit score of type 2 diabetes ($p < .01$; see Table 2). Accordingly, at low levels of CRA, PSR was related to an increase in type 2 diabetes incidence, whereas at high levels of CRA, PSR was related to a decrease in type 2 diabetes incidence.

Table 2

Summary of Effects (Standardized Units) for the Moderated Mediation Model

	Outcomes	
Predictors	BMI	T2DM
Perceived Stress Reactivity		
Direct Effect		
At High CRA	-.29*	--
At Average CRA	-.01	--
At Low CRA	.27*	--
Indirect Effect		
At High CRA	--	-.16
At Average CRA	--	-.01
At Low CRA	--	.15
BMI		
Direct Effect	--	.54**
Indirect Effect	--	--

Note. $n = 150$. *$p < .05$. **$p < .01$. CRA = Cognitive Reappraisal Ability. BMI = Body Mass Index. T2DM = Type 2 Diabetes. The simple slopes at higher and lower CRA levels yielded confidence internals that exclude zero and are statistically significant.

3.5. DISCUSSION

The present study investigated if higher CRA acts as a buffer against the pathogenic influence of higher PSR on BMI and if this buffering effect persists to type 2 diabetes. Both of our hypotheses were confirmed—when a person perceives her or himself to be highly stress reactive, greater CRA levels protects her/him against higher BMI. Moreover, the buffering effect of CRA extended to a chronic disease outcome, whereby having higher CRA mitigated the influence of higher PSR on type 2 diabetes. While cognitive reappraisal has been linked with better psychological health (Gross & John, 2003), this is the first study to show a relationship between reappraisal ability, BMI, and type 2 diabetes. Individuals with higher PSR and CRA experienced an estimated 7.5 kg/m^2 reduction in BMI, placing them in a normal weight range, compared to those with higher PSR and low CRA, who approached an obese weight range. This finding suggests that reappraisal interventions can be developed to help highly reactive individuals reduce their stress and subsequently enhance their physical health.

Interestingly, while the findings confirmed our hypothesis regarding the stress buffering effects of CRA, the observed interaction illustrates a critical finding regarding the contextual nature of reappraisal. In contrast to the decrease in weight observed in individuals with higher PSR and CRA, we found that individuals with *lower* PSR and higher CRA experienced an estimated 8.7 kg/m^2 *increase* in BMI, placing them within the obese weight range. Negative stress reactions motivate behavioral change (Ekman, 1993). We speculate that individuals who have higher reappraisal ability and lower stress reactivity may be using reappraisal to down-regulate already low negative emotions. This detrimental reduction in their stress response removes the motivation to engage in healthier behavior, which then leads to clinically higher BMI and greater incidence of type 2 diabetes.

Although the present study substantially contributes to our understanding of the relation between PSR, emotion regulation (ER) and health, future research should verify the current findings using emotions other than sadness as well as non-self-report measures (e.g., psychosocial stress testing with physiological assessments, waist circumference, and fasting plasma glucose to assess type 2 diabetes risk and diagnosis). Future research should also assess the mechanisms through which CRA interacts with PSR to affect BMI (such as diet) and include assessments over time to examine whether adaptive ER promotes positive physical health outcomes and buffers against obesity-related outcomes as a function of stress reactivity.

Despite noted limitations, the present results contribute to the burgeoning research on the stress-buffering effects of ER on physical health processes. Reappraisal may have the potential to help protect against obesity and the development of type 2 diabetes in individuals who perceive themselves to be highly stress reactive. Conversely, reappraisal may be maladaptive for promoting health behaviors in those who are low stress reactive as it decreases stress reactivity below optimal levels hindering the motivation to engage in behavioral change. This pattern of findings supports current research on ER flexibility and suggests a potential clinical application of adaptive cognitive reappraisal as a function of PSR level for weight management. While the way we regulate our emotions represents one coping strategy that likely interacts with and influences other coping processes, the current findings advance our understanding of the role ER plays in the relationship between PSR and health and highlight how adaptive cognitive reappraisal has the capacity to buffer against obesity-related health outcomes.

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CHAPTER 4: CONSIDERING CONTEXT: THE DEVELOPMENT OF A HEALTH-FOCUSED MEASURE OF EMOTION REGULATION ABILITY

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Planning to submit to the American Psychological Association journal *Emotion*.

4.1. ABSTRACT

Objective: Emotion regulation is thought to be part of a larger self-regulatory system that generates flexible responses to events, enabling the pursuit of personal goals across a variety of contexts. One context where up- and down-regulating emotions may be especially important is the self-regulation of health. Researchers have yet to consider the influence of emotion regulation ability (ERA) in behavioral and physical health processes, and no measure currently exists to assess ERA in the context of health. To address this, two studies were conducted to develop a measure of health-focused ERA. *Method*: Study 1 included stimuli development and a pilot test of prospective stimuli to collect rating data from a national community sample (n = 116). Study 2 involved preparing the task on an online platform and administering it to a national community sample (n = 235) and local college sample (n = 199). *Results*: Results suggest that the stimuli selected evoked negative emotions from participants yet were also nuanced in their elicitation of both negative and positive appraisals. Further, the ERA task appears to be robust enough to measure several different types of emotion regulatory ability (up- and down-regulation of positive and negative emotions using reappraisal and distraction) and individual differences within those abilities. *Conclusion*: This study advances emotion and health literature by developing a novel ERA paradigm that assesses multiple emotion regulation strategies using health-related stimuli. Future research can utilize this paradigm to investigate how ERA may influence physical and behavioral health outcomes and health-specific motivation to engage in behavior change.

Keywords: emotion regulation; health; weight management; task development

4.2. INTRODUCTION

Emotions play a considerable role in directing attention, informing decisions, and guiding behavior (Gross, 2014). Although emotions are often helpful (e.g., facilitating social interaction), they can also facilitate unhealthy behavior (e.g., reward-driven eating) in some situations. Thus, emotions, both positive and negative, require active management, or regulation, to achieve certain goals or outcomes. Emotion regulation involves the use of various strategies to influence the occurrence, intensity, duration, and/or expression of an emotion (Gross, 2014) and is thought to be part of a larger self-regulatory system that generates flexible responses to events, enabling the pursuit of personal goals across a variety of contexts (Mennin & Fresco, 2014). In some situations, increasing the intensity or duration of an emotion may be necessary to achieve a desired outcome ("up-regulating"), while in others, reducing an emotion is more adaptive ("down-regulating").

One context where up- and down-regulating emotions may be especially important is self-health care. Health-related situations can generate negative emotions for individuals struggling to manage their health and some patients may find themselves unable to cope with the emotional demands. For example, imagine a man's general practitioner runs a routine cardiovascular check and tells him that his blood pressure is too high and that his risk for cardiovascular disease is elevated. The man's reactions to this information could be variable—the negative emotions surrounding this situation may be overwhelming, leading to a paralyzed state of inaction, or, he may not grasp the severity of the situation, experience a low level of negative emotion, and view the information as just a transient cholesterol level that does not require behavioral change.

These two types of emotional reactions to health information necessitate different emotion regulatory techniques to facilitate an adaptive health behavior response.

Engaging in health promoting behaviors, such as a healthy diet and exercise, contributes to a reduction in all-cause mortality (Ford, Zhao, Tsai, & Li, 2011; Khaw et al., 2008); yet, many individuals struggle to engage in health-promoting behaviors that confer salutary benefits. For example, recent estimates suggest that only 10 – 20% of American adults engage in the recommended amounts of physical activity and fruit and vegetable consumption (Centers for Disease Control and Prevention [CDC], 2015; CDC Morbidity and Mortality Weekly Report, 2015). A person's ability to regulate emotions surrounding health-related situations could be an entry point for intervention to improve health behavior engagement and reduce disease risk. Affective science has considerable applicability in the field of behavior change (DeSteno, Gross, & Kubzansky, 2013), yet there has been limited work exploring emotion regulation in the context of weight-related health and health behaviors.

Emotion-focused coping has been studied in the context of psychological stress and health (Lazarus & Folkman, 1984), but this work has not considered the management of specific emotions in a health-focused context. Further, health behavior change theories typically target cognitive factors, such as self-efficacy (DiClemente & Prochaska, 1982), perceived control (Ajzen, 1991), and outcome expectancies (Schwarzer, 2008), despite the idea that health behavior change is largely an emotional process that turns into a cognitive one (Schwarzer, 2011). Importantly, emotion regulation may enable habitual control over the recurrent actions needed to adopt and sustain behavior change (Schwarzer, 2011).

Because there is a paucity of research examining health-focused emotion regulation, adequate measures of this construct are lacking. Several self-report instruments have been developed to explore emotion regulation in general (e.g., Emotion Regulation Questionnaire, Gross & John, 2003; Cognitive Emotion Regulation Questionnaire, Garnefski & Kraaji, 2007), as well as emotion-focused coping in the context of stress (e.g., Ways of Coping Scale, Folkman & Lazarus, 1980; and COPE Inventory, Carver, Scheier, & Weintraud, 1989). Although these instruments have greatly expanded our understanding of emotion regulation, their self-report nature can be subject to biases (Feldman Barrett, 1997) and they do not assess emotional regulation of health-related information. Further, in the context of health, the self-reported frequency of using an emotion regulation strategy may be less relevant than the efficacy associated with implementing a certain strategy.

To address this, Troy, Willhelm, Shallcross, and Mauss (2010) developed a measure of cognitive reappraisal ability (CRA) that assesses a person's efficacy to reframe a negative situation in a more positive way to down-regulate sad emotions. During the CRA task, participants watch a baseline film and rate their level of sadness, then are asked to implement reappraisal during the next film and again rate their sadness. The films depict an interpersonal relationship conflict and were pretested to induce sad emotions. A strength of this measure is its ability to capture the amount of emotion a participant is able change using reappraisal, with higher CRA scores indicating greater efficacy. However, the regulation of sad emotions may be less relevant for studying health behavior change and the CRA task only focuses on one strategy (reappraisal) and one framing of that strategy (down-regulating negative emotions).

To assess the influence of emotion regulation in health processes, an objective measure of health-focused emotion regulation ability (ERA) is needed. Because there are individual differences in the way people react to threatening information, such as potential negative health consequences (Ditto, Jemmott, & Darley, 1988; Ditto & Lopez, 1992), this measure should have the capacity to assess one's ability to up- and down-regulate positive and negative emotion. Relating to the scenario above, individuals who experience exaggerated negative emotions in response to threatening health information may benefit from a greater ability to down-regulate negative emotion, or up-regulate positive emotion. In contrast, individuals who experience diminished negative emotions in response to threatening self-relevant health information may benefit from a heightened ability to up-regulate negative emotion, or down-regulate positive emotion. Although typically considered maladaptive, the inclusion of conditions that assess the up-regulation of negative emotion will allow researchers to assess if this ability is beneficial in motivating people who are not inclined to engage in healthy behavior, an aspect of health promotion that remains a significant challenge to practitioners (Hardcastle et al., 2015). Finally, recent research on emotion regulation flexibility highlights the notion that different regulatory techniques may be beneficial for different people (Aldao, Sheppes, & Gross, 2015), and a measure of health-focused ERA should capture this interaction.

In addition to the need to address both the up- and down-regulation of emotion in emotion regulation research, no task measuring ability has incorporated more than one strategy. According to the process model of emotion regulation (Gross, 2014), the management of emotions can occur at five different emotion generative stages, with antecedent-focused strategies (i.e., those that are employed before emotional responses become fully activated) considered more effective in producing long-term benefits (Gross & John, 2003). Distraction and reappraisal are two antecedent-focused strategies that target the attention and appraisal stages of emotion generation, respectively (Gross, 2014), and both are useful in a health context (e.g., Iwasaki, 2006; Siep et al., 2012; Sagui & Levens, 2016).

Distraction involves disengaging from an emotion-eliciting stimulus by refocusing attention to a different stimulus (Ochsner & Gross, 2005). For example, when confronted with unhealthy blood work at a doctor's visit, an individual may think about an enjoyable hobby to get one's mind off it (up-regulate positive (URP) emotions using distraction). Or, to generate motivation for change, the individual may think about a family member who passed away from heart disease (up-regulate negative (URN) emotions using distraction). In contrast, reappraisal involves reinterpreting the initial appraisal of an event to alter its emotional impact (Gross, 2014; Gross & John, 2003). For example, after receiving a discouraging diagnosis of prediabetes, one could use URP reappraisal to increase positive emotions and view this news as an opportunity to get healthier, rather than as a negative judgment of one's lifestyle. Alternately, if the individual has been aware of her health for some time but has done nothing about it, URN reappraisal aimed at highlighting the negative consequences of inaction might motivate her to finally make a necessary behavior change. Assessing the ability to up- and down-regulate emotions using reappraisal and distraction may therefore provide a more comprehensive view of health-focused ERA and allow for examination of interactions among strategy, regulation direction, and type of emotions within a health domain.

The Present Study

To address a significant gap in the literature, the present study developed a health-focused ERA task to assess one's ability to URP and URN emotions using reappraisal and distraction in the context of health and weight management. The task was designed to assess two reappraisal strategies and two distraction strategies. URP reappraisal refers to *reframing a negative situation* in a more positive way to increase its positive emotional impact, while URN reappraisal involves *reframing a negative situation* in a more negative way to increase its negative impact. Regarding distraction strategies, URP distraction consists of disengaging from a negative emotion-eliciting stimulus by *refocusing attention* to a positive stimulus with the goal of increasing positive emotions. URN distraction involves disengaging from a negative emotion-eliciting stimulus by *refocusing attention* to a negative stimulus with the goal of increasing negative emotions.

The computer-based ERA task utilizes negative health-related film clips and subjective emotion ratings to measure individual differences in participants' ERA. Film clips were chosen over other procedures (e.g., still photos) because they are considered more ecologically valid and can be standardized, which eliminates confounds associated with recall procedures (Rottenberg, Ray, & Gross, 2007). Also, films are high in attentional capture with low levels of demand and can elicit emotions of greater strength more ethically than other procedures (Rottenberg et al., 2007). Briefly, the task consists of six film clips: one neutral clip to induce a neutral mood at the beginning of the task, and five negative health-related film clips. Participants are instructed to passively watch the first health film and the subsequent emotion ratings serve as the participants' baseline positive and negative emotions. During the following four health films, participants are instructed to implement each of the four emotion regulation strategies to manage their emotions. ERA scores are assessed by calculating the difference in positive or negative emotions from baseline to each strategy and regulation direction combination, with higher scores indicating a greater ability to utilize that strategy.

Standard procedures suggested by Rottenberg and colleagues (2007) for developing an emotion-eliciting paradigm using films were followed. In Study 1, the ERA task was developed through a stimuli selection process and pilot test of prospective stimuli to collect rating data from a national community sample. Analyses of discrete emotion ratings and qualitatively coded appraisal statements were used to select the final stimuli. Study 2 included preparation of the task on an online platform and administration of the task in a national community sample and local college sample.

4.3. STUDY 1: TASK DEVELOPMENT

4.3.1. Method

Stimuli Development

Inclusion and exclusion criteria. To be included in the ERA task, stimuli were principally required to generate negative emotions and appraisals that participants will regulate via four strategies. To successfully infer that observed condition effects are due to emotion rather than film differences, stimuli inclusion criteria was specified so that films were matched on several potentially confounding characteristics. Primary inclusion criteria included length of film clip, emotional intensity, and core themes (Rottenberg et al., 2007). Accordingly, each prospective film needed to be approximately two and a half minutes long (150 s), induce moderate amounts of negative emotion on average (for greater ecological validity and to reduce ceiling and floor effects; Rottenberg et al., 2007), and depict health-related content. Health content was defined as a situation involving one or more persons engaging in negative, weight-related health behaviors (e.g., sedentary behavior, poor eating habits), suffering from a negative weight-related physical health condition (e.g., obesity, cardiovascular disease), or receiving a negative physical health diagnosis (e.g., Type 2 diabetes diagnosis). Secondary inclusion criteria included stimuli that featured a main character over the age of 18 years old and had a vignette-style portrayal of the character's story to increase the relevance of stimuli and likelihood of capturing individual differences in illness threat appraisals (Ditto, Jemmott, & Darley, 1988; Ditto & Lopez, 1992). Exclusion criteria included health advertisements and public service announcements, films with individuals who had morbid obesity, and videos that depicted health behavior content that was not weight-related (e.g., smoking).

Stimuli searches. Undergraduate research assistants trained on stimuli inclusion and exclusion criteria searched for applicable films on websites, such as Google and YouTube, using relevant key words, such as obesity, Type 2 diabetes, unhealthy eating, and weight loss. These searches yielded approximately 20 longer films ranging in length from 5 to 90 minutes. These films were reviewed and edited to create 15 shorter film clips that followed an individual's personal weight-related story. Three of these film clips were dropped because of sound quality issues or insufficient content to create a video near or over the 2-minute length requirement. Twelve films were retained that met the inclusion and exclusion criteria and had the best sound and video quality. The films were first loaded onto Vimeo video hosting server, then embedded into an online survey using HTML code in Qualtrics software.

Pilot Testing

Participants. Stimuli rating was completed by a national community sample of 116 adults through Amazon Mechanical Turk (MTurk), an online participant recruitment website that is open to a national population (Buhrmester, Kwang, & Gosling, 2011). Participants were required to be 18 years of age or older, fluent in English, and living in the United States. They were compensated with $5.00 for completing the study, a rate consistent with other MTurk behavioral studies of similar length and difficulty at the time this study was conducted. A similar task measuring cognitive reappraisal ability (Troy et al., 2010) has been successfully implemented on this online platform in previous research (Sagui & Levens, 2016). Participants were, on average, 37 years old (*SD* = 11.94 years) and 64% identified as female. Of the participants, 73.3% identified as non-Hispanic

White, 8.6% identified as non-Hispanic African American, 9.5% identified as Hispanic or Latino(a) origin, 5.2% identified as Asian American, and 3.5% identified as ‘other’.

Procedure. After participants reviewed the study information and compensation rates provided on the MTurk recruitment page, they were directed to the survey on Qualtrics. Informed consent was obtained with an electronic signature and participants were asked to complete the study in a quiet room free from distractions. Participants first completed a series of randomly presented questionnaires. These included measures of psychological, physical and behavioral health; however, these measures were not included in stimuli selection analyses, so they are not reported here. Next, participants viewed the video instructions and a 2-minute emotionally neutral film clip (Troy et al., 2010), then watched all 12 videos (presented randomly).

After each film clip, participants completed the post-film questionnaire. The amount of time spent watching each video was also recorded and used as an additional attention check. Upon completing the task, demographic information was assessed, including age, gender, country of residence, race/ethnicity, marital status, educational background, and income. Finally, participants were debriefed and given the opportunity to comment on any video or survey issues before completing the survey and receiving their completion code. On average, the entire experimental session was completed in approximately 1 hour, and the stimuli rating task was completed in approximately 40 minutes. Institutional Review Board approval was obtained prior to data collection.

Measures.

Prospective task stimuli. The 12 prospective task films ranged in length from 1 minute 54 seconds to 2 minutes 45 seconds and were selected to induce moderate amounts of negative emotion yet be nuanced enough to elicit both positive and negative appraisals from participants (i.e., have the potential for positive and negative emotions to be up- and down-regulated). Each film depicted at least one character who was overweight or obese; films 3, 7 and 9 included more than one overweight character. All characters were struggling with weight management and/or an obesity-related illness and were diverse in age and race/ethnicity.

Post-film questionnaire. After each video, participants responded to a series of questions assessing their emotions, thoughts and attention during the film. While responding to the post-film questionnaire, participants were instructed to reflect on how they felt while watching the previous film clip. Participants first rated the greatest amount of 11 discrete emotions they experienced, including 4 positive emotions (amusement, happiness, joy, and love) and 7 negative emotions (anger, anxiety, disgust, fear, guilt, sadness, and shame) (Rottenberg et al., 2007; Troy et al., 2010). Discrete emotions were rated on a 9-point Likert scale (1 = *Not at all/None*, 5 = *Somewhat/Some*, 9 = *Extremely/A great deal*). Next, an attention check question was presented about the film’s content. Finally, participants responded to three open-ended qualitative questions that asked about their general appraisals of the film and the ways in which they positively and negatively appraised the film.

Data analysis. Before beginning analyses, the data were cleaned, and participants’ emotion ratings and qualitative statements were dropped (*M* number of ratings dropped per video = 17.38 ratings; range = 5-28 ratings) if they did not pass the two attention checks. Attention checks included providing correct responses to questions about the film’s content and staying on the video page for 75% of the duration of the neutral film and 100% of the duration of all twelve prospective film clips. According to standard analytic procedures (Rottenberg et al., 2007) and the specific needs related to our task development, we used a three-step process to analyze the stimuli rating data and select the final stimuli. Step 1 involved analyzing the discrete emotion ratings from each film to reduce the pool of stimuli, Step 2 involved coding the qualitative stimuli appraisals from the reduced pool, and Step 3 involved analyzing the qualitative codes to select the final stimuli.

Step 1. The discrete emotion ratings reported after viewing each film were used to create average positive composite and negative composite scores. Negative composite scores were derived by averaging the ratings for the 7 negative emotions and positive composite scores were derived by averaging the ratings for the 4 positive emotions. Difference scores were also calculated by subtracting the negative composite from the positive composite for each video. Composite scores were examined against the metrics of *intensity* and *discreteness*. Intensity refers to, “whether a film receives a high mean report on the target emotion relative to other candidate films,” and discreteness refers to, “the degree to which participants report feeling the target emotion more intensely than all nontargeted emotions,” (Rottenberg et al., 2007, p. 18). Composite discrete emotion ratings were reviewed against these metrics and film clips were retained for qualitative coding that demonstrated both the highest negative composite ratings (intensity) and the greatest differences between negative and positive composite ratings (discreteness).

Step 2. Next, a time-intensive, line-by-line coding system was created from participants’ qualitative responses to the stimuli to assess if prospective stimuli were capable of eliciting positive and negative appraisals. A qualitative coding manual was developed that detailed the coding instructions and six undergraduate research assistants (RAs) were trained on coding procedures, including how to code the number of positive or negative phrases (depending on which valance they were coding for) and the overall quality of the statement on a 5-point Likert scale (1 = *Poor Quality*, 5 = *Excellent Quality*) based on several indicators (e.g., depth, specificity, engagement). After training, the RAs were split into two groups of three RAs and given a preliminary round of 20 statements (10 negative, 10 positive) to code. After coding sheets were returned, the intra-class correlation (ICC) for each RA was calculated to check inter-rater reliability with their group members. When reliability was not reached, the RA was provided with individualized feedback on discrepant codes.

After two rounds of preliminary coding, all six coders reached a minimum of 80% reliability with their group members. Coders were given their final statements, where they coded the number and quality of each participant's response. There was a total of 1,384 qualitative statements, with half of the statements assigned to the first group and half assigned to the other group. Thus, each coder was given approximately 692 statements to code. Final coding submissions were gathered, and the ICC was calculated for the number, quality and composite (product of number and quality) ratings in each group, which ranged from .86-.93 in group 1 and .86-.89 in group 2.

Step 3. The qualitative codes were used to determine which stimuli had comparable potential to be negatively and positively reappraised. The number and quality metrics rated by the coders were used to develop a negative and positive composite score that combined the number and quality codes together for each prospective film clip. Difference scores were again calculated by subtracting the negative composite score from the positive composite score for each video. Because the goal was to select films with the potential to be positively or negatively reappraised or distracted from, films needed to have comparable positive and negative composite scores (i.e., difference scores close to zero). Further, the films needed to be principally negative emotion inducing; thus, if the difference scores diverged from zero, films were chosen that had slightly more negative than positive appraisals (i.e., positive difference scores). Therefore, five films were retained that demonstrated composite different scores that were close to zero or in the positive direction (i.e., elicited slightly more negative appraisals than positive appraisals).

4.3.2. Results

Discrete Emotion Ratings

Discrete emotion rating means, standard deviations, and difference scores are presented in Table 3. Regarding intensity, the average negative composite emotion rating across all 12 prospective film clips was 3.15 (range 2.77 – 3.73), while the average positive composite emotion rating was 1.60 (range 1.37 – 1.80). Regarding discreteness, the difference scores ranged from 1.08 – 2.37, indicating that all prospective stimuli engendered more negative than positive discrete emotions. An initial reduction of stimuli was performed with the discrete emotion ratings, resulting in the retention of seven film clips for qualitative coding that demonstrated the greatest intensity and discreteness.

Table 3
Study 1 Discrete Emotion Ratings and Qualitative Appraisal Codes

	Discrete Emotion Ratings					Qualitative Appraisal Codes		
	Composite NE Ratings		Composite PE Ratings		Mean Difference Scores	Composite Negative Codes	Composite Positive Codes	Mean Difference Scores
Videos	*M*	*SD*	*M*	*SD*		*M*	*M*	
Neutral	1.24	.07	4.83	.86	-3.59			
1[a,b]	3.25	1.15	1.63	.31	1.62	4.34	3.42	.92
2	3.02	1.49	1.71	.30	1.31			
3[a,b]	3.08	.89	1.46	.15	1.62	4.02	3.58	.43
4	2.99	1.12	1.55	.19	1.43			
5	2.87	.97	1.75	.17	1.12			
6[a,b]	3.09	1.31	1.38	.22	1.71	4.58	2.97	1.62
7[a,b]	3.14	.97	1.63	.26	1.51	4.16	4.00	.15
8[a,b]	3.73	1.23	1.37	.10	2.37	3.70	2.72	.97
9[a]	3.19	1.16	1.47	.19	1.72	3.28	4.00	-.72
10	2.77	1.12	1.69	.28	1.08			
11[a]	3.51	1.30	1.80	.37	1.71	3.19	4.74	-1.56
12	3.13	1.41	1.80	.41	1.33			

Note. n = 116. NE = Negative emotion; PE = Positive Emotion; *M* = Mean; *SD* = Standard deviation. [a] denotes films that were retained for qualitative coding; [b] denotes films that were retained for the final Emotion Regulation Ability Task.

Qualitative Codes

Qualitative appraisal code composite means and difference scores are presented in Table 3. The range for number ratings of negative statements was 1.37 – 2.05 (M = 1.70, SD = .26) and for number ratings of positive statements was 1.25 – 1.99 (M = 1.53, SD = .25). The range for quality ratings of negative statements was 1.97 – 2.16 (M = 2.05, SD = .07) and for quality ratings of positive statements was 1.89 – 2.22 (M = 2.05, SD = .18). The average composite score for negative statements was 3.90 (range 3.19 – 4.58), while the average composite score for positive statements was 3.63 (range 2.72 – 4.74). Composite mean difference scores ranged from -1.56 – 1.62. Five film clips that had composite mean difference scores close to zero or slightly in the positive direction were retained for the final ERA task. Therefore, the final stimuli had either comparable elicitation of positive and negative appraisals (i.e., difference scores near zero), or slightly more elicitation of negative appraisals (i.e., positive difference scores).

4.3.3. Discussion

In Study 1, prospective stimuli were developed and pilot tested within a national community sample. To select the final task stimuli, a three-step data analysis process was used to examine discrete emotion ratings and qualitative appraisals. Overall, the films yielded reasonable discrete emotion rating means and standard deviations from both samples, indicating the videos were not too extreme and that responses sufficiently varied. Average composite emotion ratings from Step 1 demonstrated that the videos elicited moderate amounts of negative emotions and that, on average, participants rated the films as more negative than positive. After examining the discrete emotion ratings in the initial pool of 12 films against intensity and discreteness metrics, seven films were retained that demonstrated the highest negative ratings and greatest difference between positive and negative ratings. These films were then examined for their potential to elicit both positive and negative appraisals.

Training for the qualitative coding yielded high inter-rater reliability, indicating stability in the coding of qualitative statements among group members. Qualitative codes generated by the coders yielded reasonable means for positive and negative number and quality statements across participants. Regarding the number of positive or negative appraisals, participants, on average, responded with slightly more negative statements than positive across the films. These findings were expected given that the clips were selected for their ability to induce negative emotions. Regarding the quality of statements, participants, on average, generated appraisals of comparable quality when asked to consider the negative and positive aspects of the films. This indicates that the stimuli were complex enough to elicit both positive and negative evaluations.

To be included in the ERA task, stimuli are principally required to generate negative emotions and appraisals that participants will regulate via four strategies. Two films demonstrated a negative difference score between negative and positive composite qualitative codes, indicating that participants generated more positive than negative thoughts about the stimuli. Thus, those two films were dropped, and five films were retained for inclusion in the ERA task that demonstrated a positive difference score. Taken together, Study 1 demonstrated sufficient video-level quantitative and qualitative analyses to retain the final five films for the ERA task.

4.4. STUDY 2: TASK PREPARATION AND ADMINISTRATION

4.4.1. Method

ERA Task Preparation

The ERA task was prepared using Qualtrics survey software and Vimeo video hosting server. A similar task measuring cognitive reappraisal ability has been successfully administered online using these platforms (see Sagui & Levens, 2016). We selected Vimeo.com to host the final five ERA videos for two reasons: 1) although Qualtrics supports the uploading of most video files directly into the survey, respondents may not have a related browser plug-in installed necessary to view the media; thus, uploading media to a hosting server, such as Vimeo, dynamically loads the appropriate version of a video file that will work on any device or browser the respondent is using, ensuring the widest compatibility; and 2) Vimeo is add-free, has robust privacy settings, and easily interfaces with Qualtrics via embedding code. After the videos were loaded to Vimeo and adjusted for size and quality, an embedded link was obtained from the hosting server and inserted into the Qualtrics survey via HTML source code. Emotion ratings and the post-film questionnaire were then built around each video in Qualtrics. Additionally, survey flow coding within Qualtrics software allowed us to present the videos in the same order while randomizing the presentation of emotion regulation instructions.

ERA Task Administration

Participants.

Sample 1: National Community Sample. The ERA task was completed by a national community sample of adults through Amazon's MTurk (Buhrmester et al., 2011). Participants were required to be 18 years of age or older, fluent in English and living in the United States. Participants were excluded from analyses using listwise deletion if they failed the two attention checks for the ERA task (see Measures section), reducing the initial sample of *n* = 235 by 81 participants and yielding a final sample size of *n* = 154. This reported decrease in sample size due to quality control measures is common for behavioral MTurk studies with a similar design (Sagui & Levens, 2016). Participants were, on average, 37.42 years old (*SD* = 11.53 years) and 59.7% identified as female. Of the participants, 72.7% identified as non-Hispanic White, 5.8% identified as Hispanic White, 8.4% identified as non-Hispanic African American, 6.5% identified as non-Hispanic Asian American, 3.9% identified as bi-racial or multi-racial, and 2.6% identified as 'other'. The average BMI of this sample was 28.12 kg/m^2 (*SD* = 8.23 kg/m^2).

Sample 2: Local College Sample. The ERA task was also completed by a local college sample recruited through a large undergraduate psychology course with instructor permission. Participation was restricted to individuals 18 years of age or older, fluent in English, and currently enrolled as an undergraduate at the university. Participants were excluded from analyses using listwise deletion if they failed the two attention checks, reducing the initial sample of *n* = 209 by 109 participants and yielding a final sample size of *n* = 100. Participants were, on average, 23.25 years old (*SD* = 4.89 years) and 82% identified as female. Of the participants, 63% identified as non-Hispanic White, 15% identified as non-Hispanic African American, 2% identified as non-Hispanic Asian American, 8% identified as bi-racial or multi-racial, 7% identified as 'other', and 5% said they did not know or preferred not to answer. The average BMI of this sample was 25.89 kg/m^2 (*SD* = 6.04 kg/m^2).

Procedure. Participants from both samples completed the same procedure. After reviewing the study information and compensation rates, participants were directed to the survey on Qualtrics. Informed consent was obtained with an electronic signature and participants were asked to complete the study in a quiet room free from distractions. Participants first completed a series of randomly presented questionnaires. Next, participants viewed the video instructions and a 2-minute emotionally neutral film clip, then completed the ERA task (see Figure 2 for task schematic). After each film clip, participants completed the post-film questionnaire. The amount of time spent on each video page was recorded.

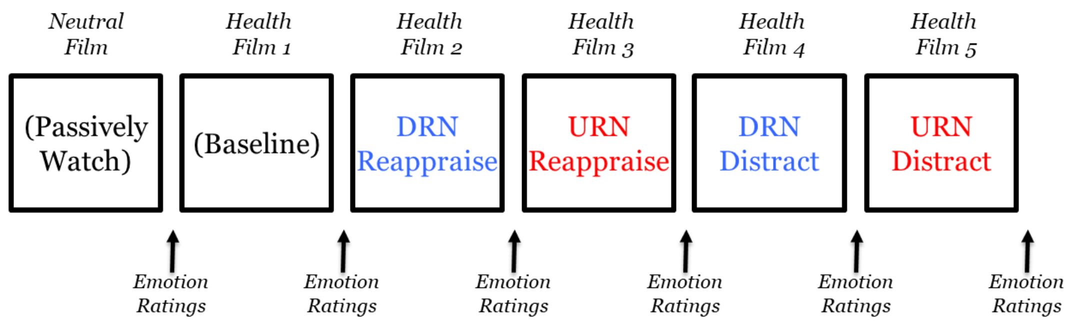

Figure 2. Schematic of experimental procedure for the emotion regulation ability (ERA) task. Order of instructions for which strategy and frame to implement was counterbalanced across participants. Following each film clip, participants rated the greatest amount of emotion experienced to 11 emotion prompts (*positive*: amusement, happiness, joy, love; *negative*: anger, anxiety, disgust, fear, guilt, sadness, shame) on a nine-point Likert scale (0 = *Not At All/None*; 8 = *Extremely/A Great Deal*).

Upon completing the task, demographic information was assessed. Finally, participants were debriefed and given the opportunity to comment on any video or survey issues before completing the survey and receiving their completion code or research participation points. Participants in the community sample received $5.00 for completing the study and participants in the local college sample received research participation extra credit points. On average, the entire experimental session was completed in approximately 1 hour, and the ERA task was completed in approximately 30 minutes. Institutional Review Board approval was obtained prior to data collection.

Measures.

Emotion regulation ability task. The ERA task is a modification of Troy and colleagues' (2010) cognitive reappraisal ability task. Briefly, participants viewed one neutral film and five short health-related film clips (see Figure 2) after which they rated their discrete emotions. Positive and negative emotion composite scores for each video were derived for each participant by averaging the emotion ratings for the 4 positive emotions and 7 negative emotions, respectively.

To induce a neutral mood at the beginning of the task, the first film was a two-minute emotionally neutral film depicting nature scenes (Troy et al., 2010). Next, participants were presented with five health-related film clips that were selected to induce moderate amounts of negative emotions. The films ranged in length from 2 minutes 2 seconds to 2 minutes 44 seconds and were diverse in age, race/ethnicity, and health status. Stimuli featured a vignette-style portrayal of an individual's struggle with weight management and included: a White, overweight female college student (Film 1), several Black, White, and Hispanic middle-age women and men with Type 2 diabetes (Film 2), a White middle-age obese man (Film 3), two older men with Type 2 diabetes (one Black, one White; Film 4), and a White middle-age obese woman (Film 5). Web links to the five videos retained for the ERA task can be found in the supplementary materials. A repeated measures design was utilized to avoid habituation or regression to the mean. Specifically, the order of the film clip presentation was the same, but the strategy (reappraisal or distraction) and regulation direction of emotion (URP emotion or URN emotion) instruction order was random across participants. URP reappraisal instructions were adapted from Troy and colleagues (2010) and are based on clinical research techniques that encourage participants to reframe a stressful situation in a positive way. URN reappraisal, URP distraction, and URN distraction instructions were also developed based on Troy et al.'s (2010) instructions (see Appendix A-D).

After viewing the neutral film, each participant was told to watch the first health-related film carefully, and the subsequent emotion composite ratings served as the participants' baseline positive and negative emotions. For the following four emotion-inducing films, participants positively or negatively reappraised the situation, or positively or negatively distracted themselves from the situation and rated their discrete emotions immediately after watching.

Post-film questionnaire. When responding to the post-film questionnaire, participants were instructed to reflect on how they felt while watching the previous film clip. Participants first rated the greatest amount of 11 discrete emotions they experienced, including 4 positive emotions (amusement, happiness, joy, and love) and 7 negative emotions (anger, anxiety, disgust, fear, guilt, sadness, and shame) (Rottenberg et al., 2007; Troy et al., 2010). Discrete emotions were rated on a 9-point Likert scale (1 = *Not at all/None*, 5 = *Somewhat/Some*, 9 = *Extremely/A great deal*). Next, an attention check question was presented about the film's content. Finally, participants responded to an open-ended question asking about the way in which they used the emotion regulation instructions to manage their emotions.

Covariates. ERA may be influenced by age (McRae et al., 2012), gender and emotional reactivity (Sagui & Levens, 2016; Troy et al., 2010); therefore, these variables were included as covariates in the partial correlation analyses. Participants self-reported their age and indicated their gender (0 = male, 1 = female). Emotional reactivity was calculated for each participant by subtracting the negative emotion composite ratings after the neutral film from the ratings given after the baseline film, with higher scores indicating greater emotional reactivity to the films. Additionally, the weight management context of the stimuli could be appraised differently by individuals across weight status categories. Thus, body mass index (BMI) was calculated from self-reports of height and weight and included as a covariate.

Data management. Participants' emotion ratings were dropped using listwise deletion if they did not pass the two attention checks (correct responses to attention check questions and staying on the page for 75% of the neutral film and 100% of all five health-related films). Calculations of ERA for each of the strategy, regulation direction, and emotion valence combinations are consistent with Troy and colleagues' (2010) study of cognitive reappraisal ability. An individual's ability to URP emotions is reflected by his or her ability to increase positive emotion, while an individual's ability to URN is reflected by his or her ability to increase negative emotion. Thus, to calculate URP reappraisal ability, composite positive ratings given after the baseline emotion-eliciting film were subtracted from the positive emotion composite ratings after the URP reappraisal film clip to create an URP reappraisal ability change score, with higher scores indicating greater URP reappraisal ability. URP distraction ability was similarly calculated using the positive emotion ratings given after the URP distraction film. URN reappraisal and distraction abilities were calculated by subtracting baseline ratings from the negative emotion composite ratings given after the URN reappraisal and distraction films, respectively, with higher scores indicating greater ability.

A unique strength of the ERA task is the measurement of positive and negative emotions after each film clip. Therefore, the task may be used to assess the up- and down-regulation of *both* positive and negative emotions in each condition. Although instructions for URP reappraisal and distraction ask the participant to increase their positive emotions, concurrent down-regulation of negative (DRN) emotions can be assessed during those conditions as well. Thus, DRN reappraisal and distraction ability were calculated by subtracting composite negative ratings given after the DRN reappraisal and distraction films, respectively, from baseline negative composite ratings.

Similarly, URN instructions ask participants to increase their negative emotions, allowing for an examination of concurrent down-regulation of positive (DRP) emotions during those conditions. Thus, DRP reappraisal and distraction ability were calculated by subtracting composite negative ratings given after the DRP reappraisal and distraction films, respectively, from baseline negative composite ratings. Analyzing the task in this way enables us to examine eight ERA conditions across participants: URP, URN, DRN, and DRP for each strategy (reappraisal and distraction). All ratings were z-scored for each film clip before calculating ability scores so that score differences could be compared across individuals.

4.4.2. Results

Descriptive statistics for both samples are presented in Table 4. ERA scores for the national community sample ranged, on average, from .16 – 1.13, and ERA scores for the local college sample ranged, on average, from -.17 - .74. Interestingly, the highest average ability scores were the same across both samples: URP distraction ability, DRN reappraisal ability, and DRN distraction ability.

Table 4

Study 2 Descriptive Statistics Among Emotion Regulation Ability Scores

Variable	Sample 1**M* (*SD*)	Sample 2** *M* (*SD*)
URP Reapp Ability	.53 (1.05)	.07 (.98)
URP Dis Ability	1.13 (1.65)	.48 (1.44)
URN Reapp Ability	.34 (1.09)	.04 (1.12)
URN Dis Ability	.23 (1.06)	-.17 (1.40)
DRN Reapp Ability	.71 (1.00)	.74 (1.18)
DRN Dis Ability	.83 (1.14)	.65 (1.34)
DRP Reapp Ability	.19 (.67)	.20 (.88)
DRP Dis Ability	.16 (.58)	.24 (.84)

Note. *National Community Sample n = 154, **Local College Sample n = 100. M = Mean, SD = Standard Deviation. URP = Up-Regulate Positive, URN = Up-Regulate Negative, DRN = Down-Regulate Negative, DRP = Down-Regulate Positive, Reapp = Reappraisal, Dis = Distraction. Descriptive statistics presented here are raw (i.e., not transformed to z-scores).

Inter-task partial correlations among the eight abilities for both samples revealed unique patterns (see Table 5). Regarding similar associations between samples, abilities that involve up-regulation (URP and URN reappraisal and distraction) were positively correlated in the community (*r*s = .15 to .23) and college sample (*r*s = .13 to .41). Abilities that involve the same regulation direction and emotional valence (URP reappraisal and URP distraction, URN reappraisal and URN distraction, DRN reappraisal and DRN distraction, and DRP reappraisal and DRP distraction) were also all positively correlated in the community (*r*s = .43 to .56) and college sample (*r*s = .37 to .86). Abilities that involve negative emotions (URN and DRN reappraisal and distraction) were negatively correlated in both the community (*r*s = -.06 to -.22) and college sample (*r*s = -.30 to -.39). Finally, abilities that involve positive emotions (URP and DRP reappraisal and distraction) and were also negatively correlated in the community (*r*s = -.22 to -.40) and college sample (*r*s = -.50 to -.75).

Regarding different associations between the samples, abilities to feel more positive and less negative (URP and DRN reappraisal and distraction) were positively correlated in the community sample (*r*s = .17 to .42) but were not correlated in the college sample. Further, URN reappraisal and DRP reappraisal (abilities to feel more negative and less positive) were positively correlated in the community sample ($r = .20$, $p < .05$), while in the college sample abilities to feel more negative and less positive were negatively associated: URN distraction was negatively correlated with DRP reappraisal ($r = -.50$, $p < .001$) and DRP distraction ($r = -.53$, $p < .001$). Finally, DRN distraction and DRP distraction (abilities that involve down-regulation) were positively correlated in the college sample ($r = .21$, $p < .05$) but none of the abilities involving down-regulation were correlated in the community sample. These patterns of results were observed when the full community and college samples were included in analyses.

Table 5

Study 2 Inter-Task Partial Correlations Among Emotion Regulation Ability Scores

Variable	1	2	3	4	5	6	7	8
1. URP Reapp Ability	--	.57[c]	.28[b]	.20[a]	-.00	-.13	-.65[c]	-.75[c]
2. URP Dis Ability	.56[c]	--	.13	.41[c]	.02	.09	-.50[c]	-.53[c]
3. URN Reapp Ability	.23[b]	.15	--	.37[c]	-.30[b]	-.31[b]	-.08	-.12
4. URN Dis Ability	.21[a]	.16	.52[c]	--	-.39[c]	-.30[b]	-.26[a]	-.22[a]
5. DRN Reapp Ability	.28[b]	.17[a]	-.22[b]	-.19[a]	--	.51[c]	.12	.06
6. DRN Dis Ability	.27[b]	.42[c]	-.06	-.12	.47[c]	--	.18	.21[a]
7. DRP Reapp Ability	-.40[c]	-.28[b]	.20[a]	.08	-.03	.02	--	.86[c]
8. DRP Dis Ability	-.33[c]	-.22[b]	.04	.15	-.01	.02	.43[c]	--

Note. National Community sample $n = 154$, Local College Sample $n = 100$. [a]$p < .05$, [b]$p < .01$, [c]$p < .001$. URP = Up-Regulate Positive, DRN = Down-Regulate Negative, URN = Up-Regulate Negative, DRP = Down-Regulate Positive, Reapp = Reappraisal, Dis = Distraction. National community sample correlations are presented below the diagonal. Local college sample correlations are presented above the diagonal. Analyses controlled for age, gender, emotional reactivity, and body mass index.

4.4.3 Discussion

In Study 2, the ERA task was prepared on an online platform and administered to both a national community and local college sample. Online preparation of the ERA task was successful due to the functionality of Qualtrics survey software and Vimeo hosting server. These are robust software platforms that allow behavioral and experimental research to be conducted online or from a computer. Study 2 was successful in providing proof-of-concept that assessing multiple strategy, regulation direction, and emotional valence combinations in the context of health is possible and can be done online without proctoring.

Regarding the descriptive statistic findings, the ERA task appears to be capable of capturing differences in regulatory ability across conditions and between samples. Interestingly, the highest three ability scores for both samples were URP reappraisal, DRN reappraisal, and DRN distraction, which are strategies that focus on feeling more positive and less negative toward health-related stimuli. With the rise in research on the benefits of positive emotions (e.g., Fredrickson, 2003), health advice and public health messages have begun focusing on positive emotions as critical aspects of healthy living. This cultural emphasis on feeling more positive and less negative may account for some of these findings.

Regarding age-related differences in ERA, the community sample demonstrated higher average ability scores on five of the eight abilities compared to the college sample. Further, the community sample’s highest average ability score was URP distraction, while the college sample’s highest average ability was DRN reappraisal. Prior research shows that emotion regulation improves with age (Urry & Gross, 2010), partly due to an enhanced ability to use strategies that compensate for changing resources. Further, older adults report using more attentional deployment strategies (Allen & Windsor, 2017), that bias their attention toward positive stimuli (Mather & Carstensen, 2005). Distraction is also a less cognitively effortful strategy (Sheppes et al., 2014) and may be easier to implement with increasing age. Although our community sample was only 37 years old, on average, the differences observed in ability scores may be capturing the positivity effect that the community sample is experiencing with a higher average URP distraction ability. According to the socioemotional selectivity theory (Carstensen, 2006), younger adults may also possess a greater ability to manage and regulate negative emotions, as demonstrated by higher average DRN reappraisal ability, because they have less awareness of limited time, giving them the capacity to think more about longer-term health-related challenges.

The ERA task was initially designed to assess four emotion regulation strategies. During each film clip, participants were asked to either reappraise the situation in a more positive way, distract themselves from the situation by thinking of something positive, reappraise the situation in a more negative way, or distract themselves from the situation by thinking of something negative. A unique component of this task was the measurement of positive and negative emotions after each film, which allowed for an examination of four additional emotion regulation strategies. For example, in the URP reappraisal condition, which assesses a person's ability to increase positive emotions using reappraisal, we can also measure her/his concurrent ability to decrease negative emotions using reappraisal (DRN reappraisal). Examining the inter-task partial correlations among these eight ERA scores in each sample revealed interesting patterns among strategy, regulation direction, and valence combinations.

Across both samples, abilities that involve the up-regulation of emotion were positively correlated, meaning a greater ability to *increase positive* emotions using reappraisal and distraction was associated with a greater ability to use these strategies to *increase negative* emotions. This suggests that ability to up-regulate emotions, at least in the context of health, may be independent of emotional valence. The reappraisal emotion regulation instructions ask participants to reframe the situation in either a more positive or more negative way, while the distraction instructions ask participants to focus attention on a positive or negative unrelated stimulus. Although the prompts do not give the participants the goal of increasing positive or negative emotions, the strong relationships between up-regulatory abilities may be a function of the way the prompts were phrased.

We also found that strategies involving the same regulation direction and valence were positively correlated in both samples. For example, participants with a higher ability to decrease negative emotions using *reappraisal* also had a higher ability to decrease negative emotions using *distraction*, and these associations were significant for all four combinations of regulation direction and valence conditions. This indicates coherence between ability scores independent of strategy, such that a greater ability to manipulate emotions with one strategy is consistent with a greater ability to manipulate emotions in the same way using a different strategy.

Interestingly, abilities involving negative emotions were negatively correlated across both samples, suggesting that a stronger ability to increase negative emotions is associated with a weaker ability to decrease those negative emotions. This potentially reflects a valence bias across both samples where participants either have a higher capacity to manipulate emotions to feel more negative or less negative. This is further supported by the negative correlations observed in both samples between abilities involving positive emotions (i.e., greater ability to increase positive emotions was associated with a lower ability to decrease positive emotions). Thus, a general pattern emerges in which some participants are better at feeling more positive, while others are better at feeling more negative.

There were also patterns of association among the ability scores that diverged between the samples. The community sample demonstrated a positive correlation between abilities used to increase positive and decrease negative emotion, whereas the college sample did not evidence these associations. Further, the community sample showed positive associations between abilities used to feel more negative and less positive, while the college sample evidenced negative correlations between these abilities. Positive and negative emotions are thought to be separate constructs on independent dimensions, rather than on a bipolar continuum (Cacioppo & Berntson, 1994). Our results suggest that the college sample has emotion regulatory abilities the align with the theory of independent emotion valence dimensions and may even experience more mixed emotional states when regulating. However, the community sample did demonstrate a concurrent decrease in negative emotions when increasing positive emotions, as well as a concurrent decrease in positive emotions when increasing negative emotions.

A final observation was that abilities used to down-regulate emotions were positively associated in the community sample but were unrelated in the college sample.

This indicates that only in community sample participants was a greater ability to decrease negative emotions related to a greater ability to decrease positive emotions. Because emotion regulation is thought to develop linearly (McRae et al., 2012) this finding may capture the community sample's mastery over emotion regulatory skills, while the college sample is still developing those abilities.

4.5. GENERAL DISCUSSION

The present study developed a measure of health-focused emotion regulation ability (ERA) within young and middle-age adult populations that is lacking within the current literature. Two studies were conducted to create a novel, computer-based paradigm that assesses the health-focused up- and down-regulation of positive and negative emotions using reappraisal and distraction. In Study 1, film stimuli were developed and rated within a national community sample and the initial pool of 12 stimuli was empirically reduced to five final ERA task films using quantitative and qualitative analyses. In Study 2, the ERA task was prepared on an online platform and administered to two separate samples. Findings suggest that the ERA task functions similarly to other emotion regulatory paradigms and represents an innovative measure of health-focused regulation that can be utilized in research and clinical settings.

The present study utilized standard emotion-eliciting task development procedures (Rottenberg et al., 2007) to empirically design a measure that could capture ERA across conditions of strategy, regulation direction, and emotional valence combinations. To design this task, we began by searching for, editing and selecting prospective stimuli in Study 1. Next, the stimuli were pilot tested within a national community sample and results indicated that, on average, participants rated the stimuli selected as being more negative than positive and were able to generate both negative and positive appraisals about the final pool of five films selected for the task. These results indicate that we succeeded in developing stimuli that are principally negative, yet complex enough to capture some of the nuances associated with weight- and health-related stressful situations.

In Study 2, participants were asked to regulate their emotions toward the final stimuli using each strategy. The means and standard deviations of ability scores indicated that participants were able to manage their emotions when prompted, yet scores varied sufficiently, suggesting that future research could explore the adaptiveness of different abilities or combinations of abilities on obesity-related health outcomes. Interestingly, the highest average scores were for strategies that focus on feeling more positive and less negative toward health-related stimuli.

Regarding age-related differences in regulatory ability, descriptive results from the ERA task suggest that, on average, the national community sample had a greater ability than the local college sample across five of the eight ability scores. ERA is thought to develop linearly (McRae et al., 2012); therefore, young adults (ages 26-39 years old) and middle-age adults (ages 40-60 years old; Arnett, 2000) are thought to exhibit better regulatory skills than emerging adults (ages 18-25 years old; Arnett, 2000). This is further supported by the findings that the college sample may have struggled to up-regulate their emotions. The average ability scores for up-regulation conditions were close to zero or negative, implying that although participants were asked to increase their emotion, they either did not change them, or decreased them while using the URP reappraisal, URN reappraisal, and URN distraction strategies. The only exception to this pattern was the college sample's higher average ability to implement URP distraction.

One of the most interesting findings to emerge from the present study was the pattern of inter-task partial correlations among ERA strategies in both Study 2 samples. We found that regardless of strategy type, abilities involving negative emotions were negatively correlated across both samples as were abilities involving positive emotions, suggesting, for example, that a stronger ability to increase positive emotions is associated with a weaker ability to decrease those positive emotions. This efficacy in implementing emotion regulation in this way, coupled with the finding on the overall valence bias of ability associations indicates that, on average, ability scores were orthogonal by valence condition. This general tendency to have greater implementation efficacy for positive or negative framing (but not both) mirrors research on health messaging framing, which suggests that some individuals are more likely to engage in healthier behavior after viewing gain-framed messages (i.e., those that highlight the benefit of an action), while others engage in healthier behavior after viewing loss-framed messages (i.e., those that highlight the consequences of inaction; Mann, Sherman, & Updegraff, 2004). This is the first study, to our knowledge, that extends those findings to one’s ability to implement self-generated positive or negative messages to manage emotions toward health-related stimuli.

Participants demonstrated that they can use multiple strategies to think positively and regulate their emotions or think negatively, but their flexibility may end there. This is one of the first studies to incorporate the up-regulation of negative emotions and down-regulation of positive emotions into an ERA task. The finding that individuals have a general tendency to be better at one type of regulation direction-valence combination may have important implications for the ways individuals emotionally cope with stressful situations.

Limitations

Although the present study was successful in developing a health-focused measure of ERA and results provide proof-of-concept that assessing multiple strategy, regulation direction, and emotion valence combinations in the context of health is possible, there are methodological limitations that warrant discussion. A strength of the ERA task is that is can be administered online and distributed to participants or patients across the country. However, assessment of health-focused ERA requires that respondents pay close attention to the film clips. Thus, we used stringent attention check criteria to include participants in the final analyses, resulting in the loss of 34% of the national community sample and 52% of the local college sample. A greater retention of community sample participants indicates that middle-age adults are more inclined to complete the task as instructed when compared to emerging adults. The ERA task is also likely to be more personally relevant to a middle-age sample because they are more likely to be struggling with obesity-related health conditions and identify with the stimuli. Further, the community sample received monetary compensation for participating, indicating a reward like this (e.g., money into a health savings account for completion) may increase motivation to pay attention. Although the observed pattern of results was consistent when the full community and college samples were included, this limitation has implications for the format in which the task should be administered in the future.

Contributions to the Field

The present study contributes to the growing literature examining the ways in which emotion regulation influences behavioral and physical health processes by providing a comprehensive measure of health-focused ERA. Researchers are becoming increasingly interested in the way individuals cope with health-related stressors and the emotional processes used to improve health and health-related behaviors (DeSteno, Gross, & Kubzansky, 2013; Sagui & Levens, 2016). The ERA task represents a context-specific approach to measuring regulatory ability within weight-management and health-related domains. Currently, only one other ERA paradigm is available (Troy et al., 2010); however, it is limited by its focus on sad emotion-inducing stimuli that is not health-related and its measurement of only one strategy ability (DRN reappraisal). The inclusion of up- and down-regulation of positive and negative emotion conditions, as well as distraction strategy conditions, in the ERA task provides a more robust measurement of the spectrum of emotion regulation. Further, the use of complex health-focused stimuli can better capture individual differences in reactions to health information and illness threat appraisals (Ditto et al., 1988; Ditto & Lopez, 1992).

The ERA task also has clinical utility as an assessment tool to gauge how an individual emotionally regulates threatening health-related stimuli. Increasing engagement in healthy behaviors, such as physical activity and fruit and vegetable consumption, remains a significant public health challenge (Office of Disease Prevention and Health Promotion, 2017a, b). The medical paradigm shift that requires patients to manage their own risk for chronic diseases (Mascie-Taylor & Karim, 2003) necessitates a research and clinical approach that considers the psychological and emotional mechanisms predisposing some individuals toward unhealthy behavior. Thus, future research should assess the utility of the ERA task for practitioners in a clinical setting where a general assessment of patients' health-focused emotion regulatory capacity could be obtained. Using the task in this way could inform individualized treatment plans and targeted ERA training to enhance regulatory skills.

Future Directions

The goal of the present study was to demonstrate proof of concept that the measurement of ERA toward negative, health-related stimuli is possible and feasible and that the task has utility for future research. To further examine the applicability of the ERA task, the next steps involve administering the measure to expand the literature on contextual emotion regulation and emotion regulation flexibility. A growing body of research suggests that claims about the adaptiveness of a particular emotion regulation strategy should take into account the dynamic interaction between the person and situation over time (Bonanno & Burton, 2014). The context of the situation (e.g., health-related) should also be considered when examining the effectiveness of emotional coping. Therefore, the ERA task has the potential to contribute to research investigating the role of emotion regulation across strategy, regulation direction, and emotional valence conditions to influence health outcomes.

One particularly interesting line of work that could utilize the ERA task involves examining the psychological and emotional factors that predict whether an individual has high ERA for several strategy, direction, and valence combinations. On average, individuals in the present study seemed to have the capacity for certain combinations of regulatory direction and valence; however, it is possible that the individuals who have a wider capacity for up- and down-regulating positive and negative emotions have a larger emotion regulation strategy repertoire, which could lead to more flexible and context-appropriate regulation. An investigation of the predictors of high ability across several strategies could inform emotion regulation interventions aimed at influencing physical and behavioral health and health-specific behavioral motivation.

Overall, the pattern of results from this study suggest that individuals can manage both their positive and negative emotions toward weight-related health stimuli when prompted to use different emotion regulation strategies. Therefore, the ERA task represents a robust tool that can be used in health research to assess how different health-focused emotion regulatory abilities, as well as variation within and across those abilities, can contribute to health promotion and disease prevention in the context of weight management.

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CHAPTER 5: THE INFLUENCE OF STRESS REACTIVITY AND HEALTH-FOCUSED EMOTION REGULATION ON BEHAVIORAL AND PHYSICAL CARDIOMETABOLIC RISK FACTORS

By Sara J. Sagui-Henson and Sara M. Levens

5.1. ABSTRACT

Overweight and obesity are serious and costly societal issues that, combined with other risk factors such as physical inactivity, hypertension, and elevated blood sugar, contribute to chronic cardiometabolic illnesses. Stress reactivity is posited as causal mechanism in the development of cardiometabolic diseases (i.e., heart disease, stroke and Type 2 diabetes), with maladaptive health outcomes associated with both high and low stress reactions. Health-focused emotion regulation ability (ERA) represents an entry point for individuals to alter their stress response, leading to reduced behavioral and physical risk for illness. Therefore, the present study 1) examined the curvilinear relation between stress reactivity and cardiometabolic risk, 2) tested a conceptual model in which the ability to up- and down-regulate negative emotions modulates the influence of stress reactivity to reduce disease risk, and 3) developed a database that will allow for a larger examination of the way psycho-emotional processes influence health and motivation. Eighty-nine participants (61% female; *M* age = 28 years) completed an online survey of psychological and behavioral health and a laboratory session where they completed an ERA task, a social evaluative stress task with psychophysiological measurements, and a physical health assessment. Polynomial regression analyses revealed that stress reactivity did not have a curvilinear relation with any cardiometabolic risk factor. Moderated regression analyses revealed that perceived stress reactivity and ERA interacted to predict sleep quality and systolic and diastolic blood pressure. Immediate and long-term future directions utilizing the larger database created, as well as implications for stress and emotion interventions aimed at reducing the societal impact of obesity-related health conditions are discussed.

5.2. INTRODUCTION

Over the last half-century, a medical shift from treating acute infections to managing noncommunicable chronic illnesses has created new problems for our healthcare system (Mascie-Taylor & Karim, 2003). Overweight and obesity alone are serious and costly societal issues affecting more than two-thirds (70.7% in 2013-2014) of American adults and placing a large economic burden ($147 billion in 2008) on the country's health care system (Centers for Disease Control and Prevention [CDC], 2016a, c). Being overweight or obese, combined with other risk factors such as physical inactivity, hypertension, and elevated blood glucose concentrations, contributes to chronic cardiometabolic illnesses, which include heart disease, stroke and Type 2 diabetes (American Heart Association [AHA], 2015). Although the risk factors that lead to these preventable causes of death are modifiable, the mechanisms that predispose some individuals toward obesity-related health concerns are not well-understood. Because the paradigm shift to managing chronic diseases requires patients to be more active in their health care, researchers must consider the psychological and emotional mechanisms that can help patients enhance their health.

One major psychological determinant of cardiometabolic disease risk is stress (Carver & Vargas, 2011). Psychological stress occurs when a person appraises a situation, experiences negative emotions, and then perceives that situation to be threatening in ways beyond her/his coping abilities (Lazarus, 1966, 1999; Lazarus & Folkman, 1984). This perception gives rise to a multifaceted stress reaction that activates experiential, cognitive, behavioral, and physiological response systems (Schlotz, Yim, Zoccola, Jansen, & Schulz, 2011), and although stress is a ubiquitous experience

(American Psychological Association, 2014), individuals differ in their reactions to stress. Contrary to prior work focusing on the linear relation between stress reactivity and health (e.g., Steptoe & Wardle, 2005), recent research suggests that both excessively high and notably low stress reactions contribute to behavioral and physical risk factors for cardiometabolic disease (e.g., Cacioppo & Berntson, 2011; Cohen & Manuck, 1995; Lovallo, 2011; Phillips, Roseboom, Carroll, & de Rooij, 2012). This implies a curvilinear relation between stress reactivity and cardiometabolic disease risk in which a moderate reaction to stress is necessary to motivate healthy behavior and maintain homeostatic balance (Lovallo, 2011).

To shift a stress response more toward the middle, individuals can manage, or regulate, the negative emotions associated with stress. Adaptive and flexible emotion regulation has become the focus of recent research (see Aldao, Sheppes, & Gross, 2015 for a review) and may represent a mechanism by which individuals can mitigate the detrimental influence of stress and engage in better health practices. Accordingly, individuals with higher stress reactivity may benefit from using a positive emotion regulation strategy that reduces their reactivity, while those with low stress reactivity may benefit from employing a negative emotion regulation strategy that increases it.

To our knowledge, this framework has not been empirically examined in the stress and health or emotion regulation literatures. Therefore, the present study seeks to better understand the behavioral and physiological adaptiveness of the up- and down-regulation of negative emotions for individuals differing in stress reactivity. Specifically, this study aims to: 1) investigate the curvilinear relation between stress reactivity and behavioral and physical risk factors for cardiometabolic disease, 2) test a conceptual model in which health-focused emotion regulation ability (ERA) modulates the influence of stress reactivity to promote reduced cardiometabolic disease risk (see Figure 3), and 3) develop a database that includes assessments of psychological, emotional, and biobehavioral health, as well as health beliefs and health-related motivation, which will allow for a larger examination of the way stress and emotions interact to influence health.

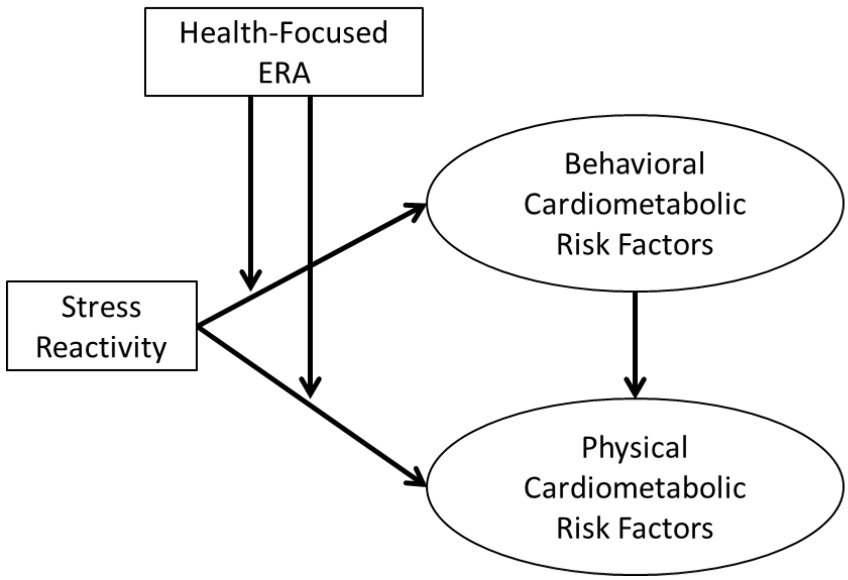

Figure 3. Conceptual model of the influence of stress reactivity and health-focused emotion regulation ability (ERA) in the prediction of cardiometabolic risk factors.

Stress and Risk for Cardiometabolic Disease

Cardiometabolic disease risk refers to a clustering of interrelated behavioral and physical factors that promote the development of atherosclerosis, cardiovascular diseases (e.g., coronary heart disease, congestive heart failure), stroke, and Type 2 diabetes mellitus (Castro et al., 2003). Behavioral risk factors include physical inactivity, unhealthy diet, tobacco use, and poor sleep quality (AHA, 2015; CDC, 2012; Wang et al., 2012). Physical risk factors include abdominal obesity, hypertension (high blood pressure; AHA, 2015), hyperglycemia (high blood sugar; American Diabetes

Association, 2016), abnormal blood cholesterol (reduced high-density lipoprotein cholesterol and elevated low-density lipoprotein; National Heart, Lung, and Blood Institute [NHLBI], 2005), and hypertriglyceridemia (elevated triglycerides; NHLBI, 2005). Cardiometabolic diseases are largely preventable (CDC, 2016b) and the risk factors that create or exacerbate these conditions are considered modifiable. Thus, research targeting these behavioral and physical components of health, as well as the psychological determinants that influence them, can serve to improve cardiometabolic disease pathogenesis.

The rise in prevalence of cardiometabolic diseases is accompanied by a medical paradigm shift from acute to chronic care models that require patients to be active participants in their physical wellness and weight management (Mascie-Taylor & Karim, 2003). The field of health psychology offers a unique approach for improving these obesity-related health conditions because it considers the multiple influences of health, including the psychological and emotional aspects that contribute to risk factors for disease (see Friedman & Adler, 2011). One main approach considers the influence of stress and coping processes on health outcomes, with considerable health psychology research dedicated to investigating the impact of stress reactivity (i.e., the dispositional psychological and physiological responses to a stressor; Schlotz et al., 2011) and the emotional coping processes that can be used to mitigate that impact (Lazarus & Folkman, 1984).

Stress reactivity is posited as a causal mechanism in the promotion of health and/or the development of cardiometabolic diseases (Carver & Vargas, 2011) and primarily influences health through two functional pathways (Carver & Vargas, 2011).

The first pathway is through behavioral mechanisms, whereby stress reactivity influences an individual's engagement in unhealthy behaviors (Smith & Leon, 1992). The second is through physiological mechanisms, whereby differing stress reactions affect biological systems that disrupt homeostasis, leading to poor health (Cacioppo & Berntson, 2011; Sapolsky, 2004). Importantly, these pathways are bidirectional, and the behavioral consequences of stress can lead to physiological health detriments.

An abundance of prior research has focused on the negative impact of heightened stress reactivity, which includes greater dispositional psychological (i.e., exaggerated perceptions of one's reactivity across multiple situations; Schlotz et al., 2011) and physiological (i.e., elevated heart rate and blood pressure, reduced heart rate variability (HRV), and heightened cortisol secretion; Sapolsky, 2004) responses to a stressor. Heightened stress reactivity has many well-established negative health correlates, including more engagement in health-compromising behavioral risk factors, such as unhealthy diet, physical inactivity, smoking and poor sleep quality (Chandola et al., 2008; Charles et al., 2011; Karvinen, Murray, Arastu, & Allison, 2013; National Sleep Foundation, 2001; Slopen et al., 2012; Smith & Leon, 1992). Physiologically, during a heightened stress reaction the hypothalamic-pituitary-adrenal (HPA) and the sympathetic-adrenal-medullary (SAM) axes are activated, eliciting the release of glucocorticoids and catecholamines (Cacioppo & Berntson, 2011). Chronic activation of these systems and the release of harmful hormones through high levels of stress reactivity are associated with physical cardiometabolic risk factors, such as increased abdominal adiposity (Sinha & Jastreboff, 2013; Steptoe & Wardle, 2005; Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011), abnormal cholesterol levels, high blood glucose levels (Sapolsky, 2004) and immune suppression (Webster Marketon, & Glaser, 2008). Stress reactions that are large, prolonged, and frequent are also associated with increased risk for cardiovascular disease and all-cause mortality (Lovallo, 2015).

Recent research also demonstrates that diminished or blunted reactivity (formerly thought to be benign or even protective) is related to poor health (Lovallo, 2011). Reduced stress reactivity, which includes decreased psychological (i.e., lower perceptions of one's reactivity across multiple situations; Schlotz et al., 2011) and physiological (e.g., reduced heart rate and blood pressure, elevated HRV, and mild cortisol secretion; Phillips, Ginty, & Hughes, 2013) responses to a stressor, was previously assumed to be adaptive in the face of adversity (Carroll, Phillips, & Lovallo, 2012). However, accumulating research challenges this assumption, demonstrating the detrimental effects of diminished reactivity on health impairment and cardiometabolic disease risk factors.

Behaviorally, low stress reactivity has been associated with motivational dysregulation and may accompany biases in food intake and risk for alcoholism (Carroll et al., 2012), as well as increased tobacco use (Phillips, Der, Hunt, & Carroll, 2009). In fact, reduced stress reactivity has been associated with addiction and dysregulated consummatory behaviors in adolescent (Moss, Vanyukov, Yao, & Kirillova, 1999), young adult (Sorocco, Lovallo, Vincent, & Collins, 2006) and adult populations (Lovallo, Dickensheets, Myers, Thomas, & Nixon, 2000). Research has also documented an association between low cardiac and cortisol stress reactivity and abdominal obesity (Carroll, Phillips, & Der, 2008; Phillips, Roseboom, Carroll, & de Rooij, 2012), as well as increased risk for autoimmune disease (Lovallo, 2011).

This evidence suggests that both larger-than-normal and smaller-than-normal stress responses can contribute to behavioral and physical cardiometabolic risk factors (Lovallo, 2011). Thus, a hypothetical stress reactivity distribution is proposed, where deviations from the middle in either direction signal dysregulation. Indeed, a stress response in the midrange of intensity can be a powerful motivator of behavior change (Ekman, 1993) and may be associated with psychophysiological resilience (Liu, 2015). This curvilinear relation between stress reactivity and risk for disease suggests that a moderate reaction to stress is the healthiest and that the individuals with extreme reactions on either end need a mechanism for improving the adaptiveness of their response.

Therefore, highly stress reactive individuals may benefit from an ability to implement an emotional coping style that decreases the negative emotions that give rise to stress reactions, thereby reducing their reactivity and promoting healthier behavioral and physiological outcomes. Conversely, lower stress reactive individuals may benefit from an ability to implement an emotional coping style that increases that negative emotions that give rise to stress reactions. Regulating emotions in this contextually based way may shift individuals toward the optimal mid-point necessary to maintain healthy behavioral and physical functioning. Critically, research focusing on stress and motivation notes that effective strategies to promote healthy behavior in individuals with little or no motivation to change are relatively scarce (Hardcastle et al., 2015), highlighting an area of research that is ideal for investigation.

Emotion Regulation Ability

Because negative emotions arise from stressful appraisals, emotional coping styles offer an entry point for high stress reactive individuals to lower their stress response and low stress reactive individuals to increase it, thereby bringing both groups closer the optimal midrange. In the context of health, the management of emotions surrounding negative health situations is especially relevant in modulating the influence of stress on cardiometabolic disease risk. Individual differences in how people interpret and react to threatening health information (i.e., the model of illness threat appraisal; Ditto, Jemmott, & Darley, 1988; Ditto & Lopez, 1992) provide a window through which researchers can seek to better understand the application of emotion regulation in stress and health (DeSteno, Gross, & Kubzansky, 2013).

Emotion regulation is a process in which individuals use various strategies to influence the occurrence, intensity, duration, and/or expression of an emotion (Campbell-Sills, Ellard, & Barlow, 2014; Gross, 1998). According to the process model of emotion regulation (Gross, 1998, 2002), antecedent-focused strategies that are employed before emotional responses become fully activated are more effective in producing long-term benefits and have fewer physiological costs. Reappraisal is an antecedent focused strategy that can be implemented to change an individual’s level of emotional reactivity to a stimulus (Gross & John, 2003). This strategy involves reinterpreting the initial appraisal of stressful event to alter its emotional impact and modifies the important appraisal stage of emotion generation (Gross, 1998, 2002; Gross & John, 2003). For example, after receiving a discouraging diagnosis of prediabetes, a person might view this news as an opportunity to get healthier, rather than as a negative judgment of one's lifestyle.

Reappraisal has demonstrated utility in a stressful context: it has been shown to be protective factor against stressful life events (Troy, Wilhelm, Shallcross, & Mauss, 2010), it mediates the stress-reductive benefits of mindfulness meditation interventions (Garland, Gaylord, & Fredrickson, 2011), and individuals high in trait reappraisal are more stress resilient (Carlson, Dikecligil, Greenberg, & Mujica-Parodi, 2012). Critically, reappraisal can be employed to increase or decrease negative emotions, depending on the way the strategy is framed (Gross, 2014). For example, positively framed reappraisal can be employed to help an individual reduce, or down-regulate, the negative emotions that give rise to a high stress reaction (Troy & Mauss, 2011). Whereas negatively framed reappraisal can be employed to help an individual increase, or up-regulate, the negative emotions that give rise to a low stress reaction (Ochsner et al., 2004).

Although any regulatory strategy can be positively or negatively framed, the present study focuses on reappraisal because it occurs early in the emotion generative process, altering the entire subsequent emotion trajectory and enabling individuals to more effectively change their affect (Gross & John, 2003). Reappraisal is also most appropriately aligned with stress and coping theory, as emotion-focused coping principally influences psychological stress via appraisal processes (Lazarus, 1993). Additionally, the present research focuses on one's *ability* to implement reappraisal to manage emotions, not just their self-reported use of the strategy. This is an important distinction because most of the research exploring individual differences in reappraisal (especially in the context of physical health) uses self-report measures of cognitive reappraisal use, which are subject to biases (Feldman Barrett, 1997). Research has also shown that ERA does not correlate with self-reported use (Troy et al., 2010), indicating that ERA represents a unique construct that taps into the efficacy associated with using a strategy, not just the frequency of emotion regulation attempts. Thus, experimental paradigms that ask people to implement a strategy and measure their efficacy to change emotions in line with the goal of that strategy are more objective and useful in research connecting emotions, stress and health.

Stress Reactivity and Emotion Regulation Ability Interact

According to the posited framework, individuals higher in stress reactivity may benefit from having a greater ability to down-regulate negative (DRN) emotions using reappraisal, while those lower in stress reactivity may benefit from having a greater ability to up-regulate negative (URN) emotions via reappraisal. Although no research to our knowledge has empirically tested this entire framework, several studies examining the up- and down-regulation of negative emotions, including research from our lab (Sagui & Levens, 2016), provide evidence for the plausibility of this interaction.

Positively framed emotion regulation used to reduce negative emotion has been shown to lower self-reported negative emotion (Ray, McRae, Ochsner, & Gross, 2010), reduce cravings for appetitive foods and cigarettes (Kober et al., 2010) and decrease cardiovascular reactivity (Driscoll, Tranel, & Anderson, 2009). Conversely, negatively framed emotion regulation used to increase negative emotion has been shown to increase cardiovascular reactivity (Demaree, Schmeichel, & Robinson, 2004; Driscoll et al., 2009) and self-reported negative affect (Ray et al., 2010), as well as heighten cognitive control and task performance (Moser, Most, & Simons, 2010). In a health message-framing context, avoidance-oriented people (i.e., those who avert negative events and may be low in stress reactivity) reported healthier behavior when given loss-framed messages, which ask participants to consider the negative consequences of an action and are similar to negatively framed ERA. However, approach-oriented people (i.e., those who engage with positive events) reported healthier behavior when given gain-framed messages, which highlight the benefits of an action and may be similar to positively framed ERA (Mann, Sherman, & Updegraff, 2004).

Further, research from our lab indicates that DRN reappraisal ability—framing a stressful situation in a more positive way to decrease its negative emotional impact—is associated with lower body mass index (BMI; a proxy for body fat) and incidence of Type 2 diabetes, but only for individuals with higher perceived stress reactivity (Sagui & Levens, 2016). By utilizing a positive strategy aimed at reducing the negative emotions that give rise to a stress reaction, these individuals were presumably able to reduce their stress reactivity to an optimal level, leading to positive health outcomes. However, high DRN reappraisal ability was related to higher BMI and Type 2 diabetes incidence for those with lower perceived stress reactivity, indicating that the adaptiveness of this emotion regulation strategy depends on the context of one's internal stress reactions. Presumably, individuals already low in stress reactivity may need to possess the ability to utilize a strategy that increases their reactivity, such as URN reappraisal.

Although numerous studies have examined the association among reappraisal and *mental* health (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Troy et al., 2010), this was one of the first studies to demonstrate that emotion regulation has the capacity to interact with perceived stress reactivity to affect *physical* health. This was a significant contribution to the literature and an important first step; however, evidence of this interaction was obtained using a subjective self-report measure of stress reactivity which asked participants what they perceived their typical stress responses to be (Schlotz et al., 2011). Further, the main health outcomes assessed were also self-reported (BMI and Type 2 diabetes prevalence). Finally, to adequately test the premise that stress reactivity and reappraisal interact to influence health, the measure of ERA needed to be contextualized around health.

The Present Study

To address these gaps, the present study extended this prior research in three important ways. First, stress reactivity was measured using psychophysiological techniques to assess cardiovascular responses to stress. This not only allowed for an investigation of the influence of psychophysiological stress reactivity on behavioral and physical cardiometabolic risk factors, but also permitted a test of the differential impact of perceived and physiological reactivity. Second, a novel health-focused ERA task (Sagui-Henson & Levens, *in preparation*) was utilized that assesses individual differences in the ability to implement reappraisal to up- and down-regulate negative emotions surrounding anxiety-provoking health and weight management situations. Third, the health outcomes examined in the present research were expanded to include objective markers of cardiometabolic disease risk, including abdominal obesity, high blood pressure, abnormal levels of cholesterol and triglycerides, and elevated glycated hemoglobin (HbA1c).

The current study advances a systematic investigation of the psychological stress and emotion regulatory processes that may reduce the development and/or progression of cardiometabolic disease. Three main objectives are investigated: 1) examine the curvilinear relation between stress reactivity and behavioral and physical risk factors for cardiometabolic disease, 2) test a conceptual model in which health-focused ERA modulates the influence of stress reactivity to promote reduced cardiometabolic disease risk (see Figure 3), and 3) develop a database that includes assessments of psychological, emotional, and biobehavioral health, as well as health beliefs and health-related motivation, which will allow for a larger examination of the way stress and emotions interact to influence health.

Participants completed well-validated self-report measures of perceived stress reactivity and behavioral risk factors for cardiometabolic disease (physical activity and sleep quality). They also completed the ERA task and a social evaluative stress task while their cardiovascular stress reactivity was assessed via electrocardiography. Finally, participants completed a physical health assessment to measure abdominal obesity, blood pressure, cholesterol, triglycerides, and HbA1c. Aligned with the framework presented above and with support from prior literature, the following three hypotheses were tested:

Hypothesis 1: Curvilinear Relation Between Stress Reactivity and Risk Factors

H1a: Stress reactivity will demonstrate a curvilinear relation with behavioral cardiometabolic risk factors, such that higher and lower stress reactivity will be associated with poorer health behavior engagement (i.e., less physical activity, poorer sleep quality).

H1b: Stress reactivity will demonstrate a curvilinear relation with physical cardiometabolic risk factors, such that higher and lower stress reactivity will be associated with higher abdominal obesity, systolic and diastolic blood pressure, low-density lipoprotein (LDL) cholesterol, triglycerides, and HbA1c, and lower high-density lipoprotein (HDL) cholesterol.

Hypothesis 2: Stress reactivity and ERA Interact to Predict Risk Factors

H2a: Stress reactivity and DRN reappraisal ability will interact to predict behavioral cardiometabolic risk factors, such that individuals with higher DRN reappraisal ability and higher stress reactivity, compared to those with lower DRN reappraisal ability and higher stress reactivity, will engage in healthier behavior (i.e., more physical activity, better sleep quality).

H2b: Stress reactivity and URN reappraisal ability will interact to predict behavioral cardiometabolic risk factors, such that individuals with higher URN reappraisal ability and lower stress reactivity, compared to those with higher URN reappraisal ability and lower stress reactivity, will engage in healthier behavior (i.e., more physical activity, better sleep quality).

H2c: Stress reactivity and DRN reappraisal ability will interact to predict physical cardiometabolic risk factors, such that individuals with higher DRN reappraisal ability and higher stress reactivity, compared to those with lower DRN reappraisal ability and higher stress reactivity, will have lower abdominal obesity, systolic and diastolic blood pressure, LDL cholesterol, triglycerides, and HbA1c, and higher HDL cholesterol.

H2d: Stress reactivity and URN reappraisal ability will interact to predict physical cardiometabolic risk factors, such that individuals with higher URN reappraisal ability and lower stress reactivity, compared to those with higher URN reappraisal ability and lower stress reactivity, will have lower abdominal obesity, systolic and diastolic blood pressure, LDL cholesterol, triglycerides, and HbA1c, and higher HDL cholesterol.

Hypothesis 3: Relation Between Behavioral and Physical Risk Factors

H3: Physical activity and sleep quality will be negatively associated with physical cardiometabolic risk factors.

5.3. METHOD

Participants

Adults between the ages of 18 and 65 were recruited through study advertisement emails and flyers in the UNC Charlotte campus community, as well as the greater Charlotte area. A simple quota sampling method was employed to ensure that weight status categories in the general U.S. population were represented in the study sample. The World Health Organization (2017) defines three main categories of weight status: normal weight (BMI 18.50 – 24.99 kg/m^2), overweight (BMI 25 – 29.99 kg/m^2), and obese (BMI $\geq$ 30 kg/m^2). The CDC (2016c) estimates that 27.6% of U.S. adults age 20 years and over were normal weight, 32.8% were overweight and 37.9% were obese in 2013-2014. Therefore, of the eighty-nine participants recruited, 37% were in a normal BMI weight status category (n = 33), 37% were in an overweight BMI weight status category (n = 33), and 26% were in an obese BMI weight status category (n = 26).

Participant inclusionary criteria consisted of being 18 years of age or older, fluent in English, and having a body composition that puts them in one of the three BMI weight status categories. Participant exclusionary criteria consisted of being less than 18 years of age, not fluent in English, and having a BMI < 18.5 kg/m^2 (indicative of being underweight). Additional exclusion criteria specific to the measurement of HRV, blood pressure, cholesterol, and body fat percentage consisted of weighing less than 110 pounds (finger stick blood sample requirement), weighing more than 350 pounds (DEXA scan weight limit), females who were pregnant or attempting to become pregnant, self-reporting a heart condition or overt cardiovascular disease, being currently distressed by a traumatic event, currently using any tobacco products, currently using any hypertensive medications (e.g., ACE inhibitors, angiotensin receptor blockers, calcium channel blockers, thiazide diuretics), currently using any mood-altering medications (e.g., selective serotonin reuptake inhibitors, serotonin and norepinephrine reuptake inhibitors, norepinephrine and dopamine reuptake inhibitors, tricyclic antidepressants, monoamine oxidase inhibitors, benzodiazepines, beta-blockers), currently using any cholesterol medications (e.g., statins, niacin, fibrates), currently using any illicit drugs (e.g., amphetamines, cocaine, hallucinogens, inhalants), and using marijuana more than once per week for the previous three weeks.

Participants were compensated with either 7 research credits (UNC Charlotte psychology subject pool) or $30 in Target gift cards (all other participants) for completing the study. All participants also received a health snapshot that provided information on their resting blood pressure, heart rate, BMI, HbA1c, cholesterol, triglycerides, and DEXA body scan results at the end of the study.

Pairwise deletion was used to exclude participant values from analyses and was specific to each variable (see Measures section for detailed information on the values excluded for each variable and Table 6 for the *N* for each focal variable). These exclusions reduced the initial sample size of n = 89 by between 1-26 participants, yielding a final sample size of n = 63-88 depending on the analysis. Participants (60.7% female, 24.7% from psychology subject pool) were, on average, 27.82 years old (*SD* = 8.69 years; range = 18-58 years). Regarding race and ethnicity, 56.18% of participants identified as White, non-Hispanic, 1.12% identified as White, Hispanic, 16.85% identified as Black or African American, non-Hispanic, 8.99% identified as Hispanic for their race and ethnicity, 8.99% identified as Asian, non-Hispanic, 1.12% identified as

Asian, Hispanic, and 6.74% identified as biracial, multiracial, or other. Regarding educational attainment, 16.9% of participants reported being a high school graduate or completing their GED, 33.7% reported completing some college, including 2-year degrees, 18% reported completing a Bachelor's Degree, 22.5% reported completing a Master's Degree, and 9% reported completing a Doctoral Degree. Regarding household income, 11.2% of participants reported earning less than $10K, 16.9% reported earning $10K-$24,999, 20.2$ reported earning $25K-$49,999, 15.7% reported earning $50K-$74,999, 11.2% reported earning $75K-$99,999, 11.2% reported earning more than $100K, and 13.5% chose not to report their income. Regarding participant body composition, the average BMI of participants was 27.15 kg/m^2 (*SD* = 5.00 kg/m^2, range = 19.99-46.56 kg/m^2) and the average DEXA-scanned body fat percentage was 34.32% (*SD* = 8.89%, range = 14.80-52.10%).

Procedure

The present study consisted of three parts: Part 1—an online questionnaire, Part 2—an in-person experimental laboratory session, Part 3—a DEXA scan session. We also included a brief follow-up survey not reported here asking questions about participants' thoughts about the study and their reactions to receiving their health information. Prospective participants were asked to complete an online screening questionnaire prior to being invited to participate in the study. The screening questionnaire included demographic, weight status, health status, and medication use questions. The research team reviewed the screening questionnaires to determine study eligibility, after which eligible individuals were emailed a link to complete the Part 1 online survey and scheduled for Part 2.

In Part 1, informed consent was obtained with an electronic signature and participants were asked to complete the study in a quiet room free from distractions. The online survey took approximately 1 hour to complete and included measures of stress, emotion, health behavior engagement, physical and mental health, and demographic characteristics.

In the Part 2 in-person lab session, informed consent was obtained, and the researcher reviewed the participant's screening questionnaire responses. Participants were also asked about the activities they engaged in the night before the session and immediately before the session, as well as everything they ate and drank that day. Because blood pressure and HRV follow a diurnal rhythm (Bilan et al., 2005), all participants were scheduled for Part 2 between 11:00am and 8:00pm. Anthropometric measurements were taken first, including height, weight, and waist circumference. Then, three consecutive brachial artery blood pressure readings were taken with two minutes between each reading. Participants were then directed into the experimental room where electrodes from a Biopac electrocardiogram (ECG) amplifier were attached in a standard lead II configuration (electrodes were attached to the right and left of the sternum and left ankle; the ankle has the positively charged lead). After a three-minute acclimation period, participants completed a three-minute paced breathing exercise where they were instructed to inhale for five seconds and exhale for five seconds. The first baseline measure of resting HRV was obtained during this exercise.

Next, the research assistant instructed participants on how to complete the emotion regulation tasks. The participant was left alone in the experimental room to complete a 20-minute emotion regulation task that is not part of the present study, then they completed the 35-minute ERA task. For the ERA task, participants viewed a two-minute emotionally neutral film clip, followed by five two-minute film clips depicting a weight-related health situation pretested to induce moderate amounts of negative emotion (see Measures section for a full description and Figure 4 for task schematic). After each film clip, participants completed a post-film clip questionnaire.

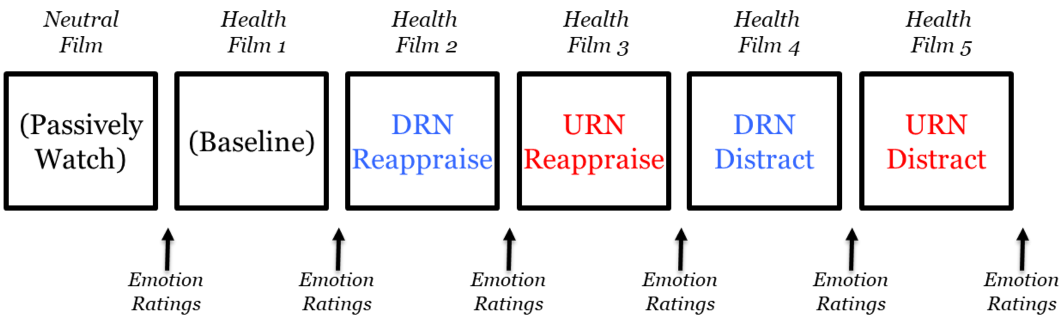

Figure 4. Schematic of experimental procedure for the emotion regulation ability (ERA) task. Order of instructions for which strategy and regulation direction to implement were counterbalanced across participants. Following each film clip, participants rated the greatest amount of emotion experienced to 11 positive and negative emotion prompts (*positive*: amusement, happiness, joy, love; *negative*: anger, anxiety, disgust, fear, guilt, sadness, shame) on a nine-point Likert scale (1 = *Not at all/None*, 5 = *Somewhat/Some*, 9 = *Extremely/A great deal*). DRN = Down-Regulation Negative, URN = Up-Regulate Negative.

Upon completing the ERA task, participants sat quietly for a short recovery period, then completed another three-minute paced breathing task to establish another baseline HRV measurement. Then participants completed a five-minute well-validated social evaluative stress task (counting backwards in front of a judge; Chida & Hamer, 2008; Waugh et al., 2012) in front of an evaluator, followed by a five-minute recovery period of sitting quietly and coloring in a coloring book. Finally, the ECG electrodes were removed, and the finger stick blood sample was completed to test participants' cholesterol, and triglycerides, HbA1c. Participants were then debriefed and scheduled for the DEXA scan session if they had not already done so. The entire Part 2 lab session took approximately 2 hours and 30 minutes to complete.

In Part 3, participants visited the Health Risk Assessment Lab within the Kinesiology department for the DEXA body scan. A research assistant first measured the participant's height and weight. The participant then laid down face-up in the DEXA scanner and the scanning arm moved over their body measuring body fat percentage (including abdominal body fat), lean mass percentage, and bone mineral density. The DEXA scan lasted 6-10 minutes and the entire Part 3 session lasted approximately 20 minutes. This study was approved by the university Institutional Review Board and Institutional Biosafety Committee before data collection began.

Measures

Physiological stress reactivity. Participants completed a social evaluative mental arithmetic stressor during the Part 2 lab session and HRV was measured via a Biopac MP36R with a 3-lead ECG that measured heart rate continuously. HRV refers to beat-to-beat alterations in heart rate and is sensitive and responsive to acute stress because it is posited to be a dynamic index of autonomic nervous system reactivity and sympathovagal balance (Berntson et al., 1997; Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). Following a three-minute pre-task paced breathing baseline period, participants completed one of three versions of a serial subtraction task in front of an evaluator using different starting numbers and subtraction values (4,672 by 17s, 3,412 by 13s, 5,870 by 19s; counterbalanced; Waugh et al., 2012). After the five-minute stress task, the evaluator left the room and participants sat quietly and colored in a coloring book for a five-minute recovery period.

The ECG measurement took 2000 samples per second and HRV was assessed using a frequency domain spectral analysis, which decomposes a complex HRV wave form into its constituent frequencies. The HRV spectrum contains a high frequency (HF) component (0.18 – 0.4 Hz), which is posited to represent primarily parasympathetic nervous system (PNS) influence, and a low frequency (LF) component (0.04 – 0.15 Hz), which is posted to reflect sympathetic nervous system (SNS) and PNS influence (Berntson et al., 1997). Therefore, we assessed the ratio of LF to HF HRV to capture the balance of PNS and SNS activity and thus an individual's autonomic reaction to the stressor.

To process the HRV data, Acqknowledge 5.0 software was first used to clean the data and remove any artifacts. Then, the autoregressive modeling function within Kubios HRV Standard (ver. 3.0) software was used to obtain the fast Fourier transformed LF/HF ratio for appropriate bins representing baseline and peak reactivity. The baseline bin was the final one minute of the second paced breathing baseline period just before the stress task. Peak reactivity was based on the individual and was developed by using the LF/HF ratio from the 30-second bin during the stress task for which the participant's root mean square of the successive RR interval differences (RMSSD; a time-domain measure of HRV) was the lowest (indicating peak SNS activity and/or peak PNS withdrawal).

The average LF/HF ratio during the baseline bin was 11.88 ms^2 (SD = 9.10 ms^2) and the average LF/HF ratio during the peak reactivity bin was 3.06 ms^2 (SD = 3.04 ms^2). Both variables were log 10 transformed before calculating the physiological stress reactivity variable to achieve a residual distribution that was approximately normal. This spectral analysis of each bin in the time series allowed us to calculate the percent change of the LF/HF ratio from baseline to peak reactivity, with a higher percent change reflecting greater physiological stress reactivity.

Four participants were excluded from physiological stress reactivity analyses due to experimenter error related to the ECG data collection (e.g., stress task file was shorter than five minutes and could not be fully binned, baseline file was missing, etc.). An additional two participants were excluded due to outlier values on the baseline and peak reactivity variables—one value three *SD* above the mean for the baseline ratio and one value three *SD* above the mean for the peak reactivity ratio were removed. Additionally, the physiological stress reactivity variable (reflecting the percent change from baseline to peak reactivity) was inspected for outliers and two participants were removed who demonstrated values more than three *SD* above or below the mean.

Perceived stress reactivity. Perceived stress reactivity was assessed in the Part 1 online survey via the Perceived Stress Reactivity Scale (PSRS; Schlotz et al., 2011), a 23-item questionnaire that assesses an individual's typical response style across stressful situations in daily life. Participants were asked to indicate their general reactions to psychologically stressful situations, such as, "when I am criticized by others," on a three-point Likert scale ranging from 0 to 2, with each set of three responses differing for each question. Responses were averaged, with higher total scores indicating higher levels of perceived stress reactivity. The reliability of the PSRS in the present sample was $\alpha = .84$ and this measure has been validated against objective assessments of stress reactivity in other studies (e.g., higher scores were associated with steeper cortisol responses to psychosocial stress; Schlotz, Hammerfald, Ehlert, & Gaab, 2011).

Health-focused emotion regulation. Health-focused emotion regulation was assessed during the Part 2 lab session with a novel ERA task (Sagui-Henson & Levens, *in preparation*). Participants view one neutral film (Troy et al., 2010) and five short health-related film clips that induced moderate amounts of negative emotion (see Figure 4). Participants passively watch the neutral and first health-related films, then actively up- or down-regulated their negative emotions using reappraisal or distraction. Participants rated their emotions after each clip. A negative emotion composite rating was calculated for each video, with the composite score after the first health film clip serving as the participants' baseline negative emotions. A repeated measures design was utilized to avoid habituation or regression to the mean. Specifically, the order of the film clip presentation was the same, but the strategy (reappraisal or distraction) and regulation direction (up or down) instructions were counterbalanced across participants. Instructions for up- and down-regulating negative emotions were developed based on Troy et al.'s (2010) instructions (see Appendix A-D). Although the present study assessed distraction and reappraisal ability, analyses only focused on reappraisal ability.

Post-film questionnaire. When responding to the post-film questionnaire, participants were instructed to reflect on how they felt while watching the previous film clip. Participants first rated the greatest amount of 11 discrete emotions they experienced, including 4 positive emotions (amusement, happiness, joy, and love) and 7 negative emotions (anger, anxiety, disgust, fear, guilt, sadness, and shame) (Rottenberg, Ray, & Gross, 2007; Troy et al., 2010). Discrete emotions were rated on a nine-point Likert scale (1 = *Not at all/None*, 5 = *Somewhat/Some*, 9 = *Extremely/A great deal*). Next, an attention check question was presented about the film's content. Finally, participants responded to an open-ended question asking about the way in which they used the emotion regulation instructions to manage their emotions.

Calculation of ERA. An individual's ability to DRN using reappraisal is reflected by his or her ability to reduce negative emotion, while an individual's ability to URN using reappraisal is reflected by his or her ability to increase negative emotion. Thus, to calculate DRN ability, negative emotion composite ratings after the film clip in which they decreased negative emotions were subtracted from the composite ratings given after the baseline emotion-eliciting film to create a DRN change score, with higher scores indicating greater DRN reappraisal ability. Alternately, URN ability was calculated by subtracting baseline ratings from the negative emotion composite ratings given after the film in which they increased negative emotions, with higher scores indicating greater URN reappraisal ability. All ratings were z-scored for each film clip before calculating ability scores so that score differences could be compared across individuals.

Five participants' ERA scores were excluded pairwise from analyses due to experimental session notes that indicated equipment or participant error during the ERA task. Four of these participants had both DRN and URN ability scores excluded, one participant had only their DRN ability score excluded, and one participant had only their URN ability score excluded.

Behavioral cardiometabolic risk factors.

Physical activity. Physical activity was measured during the Part 1 online survey via the 31-item International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) that asks about specific types of activities undertaken in a typical 7-day period for work, transportation, domestic and garden, and leisure-time at three levels of activity (walking, moderate, and vigorous). The present study did not assess transportation-related activity or include it in the total physical activity score. Physical activity expends energy; therefore, a metabolic equivalent (MET) is a commonly used unit for describing an individual's energy expenditure. Each type of activity is weighted by its energy requirements defined in METs to yield a score in MET-minutes. The number of MET-minutes per week is computed by multiplying the MET score of an activity by the minutes performed and the number of days per week. Three activity level domain scores were calculated by summing the total walking, moderate, and vigorous MET-minutes per week for the different types of activities. These three domain scores were summed to yield a total physical activity score. Reliability and validity testing indicates that this measure has acceptable psychometric properties and is suitable for national population-based studies of physical activity participation (Brown, Trost, Bauman, Mummery, & Owen, 2004; Craig et al., 2003). Higher scores indicate greater physical activity in MET-minutes per week. Three participants were excluded from physical activity analyses due to outlier values that were three *SD* above the mean.

Sleep quality. Sleep quality was measured during the Part 1 online survey via the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), a 19-item self-report questionnaire developed to assess sleep quality and disturbances over a one-month time interval. The items were combined to form seven component scores (e.g., poor sleep quality, duration, disturbance), each weighted equally on a scale from 0 to 3 (0 = *no difficulty*, 3 = *severe difficulty*). Component scores were reverse scored and summed to yield one PSQI score ranging from 0 to 21, with higher scores indicating better sleep quality. The reliability of all the components of the PSQI in the present sample was $\alpha = .67$. One participant was removed from sleep quality analyses due to an outlier value three *SD* below the mean.

Physical cardiometabolic risk factors.

Abdominal obesity. Dual-Energy X-Ray Absorptiometry (DEXA) scanning was used to assess abdominal obesity. Total body imaging was acquired during the Part 3 lab session via a GE Healthcare Lunar iDXA scanner. Participants were scanned using standard imaging and positioning protocols and Encore software version 15 generated measures of overall body fat percentage, lean body mass, and bone mineral density. Regions-of-interest were defined by the analytical program including six different corporeal districts: total body, trunk, upper limbs, lower limbs, android region, and gynoid region. Percent body fat in the android region denotes abdominal obesity (Kaul et al., 2012), with higher percentages indicating higher obesity. One participant was not included in abdominal obesity analyses due to missing DEXA scan values.

Blood pressure. Resting systolic and diastolic blood pressure were assessed during the Part 2 experimental lab session. An aneroid sphygmomanometer Omron blood pressure monitor was used to take three successive arterial blood pressure readings on the participant's left arm, with a two-minute interval between each reading (Pickering et al., 2005). All three systolic and diastolic readings were averaged to represent the participant's systolic and diastolic blood pressure, respectively. If consecutive values were more than 10 mmHg different (indicating that something happened in the environment, the machine had an issue, or the participant engaged in a behavior that would significantly alter blood pressure), that value was removed, and the other two readings were averaged. Higher levels indicate higher systolic and diastolic blood pressure.

Cholesterol. Research indicates that both elevated LDL cholesterol and reduced HDL cholesterol contributes to cardiometabolic disease risk (see Cannon, 2008). LDL cholesterol contributes to atherosclerosis (plaque build-up that narrows arteries), which can contribute to a heart attack or stroke, while HDL cholesterol helps remove LDL cholesterol from the arteries and may be protective against cardiometabolic disease progression. Non-fasting cholesterol was measured during the Part 2 lab session with a CardioChek portable blood test system, which used 15-40 µl of blood from a finger stick blood draw and provided measures of LDL and HDL cholesterol. Non-fasting lipid tests can be used for assessing cardiovascular risk (Nordestgaard et al., 2016; Stone et al., 2013). HDL cholesterol below 40 mg/dL and LDL cholesterol above 130 mg/dL are considered abnormal; however, these variables were treated as continuous, with higher levels indicating a higher amount of that type of cholesterol. HDL cholesterol was log 10 transformed to achieve a residual distribution that was approximately normal. Due to missing values from equipment error, eight participants were not included in HDL cholesterol analyses and ten participants were not included in LDL cholesterol analyses.

Triglycerides. Triglycerides were assessed during the Part 2 lab session with a CardioChek portable blood test system. Triglycerides are used to store excess energy from food consumption and elevated levels are associated with atherosclerosis. Elevated triglycerides above 150 mg/dL are considered abnormal and increase risk for cardiometabolic diseases. This variable was treated as continuous, with higher levels of this variable indicating elevated serum triglyceride levels. The triglycerides variable was log 10 transformed to achieve a residual distribution that was approximately normal. Eight participants were not included in triglycerides analyses due to missing values from equipment error. One participant was excluded from triglycerides analyses due to outlier value that was three *SD* above the mean.

HbA1c. Glycated hemoglobin (HbA1c), a form of hemoglobin that represents the three-month average plasma glucose concentration, was assessed during the Part 2 lab session with a DCA Vantage Analyzer. This point-of-care system uses 1 µl of blood from a finger stick blood draw and provides rapid on-site blood chemistry values and measurements. The HbA1c test does not require fasting and blood can be drawn for the test at any time of day (National Institute of Diabetes, Digestive and Kidney Diseases, 2014). Non-fasting levels of HbA1c ≤ 5.6% are considered normal, levels between 5.7 and 6.4% are considered elevated and in the prediabetes range, and levels ≥ 6.5% are considered in the diabetes range. This variable was treated as a continuous variable with higher levels indicating higher HbA1c. One participant was not included in HbA1c analyses due to a missing value from equipment error. Two participants were excluded from HbA1c analyses due to outlier values that were three *SD* below the mean.

Demographics. Demographics were assessed during the Part 1 online survey. Participants self-reported their age and biological sex assigned at birth (0 = male, 1 = female). For racial and ethnic identity, participants indicated if they identified as Spanish, Hispanic, or Latino/a and reported the racial group that best represented themselves from preselected options (e.g., White, Black or African American, etc.). Educational background was assessed by asking respondents the highest level of education they had completed on a six-point scale (1 = *11th grade or less (not high school graduate),* 7 =

Doctoral Degree (PhD, MD, JD, etc.)). Income was assessed by asking participants the range that best described their pre-tax annual household income on a seven-point scale (1 = *less than $10,000*, 6 = *more than $100,000*). Subjective social status was assessed with the well-validated MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo, & Ickovics, 2000).

Body mass index (BMI). Height and weight were assessed during the Part 2 lab session to calculate participants' BMI. Height was measured using a stadiometer and weight was assessed with an electronic weight scale. BMI was calculated using the imperial formula of weight in pounds multiplied by 703 and divided by height in inches squared. Self-reported height and weight were also assessed in the screening questionnaire as an initial check of participants' BMI status.

Covariates.

Emotional reactivity. Emotional reactivity was calculated for each participant by subtracting the negative emotion composite ratings after the neutral film from the ratings given after the baseline film, with higher scores indicating greater emotional reactivity to the films (M = 2.23, SD = 1.47).

Reappraisal use. The 6-item reappraisal subscale from the Emotion Regulation Questionnaire (Gross & John, 2003) was used to assess habitual reappraisal use, a theoretically distinct construct from reappraisal ability. Respondents were asked questions such as, "I control my emotions by *changing the way I think* about the situation I'm in," on a seven-point Likert scale (1 = *strongly disagree*, 7 = *strongly agree*). Scores were averaged, with higher scores indicating higher reappraisal use (M = 5.07, SD = 1.21). The reliability of the reappraisal subscale in the present sample was α = .90.

Depressive symptoms. Prior literature associates depressive symptoms with stress reactivity (Felsten, 2004) and reappraisal ability (Troy et al., 2010). Depressive symptoms were assessed via the Center for Epidemiologic Studies Short Depression Scale (CES-D 10; Radloff, 1977), a well-validated, 10-item scale that measures depressive symptomatology during the past week. Responses were noted on a four-point Likert scale (0 = *rarely or none of the time (less than 1 day)*, 4 = *most or all of the time (5-7 days)*), and scores were averaged with higher scores indicating greater depressive symptoms (M = .84, SD = .56). The reliability of CES-D in the present sample was α = .82.

Anxiety symptoms. Anxiety symptoms were measure with the Generalized Anxiety Disorder scale (Spitzer, Kroenke, Williams, & Lowe, 2006), a 7-item questionnaire used to evaluate the presence and severity of anxiety symptoms during the past two weeks. Responses were noted on a four-point Likert scale (1 = *not at all sure,* 4 = *nearly every day*) and scores were averaged, with higher scores indicating higher anxiety symptoms (M = .82, SD = .66). The reliability of this measure in the present sample was α = .85.

Social desirability. The Marlowe Crown Social Desirability Scale Form C (Reynolds, 1982) was utilized to control for the presence of socially desirable responding, which is particularly relevant for self-reported health behavior engagement. This 13-item questionnaire assessed the extent to which respondents answer truthfully or misrepresent themselves to manage their self-presentation. Responses were noted in a true (0) false (1) format and one point was assigned for each socially desirable response. Scores were summed, with higher values indicating higher socially desirable response tendencies (*M* = 6.47, *SD* = 2.57).

Statistical Analyses

First, the data were cleaned, and all measures were scored. The ECG data was screened for evidence of atypical heart function or significant abnormalities (e.g., lack of any component of the QRS complex, lack of the P, S, or T complex, etc.) Before scoring the ERA task, participants' emotion ratings were dropped using pairwise deletion if the experimental notes from their session indicated they had any issues with the task (e.g., video skipping or not loading). Descriptive statistics and tests for normality were used to identify outliers on focal variables and determine which variables were non-normally distributed and required transformation. Additionally, all targeted variables were correlated to assess if all associations were in the expected direction, as posited by the literature.

Principle Components Analysis (PCA) was used to combine the physical risk factors one composite score. Because the set of risk factors are not conceptualized as indicators of a latent construct (i.e., blood pressure and HbA1c are both physical risk factors but are not indicators of the same underlying construct), linear components were constructed using PCA. Unlike latent variable modeling, PCA creates observed variables that are linear composites of the set of component variables. PCA does not assume that they reflect the same construct (i.e., a reflective model), but rather only that they can all be joined to index a larger formative concept (i.e., a formative model).

To accomplish this, the set of physical risk factors were submitted to a PCA and the first unrotated linear component was extracted. The set of physical risk factors included abdominal obesity, systolic and diastolic blood pressure, HDL and LDL cholesterol, triglycerides, and HbA1c and the first unrotated principle component based on these seven items was extracted. The component account for 32.29% of the observed score variance and physical risk factors is reported in a z-score metric with a mean of 0 and standard deviation of 1. These standardized component scores served as the primary criterion in the regression models. Physical activity and sleep quality were modeled as separate outcomes.

Multiple linear regression in SPSS 23.0 was used to test the conceptual model (see Figure 3). Briefly, polynomial regression was used to test Hypothesis 1, moderated regression was used to test Hypothesis 2, and hierarchical linear regression was used to test Hypothesis 3. Partially adjusted models that control for age, sex, and emotional reactivity are presented for each analysis. If a model was significant ($p < .05$) or trending toward significance ($p < .10$) after being partially adjusted, a fully adjusted model controlling for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability was conducted and differences in significance presented. Further, if a model was significant with the physical risk factors PCA as the criterion, additional analyses are presented testing each risk factor as the criterion separately to see which factor(s) were driving the relationship. Listwise deletion was used in all regression models.

Hypothesis 1: Curvilinear relation between stress reactivity and risk factors

Polynomial regression was used to assess the curvilinear relation between stress reactivity and the behavioral and physical risk factors. Six polynomial regressions were conducted using SPSS 23.0: two regressions assessing the association of physiological and perceived stress reactivity with physical activity (H1a), two regressions assessing the association of physiological and perceived stress reactivity and sleep quality (H1a), and two regressions assessing the association of physiological and perceived stress reactivity with physical risk factors (H1b). All variables were standardized before analyses (i.e., continuous variables were standardized and categorial covariates were weighted effect coded). Additionally, Centered Leverage Value and Mahalanobis Distance case diagnostics were used to identify and remove multivariate outliers before analysis. For each model, a quadratic term was created by squaring the respective standardized stress reactivity variables. Using hierarchical regression and one of the cardiometabolic risk factors as the criterion, covariates were entered as predictors in step one, stress reactivity was entered as a predictor in step two, and the quadratic term was entered as a predictor in step three to determine the incremental variance of the quadratic effect. A significant curvilinear relation was evident if there was a significant increase in R^2 after introducing the quadratic term as a predictor in the third step of the regression analysis.

Hypothesis 2: Stress reactivity and ERA interact to predict risk factors

Moderated regression was used to assess the interaction between stress reactivity and ERA in the prediction of health outcomes. Physiological and perceived stress reactivity were interacted with DRN reappraisal ability to predict physical activity and sleep quality (H2a) and physical risk factors (H2b). Physiological and perceived stress reactivity were also interacted with URN reappraisal ability to predict physical activity and sleep quality (H2c) and physical risk factors (H2d). All variables were standardized before analyses. For each model, an interaction term was computed as the product of the standardized stress reactivity and the ERA variables. Using hierarchical regression and one of the cardiometabolic risk factors as the criterion, covariates were entered as predictors in step one, the standardized stress reactivity and ERA variables were entered as predictors in step two, and the interaction term was entered as a predictor in step three to determine if these two variables had a synergistic effect above and beyond the variables by themselves. A significant interaction was evident if there was a significant increase in R^2 after introducing the interaction term as a predictor in the third step of the regression analysis. The simple slopes were graphed for any significant findings to better understand the nature of the interaction.

Hypothesis 3: Relation between behavioral and physical risk factors

Linear regression was used to assess the relation between the behavioral and physical cardiometabolic risk factor variables. Using hierarchical linear regression and physical cardiometabolic risk factors as the criterion, covariates were entered in step one and physical activity and sleep quality were entered in step two. The practical and statistical significance of the change R^2 from step one to step two, and the partial regression coefficients for the behavioral risk factors variable were examined.

5.4. RESULTS

Descriptive Statistics and Zero-Order Correlations

Descriptive statistics and Pearson correlations for all focal variables are presented in Table 6 and Table 7, respectively. Physiological stress reactivity demonstrated a trending negative correlation with URN reappraisal ability (r = -.19, p < .10) and was negatively associated with sleep quality (r = -.26, p < .05). Perceived stress reactivity was positively associated with DRN reappraisal ability (r = .25, p < .05) and negatively associated with sleep quality (r = .31, p < .01). DRN reappraisal ability was negatively associated with URN reappraisal ability (r = -.27, p < .05) and physical activity (r = -.22, p < .05) and positively correlated with LDL cholesterol (r = .25, p < .05). URN reappraisal ability demonstrated a trending positive correlation with HbA1c (r = .21, p < .10). Regarding associations among the behavioral and physical risk factors, physical activity was negatively associated with HDL cholesterol (r = -.25, p < .05). Regarding associations among the physical risk factors, abdominal obesity was positively associated with diastolic blood pressure (r = .24, p < .05), triglycerides (r = .33, p < .01), and HbA1c (r = .22, p < .05) and was negatively associated with negatively associated with HDL cholesterol (r = -.28, p < .05). Additionally, systolic and diastolic blood pressure were positively correlated (r = .47, p < .01), diastolic blood pressure was positively associated with HbA1c (r = .24, p < .05), and HDL cholesterol was negatively associated with triglycerides (r = -.41, p < .01).

Table 6

Descriptive Statistics for Focal Variables

Variables	*N*	*M*	*SD*	Min	Max
Physiological Stress Reactivity (%)	81	-.71	.57	-2.53	.67
Perceived Stress Reactivity	89	.89	.33	.09	1.65
Down-Regulate Neg Reappraisal Ability	84	.65	1.23	-2.00	6.14
Up-Regulate Neg Reappraisal Ability	84	.23	1.17	-3.14	4.00
Physical Activity (MET-minutes)	86	4867.17	4321.30	0.00	17670.00
Sleep Quality	88	14.97	2.79	8.00	20.00
Abdominal Obesity (%)	88	36.39	12.12	7.90	60.40
Systolic Blood Pressure (mmHg)	89	116.75	12.48	78.33	148.00
Diastolic Blood Pressure (mmHg)	89	70.05	6.50	58.33	86.67
HDL Cholesterol (mg/dL)	81	50.89	15.18	27	94
LDL Cholesterol (mg/dL)	79	85.68	27.24	37	167
Triglycerides (mg/dL)	79	105.96	53.64	52	266
HbA1c (%)	86	5.44	.30	4.7	6.0

Note. n = 89. Neg = Negative. HDL = High-density lipoprotein; LDL = Low-density lipoprotein.

Table 7

Zero-Order Correlations Among Focal Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Physiological Stress Reactivity (%)													
2. Perceived Stress Reactivity	.05												
3. DRN Reappraisal Ability	.18	.25[a]											
4. URN Reappraisal Ability	-.19[†]	-.01	-.27[a]										
5. Physical Activity (MET-minutes)	.06	-.11	-.22[a]	.13									
6. Sleep Quality	-.26[a]	-.31[b]	.09	-.12	-.06								
7. Abdominal Obesity (%)	-.07	.15	.12	-.01	-.07	-.17							
8. Systolic Blood Pressure (mmHg)	-.03	-.02	-.08	.09	.16	.05	-.01						
9. Diastolic Blood Pressure (mmHg)	-.02	.10	.11	.05	-.10	.00	.24[a]	.47[b]					
10. HDL Cholesterol (mg/dL)	-.04	.19	.00	-.06	-.25[a]	-.11	-.28[a]	-.14	-.10				
11. LDL Cholesterol (mg/dL)	.01	.16	.25[a]	.01	-.17	.07	.16	.02	.02	-.08			
12. Triglycerides (mg/dL)	.17	.02	-.15	.08	.10	-.09	.33[b]	.17	.20[†]	-.41[b]	.20[†]		
13. HbA1c (%)	-.13	-.10	-.06	.21[†]	.02	.14	.22[a]	.19[†]	.24[a]	-.18	.10	.17	

Note. n = 71-81. [†] $p < .10$, [a] $p < .05$, [b] $p < .01$. HDL = High-density lipoprotein; LDL = Low-density lipoprotein.

H1a: Curvilinear Relation Between Stress Reactivity and Behavioral Risk Factors

The first polynomial regression tested the curvilinear relation between *physiological* stress reactivity and physical activity (n = 77). Two multivariate outliers were removed due to Centered Leverage and Mahalanobis Distance values that were above the case diagnostic cutoff. In step one, the combination of control variables (age and sex) explained a significant amount of variance in physical activity ($R^2 = .09$, $p < .05$). In step two, physiological stress reactivity ($\beta = .05$, $p = .55$) did not significantly predict physical activity ($R^2 = .09$; $\Delta R^2 = .00$, $p = .55$). In step three, the quadratic term (β

= .03, p = .71) did not incrementally predict physical activity (R^2 = .09; ΔR^2 = .00, p = .71), indicating that physiological stress reactivity had no curvilinear relation with physical activity.

The second polynomial regression tested the curvilinear relation between *perceived* stress reactivity and physical activity (n = 86). In step one, the combination of control variables (age and sex) explained a significant amount of variance in physical activity (R^2 = .08, p < .05). In step two, perceived stress reactivity (β = -.04, p = .47) did not significantly predict physical activity (R^2 = .08; ΔR^2 = .00, p = .47). In step three, the quadratic term (β = -.03, p = .47) did not incrementally predict physical activity (R^2 = .09; ΔR^2 = .01, p = .47), indicating that perceived stress reactivity had no curvilinear relation with physical activity.

The third polynomial regression tested the curvilinear relation between *physiological* stress reactivity and sleep quality (n = 79). Two multivariate outliers were removed due to Centered Leverage and Mahalanobis Distance values that were above the case diagnostic cutoff. In step one, the combination of control variables (age and sex) did not explain a significant amount of variance in sleep quality (R^2 = .01, p = .76). In step two, physiological stress reactivity (β = -.33, p < .05) significantly predicted sleep quality (R^2 = .08; ΔR^2 = .07, p < .05). In step three, the quadratic term (β = -.05, p = .72) did not incrementally predict sleep quality (R^2 = .08; ΔR^2 = .00, p = .72), indicating that physiological stress reactivity had no curvilinear relation with sleep quality.

The fourth polynomial regression tested the curvilinear relation between *perceived* stress reactivity and sleep quality (n = 88). In step one, the combination of control variables (age and sex) did not explain a significant amount of variance in sleep quality (R^2 = .01, p = .55). In step two, perceived stress reactivity (β = -.30, p < .05) significantly predicted sleep quality (R^2 = .11; ΔR^2 = .10, p < .05). In step three, the quadratic term (β = .06, p = .40) did not incrementally predict sleep quality (R^2 = .12; ΔR^2 = .01, p = .40), indicating that perceived stress reactivity had no curvilinear relation with sleep quality.

H1b: Curvilinear Relation Between Stress Reactivity and Physical Risk Factors

The fifth polynomial regression tested the curvilinear relation between *physiological* stress reactivity and physical risk factors (n = 66). Two multivariate outliers were removed due to Centered Leverage and Mahalanobis Distance values that were above the case diagnostic cutoff. In step one, the combination of control variables (age and sex) did not explain a significant amount of variance in physical risk factors (R^2 = .03, p = .35). In step two, physiological stress reactivity (β = .03, p = .88) did not significantly predict physical risk factors (R^2 = .03; ΔR^2 = .00, p = .88). In step three, the quadratic term (β = .31, p = .18) did not incrementally predict physical risk factors (R^2 = .06; ΔR^2 = .03, p = .18), indicating that physiological stress reactivity had no curvilinear relation with physical risk factors.

The sixth polynomial regression tested the curvilinear relation between *perceived* stress reactivity and physical risk factors (n = 75). In step one, the combination of control variables (age and sex) did not explain a significant amount of variance in physical risk factors (R^2 = .05, p = .13). In step two, perceived stress reactivity (β = .04, p = .76) did not significantly predict physical risk factors (R^2 = .05; ΔR^2 = .00, p = .76). In step three, the quadratic term (β = .13, p = .21) did not incrementally predict physical risk factors (R^2

= .08; ΔR^2 = .02, p = .21), indicating that perceived stress reactivity had no curvilinear relation with physical risk factors.

H2a: Stress Reactivity and DRN Ability Interact to Predict Behavioral Risk Factors

The first moderated regression tested the interaction between *physiological* stress reactivity and DRN reappraisal ability with physical activity as the criterion (n = 74). In step one, the combination of control variables (age, sex, and emotional reactivity) explained a significant amount of variance in physical activity (R^2 = .11, p < .05). In step two, physiological stress reactivity (β = .10, p = .26) did not predict the criterion; however, DRN reappraisal ability (β = -.16, p < .05) significantly predicted physical activity (R^2 = .17; ΔR^2 = .06, p = .09). This indicates there was only an overall main effect for DRN reappraisal ability. In step three, the interaction term (β = .15, p = .11) did not incrementally predict physical activity (R^2 = .20, ΔR^2 = .03, p = .11) indicating that together, physiological stress reactivity and DRN reappraisal ability do not have an interactive effect that predicts physical activity.

The second moderated regression tested the interaction between *perceived* stress reactivity and DRN reappraisal ability with physical activity as the criterion (n = 81). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical activity (R^2 = .08, p = .09). In step two, neither perceived stress reactivity (β = -.07, p = .31) nor DRN reappraisal ability (β = -.12, p = .10) significantly predicted physical activity (R^2 = .14; ΔR^2 = .06, p = .09). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term (β = .02, p = .79) did not incrementally predict physical activity (R^2 =

.14, $\Delta R^2 = .00$, $p = .79$) indicating that together, perceived stress reactivity and DRN reappraisal ability do not have an interactive effect that predicts physical activity.

The third moderated regression tested the interaction between *physiological* stress reactivity and DRN reappraisal ability with sleep quality as the criterion ($n = 76$). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in sleep quality ($R^2 = .01$, $p = .86$). In step two, physiological stress reactivity ($\beta = -.39$, $p < .01$) significantly predicted sleep quality; however, DRN reappraisal ability ($\beta = .13$, $p = .32$) did not predict the criterion ($R^2 = .11$; $\Delta R^2 = .10$, $p < .05$). This indicates there was only an overall main effect for physiological stress reactivity. In step three, the interaction term ($\beta = -.18$, $p = .25$) did not incrementally predict sleep quality ($R^2 = .13$, $\Delta R^2 = .02$, $p = .25$) indicating that together, physiological stress reactivity and DRN reappraisal ability do not have an interactive effect that predicts sleep quality.

The fourth moderated regression tested the interaction between *perceived* stress reactivity and DRN reappraisal ability with sleep quality as the criterion ($n = 83$ for the partially adjusted model and $n = 82$ for the fully adjusted model; see Table 8). In step one of the partially adjusted model, the combination of control variables did not explain a significant amount of variance in sleep quality ($R^2 = .01$, $p = .77$). In step two, perceived stress reactivity ($\beta = -.38$, $p < .01$) significantly predicted sleep quality; however, DRN reappraisal ability ($\beta = .22$, $p = .09$) did not predict the criterion ($R^2 = .16$; $\Delta R^2 = .15$, $p < .01$). This indicates there was only an overall main effect for perceived stress reactivity. In step three, the interaction term ($\beta = -.27$, $p = .098$) incrementally predicted sleep quality at the trend level ($R^2 = .19$, $\Delta R^2 = .03$, $p = .098$) indicating that together, perceived stress reactivity and DRN reappraisal ability have a marginal interactive effect that predicts sleep quality. After fully adjusting the model, the interaction term (β = -.26, p = .076) was still trending in significance.

Although this interaction was only trending in significance, we plotted the simple slopes from the fully adjusted model to better understand the nature of the potential interaction. The simple slopes (see Figure 5; Hayes & Matthes, 2009) revealed an interesting relationship between perceived stress reactivity and sleep quality at varying levels of DRN reappraisal ability. When an individual has lower DRN ability, there is no relationship between perceived stress reactivity and sleep quality (β = -.01, 95% CI [-.35, .33]); however, when DRN ability is higher, higher perceived stress reactivity predicts poorer sleep quality (β = -.53, 95% CI [-.91, -.15]). Interestingly, those with lower levels of perceived stress reactivity yet higher DRN ability exhibited the best sleep quality; whereas for those with higher levels of perceived stress reactivity, varying levels of DRN ability had no influence on sleep quality.

Table 8
Summary of Hypothesis 2a – Moderated Multiple Regression Analyses for the Interaction Between Perceived Stress Reactivity and DRN Reappraisal Ability Predicting Sleep Quality

	Step 1		Step 2		Step 3			
	β	*S.E.*	β	*S.E.*	β	*S.E.*	R^2	ΔR^2
Partially Adjusted								
(Intercept)	.00	.12	.04	.11	.08	.11		
Age	-.09	.10	-.13	.10	-.16	.10		
Female	-.02	.03	-.01	.03	-.01	.03		
Emotional Reactivity	.05	.09	.06	.09	.05	.09	.01	
Perceived Stress Reactivity			-.38[b]	.11	-.40[c]	.11		
DRN Reappraisal Ability			.22[†]	.13	.25[†]	.13	.16[b]	.15[b]
PSR*DRN					-.27[†]	.16	.19[b]	.03[†]
Fully Adjusted								
(Intercept)	.00	.10	.05	.10	.08	.10		
Age	-.14	.09	-.16[†]	.09	-.18[a]	.09		
Female	-.01	.03	.00	.03	.00	.03		
Subjective Social Status	.04	.10	.07	.10	.06	.10		
Emotional Reactivity	.06	.08	.06	.08	.05	.08		
Reappraisal Use	-.08	.10	-.13	.10	-.12	.10		
Depressive Symptoms	-.37[b]	.14	-.36[a]	.13	-.36[b]	.13		
Anxiety Symptoms	-.17	.14	-.11	.14	-.11	.14		
Social Desirability	.06	.10	.03	.10	.02	.09	.30[b]	
Physio Stress Reactivity			-.25[a]	.11	-.27[a]	.11		
DRN Reappraisal Ability			.20[†]	.12	.23[†]	.12	.37[c]	.06[a]
Physio*DRN					-.26[†]	.14	.39[c]	.03[†]

Note. Partially Adjusted n = 83. Fully Adjusted n = 82. [†]$p < 0.10$, [a] $p < .05$, [b] $p < .01$, [c] $p < .001$. Dependent variable = Sleep Quality; β = standardized beta weight; *S.E.* = standard error; DRN = Down-Regulate Negative; PSR = Perceived Stress Reactivity. The interaction term is the product of the z-scored Perceived Stress Reactivity and DRN Reappraisal Ability variables.

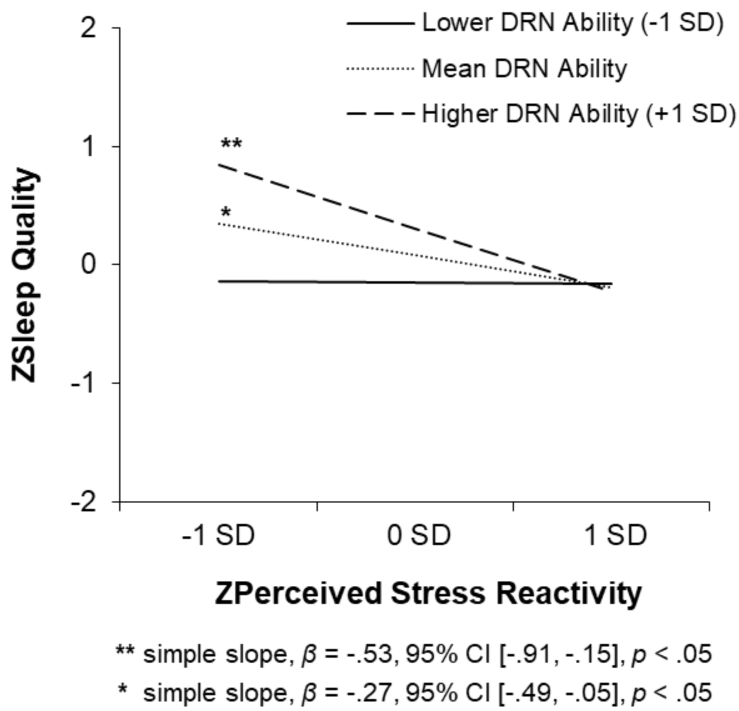

Figure 5. Interactive effect of perceived stress reactivity and down-regulate negative (DRN) reappraisal ability on sleep quality. Analyses controlled for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability. The line representing -1 SD DRN Ability level does not significantly differ from zero.

H2b: Stress Reactivity and URN Ability Interact to Predict Behavioral Risk Factors

The fifth moderated regression tested the interaction between *physiological* stress reactivity and URN reappraisal ability with physical activity as the criterion (n = 73). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical activity (R^2 = .10, p = .07). In step two, neither physiological stress reactivity (β = .10, p = .24) nor URN reappraisal ability (β = .16, p = .12) significantly predicted physical activity (R^2 = .14; ΔR^2 = .04, p = .21). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term (β = .10, p = .49) did not incrementally predict physical activity (R^2 =

.14, ΔR^2 = .00, p = .49) indicating that together, physiological stress reactivity and URN reappraisal ability do not have an interactive effect that predicts physical activity.

The sixth moderated regression tested the interaction between *perceived* stress reactivity and URN reappraisal ability with physical activity as the criterion (n = 81). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical activity (R^2 = .07, p = .13). In step two, neither perceived stress reactivity (β = -.08, p = .23) nor URN reappraisal ability (β = .14, p = .11) significantly predicted physical activity (R^2 = .12; ΔR^2 = .05, p = .12). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term (β = -.01, p = .92) did not incrementally predict physical activity (R^2 = .12, ΔR^2 = .00, p = .92) indicating that together, perceived stress reactivity and URN reappraisal ability do not have an interactive effect that predicts physical activity.

The seventh moderated regression tested the interaction between *physiological* stress reactivity and URN reappraisal ability with sleep quality as the criterion (n = 75). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in sleep quality (R^2 = .01, p = .87). In step two, physiological stress reactivity (β = -.40, $p < .01$) significantly predicted sleep quality; however, URN reappraisal ability (β = -.14, p = .40) did not predict the criterion (R^2 = .11; ΔR^2 = .10, $p < .05$). This indicates there was only an overall main effect for physiological stress reactivity. In step three, the interaction term (β = .23, p = .36) did not incrementally predict sleep quality (R^2 = .12, ΔR^2 = .01, p = .36) indicating that together, physiological stress reactivity and URN reappraisal ability do not have an interactive effect that predicts sleep quality.

The eighth moderated regression tested the interaction between *perceived* stress reactivity and URN reappraisal ability with sleep quality as the criterion (n = 83 for the partially adjusted model and n = 82 for the fully adjusted model; see Table 9). In step one of the partially adjusted model, the combination of control variables did not explain a significant amount of variance in sleep quality ($R^2 = .01$, $p = .79$). In step two, perceived stress reactivity ($\beta = -.34$, $p < .01$) significantly predicted sleep quality; however, URN reappraisal ability ($\beta = -.11$, $p = .47$) did not predict the criterion ($R^2 = .13$; $\Delta R^2 = .12$, $p < .01$). This indicates there was only an overall main effect for perceived stress reactivity. In step three, the interaction term ($\beta = .50$, $p < .05$) incrementally predicted sleep quality ($R^2 = .20$, $\Delta R^2 = .07$, $p < .05$) indicating that together, perceived stress reactivity and URN reappraisal have an interactive effect which predicted an additional 7% of the variance in sleep quality. After fully adjusting the model, the interaction term ($\beta = .43$, $p < .05$) was still significant.

The simple slopes from the fully adjusted model (see Figure 6; Hayes & Matthes, 2009) revealed an interesting dis-ordinal interaction between perceived stress reactivity and URN reappraisal ability. When an individual has lower URN ability, there is a strong negative relationship between perceived stress reactivity and sleep quality ($\beta = -.66$, 95% CI [-1.08, -.24]); however, when URN is higher, higher perceived stress reactivity is associated with better sleep quality ($\beta = .20$, 95% CI [-.20, .61]). Interestingly, those with lower levels of perceived stress reactivity yet lower URN ability exhibited the best sleep quality; whereas for those with higher perceived stress reactivity, higher URN ability was marginally associated with better sleep quality.

Table 9

Summary of Hypothesis 2a – Moderated Multiple Regression Analyses for the Interaction Between Perceived Stress Reactivity and URN Reappraisal Ability Predicting Sleep Quality

	Step 1		Step 2		Step 3			
	β	*S.E.*	*β*	*S.E.*	*β*	*S.E.*	R^2	ΔR^2
Partially Adjusted								
(Intercept)	.00	.12	.03	.11	.04	.11		
Age	-.09	.10	-.12	.10	-.10	.10		
Female	-.02	.03	-.01	.03	-.01	.03		
Emotional Reactivity	.05	.09	.05	.09	.02	.09	.01	
Perceived Stress Reactivity			-.34[b]	.11	-.36[b]	.10		
URN Reappraisal Ability			-.11	.15	-.17	.14	.13[a]	.12[b]
PSR*URN					.50[a]	.19	.20[b]	.07[a]
Fully Adjusted								
(Intercept)	.00	.10	.03	.10	.04	.10		
Age	-.14	.09	-.14	.09	-.12	.09		
Female	-.01	.03	.00	.03	-.01	.03		
Subjective Social Status	.03	.10	.06	.10	.04	.10		
Emotional Reactivity	.05	.08	.06	.08	.02	.08		
Reappraisal Use	-.08	.10	-.14	.10	-.12	.10		
Depressive Symptoms	-.37[b]	.14	-.38[b]	.14	-.33[a]	.13		
Anxiety Symptoms	-.17	.14	-.07	.14	-.12	.14		
Social Desirability	.06	.10	.05	.10	.03	.09	.30[b]	
Physio Stress Reactivity			-.23[†]	.12	-.23[a]	.11		
URN Reappraisal Ability			-.11	.13	-.17	.13	.34[c]	.04
Physio*URN					.43[a]	.18	.39[c]	.05[a]

Note. Partially Adjusted n = 83. Fully Adjusted n = 82. [†]p < 0.10, [a] p < .05, [b] p < .01, [c] p < .001. Dependent variable = Sleep Quality; β = standardized beta weight; *S.E.* = standard error; URN = Up-Regulate Negative; PSR = Perceived Stress Reactivity. The interaction term is the product of the z-scored Perceived Stress Reactivity and URN Reappraisal Ability variables.

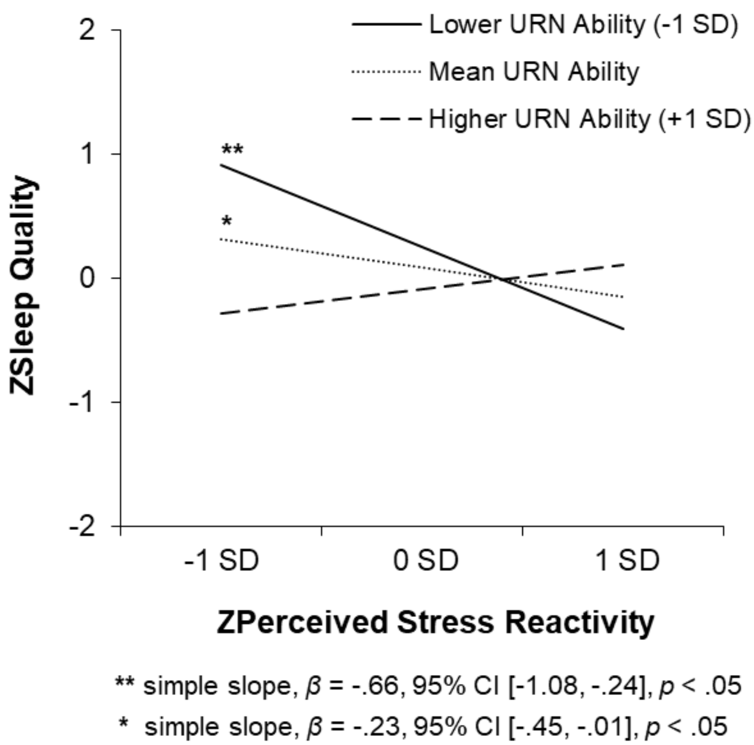

Figure 6. Interactive effect of perceived stress reactivity and up-regulate negative (URN) reappraisal ability on sleep quality. Analyses controlled for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability. The line representing +1 SD URN Ability level does not significantly differ from zero.

H2c: Stress Reactivity and DRN Ability Interact to Predict Physical Risk Factors

The ninth moderated regression tested the interaction between *physiological* stress reactivity and DRN reappraisal ability with physical risk factors as the criterion (n = 64). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical risk factors (R^2 = .04, p = .51). In step two, neither physiological stress reactivity (β = -.01, p = .92) nor DRN reappraisal ability (β = .05, p = .74) significantly predicted physical risk factors (R^2 = .04, ΔR^2 = .00, p = .95). This indicates there was no main effect for either focal predictor. In step three, the interaction term (β = .08, p = .67) did not incrementally predict physical risk factors

(R^2 = .04, ΔR^2 = .00, p = .67) indicating that together, physiological stress reactivity and DRN reappraisal ability do not have an interactive effect that predicts physical risk factors.

The tenth moderated regression tested the interaction between *perceived* stress reactivity and DRN reappraisal ability with physical risk factors as the criterion (n = 71 for the partially adjusted model and n = 70 for the fully adjusted model; see Table 10). In step one of the partially adjusted model, the combination of control variables did not explain a significant amount of variance in physical risk factors (R^2 = .05, p = .31). In step two, neither perceived stress reactivity (β = .08, p = .58) nor DRN reappraisal ability (β = .01, p = .97) significantly predicted physical risk factors (R^2 = .06; ΔR^2 = .01, p = .85). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term (β = -.28, p = .096) incrementally predicted physical risk factors at the trend level (R^2 = .10, ΔR^2 = .04, p = .096) indicating that together, perceived stress reactivity and DRN reappraisal ability have a marginal interactive effect that predicts physical risk factors. After fully adjusting the model, the interaction term (β = -.28, p = .098) was still trending in significance.

Although this interaction was only trending in significance, we plotted the simple slopes from the fully adjusted model to better understand the nature of the potential interaction. The simple slopes (see Figure 7; Hayes & Matthes, 2009) revealed an interesting dis-ordinal interaction between perceived stress reactivity and DRN reappraisal ability. When an individual has lower DRN ability, higher perceived stress reactivity intuitively predicts higher physical risk for cardiometabolic diseases (β = .28, 95% CI [-.12, .68]; however, when DRN ability is higher, higher perceived stress reactivity predicts *lower* physical risk (β = -.28, 95% CI [-.77, .21]. In other words, DRN ability acts as a buffer against the negative influence of higher perceived stress reactivity. Interestingly, those with lower levels of perceived stress reactivity yet higher DRN ability exhibited higher physical risk factors. This pattern of findings highlights that higher DRN ability may be protective against the detrimental impact of *higher* perceived stress reactivity on physical risk for cardiometabolic illness; however, the ability to DRN emotions using reappraisal appears to be harmful when perceived stress reactivity is lower.

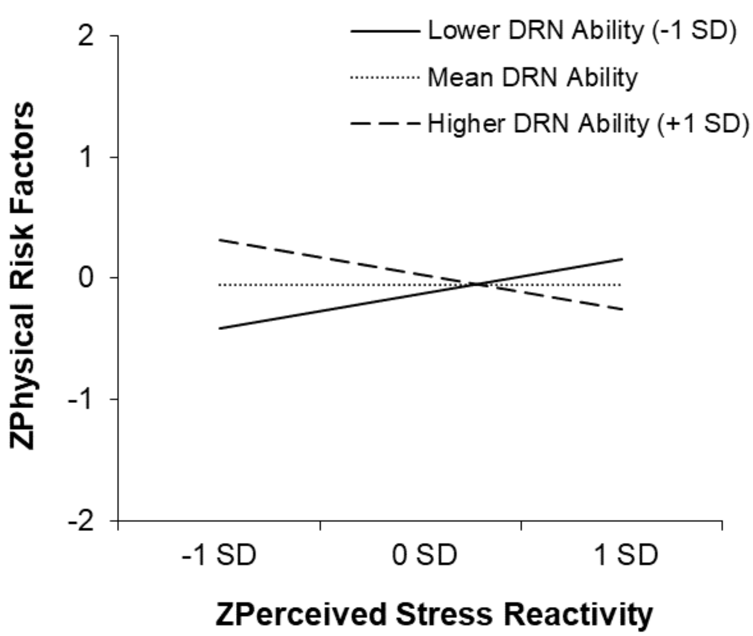

Figure 7. Interactive effect of perceived stress reactivity and down-regulate negative (DRN) reappraisal ability on physical risk factors. Analyses controlled for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability. The lines representing the mean and +/-1 SD DRN Ability levels do not significantly differ from zero.

Table 10
Summary of Hypothesis 2c – Moderated Multiple Regression Analyses for the Interaction Between Perceived Stress Reactivity and DRN Reappraisal Ability Predicting Physical Risk Factors

	Step 1		Step 2		Step 3			
	β	*S.E.*	*β*	*S.E.*	*β*	*S.E.*	R^2	ΔR^2
Partially Adjusted								
(Intercept)	-.09	.13	-.10	.13	-.04	.14		
Age	.10	.12	.11	.12	.08	.12		
Female	-.06	.04	-.06	.04	-.06	.04		
Emotional Reactivity	-.00	.10	-.01	.11	-.00	.10	.05	
Perceived Stress Reactivity			.08	.14	.03	.14		
DRN Reappraisal Ability			.01	.14	.08	.14	.06	.01
PSR*DRN					-.28†	.17	.10	.04†
Fully Adjusted								
(Intercept)	-.11	.13	-.12	.14	-.05	.14		
Age	.16	.13	.16	.13	.13	.13		
Female	-.07†	.04	-.07†	.04	-.07†	.04		
Subjective Social Status	-.05	.13	-.05	.14	-.04	.13		
Emotional Reactivity	.02	.10	.02	.11	.02	.11		
Reappraisal Use	.10	.13	.12	.15	.13	.14		
Depressive Symptoms	-.27	.18	-.26	.19	-.24	.19		
Anxiety Symptoms	.42^{a}	.20	.40†	.22	.39†	.21		
Social Desirability	.06	.13	.06	.13	.04	.13	.13	
Physio Stress Reactivity			.05	.16	-.00	.16		
DRN Reappraisal Ability			.00	.14	.08	.15	.13	.00
Physio*DRN					-.28†	.17	.17	.04†

Note. Partially Adjusted n = 71. Fully Adjusted n = 70. $^{\dagger}p < 0.10$, ^{a} $p < .05$, ^{b} $p < .01$, ^{c} $p < .001$. Dependent variable = Physical Risk Factors; β = standardized beta weight; *S.E.* = standard error; DRN = Down-Regulate Negative; PSR = Perceived Stress Reactivity. The interaction term is the product of the z-scored Perceived Stress Reactivity and DRN Reappraisal Ability variables.

Because the fully adjusted model was trending with physical risk factors as the criterion, additional analyses were explored with each risk factor as a separate criterion to see which factor(s) may be driving the relationship. There were no significant interactions between *perceived* stress reactivity and DRN reappraisal ability in predicting abdominal obesity, HDL cholesterol, LDL cholesterol, or HbA1c. However, there were significant interactions between these predictor variables with both systolic and diastolic blood pressure as outcomes. These models were significant ($p < .05$) after fully adjusting for all covariates; thus, only fully adjusted models are presented.

The first exploratory moderated regression tested the interaction between *perceived* stress reactivity and DRN reappraisal ability with systolic blood pressure as the criterion ($n = 83$; see Table 11). In step one, the combination of control variables (age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability) explained a significant amount of variance in systolic blood pressure ($R^2 = .22$, $p < .05$). In step two, neither perceived stress reactivity ($\beta = .02$, $p = .91$) nor DRN reappraisal ability ($\beta = -.07$, $p = .60$) significantly predicted systolic blood pressure ($R^2 = .23$; $\Delta R^2 = .00$, $p = .87$). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term ($\beta = -.34$, $p < .05$) incrementally predicted systolic blood pressure ($R^2 = .28$, $\Delta R^2 = .05$, $p < .05$) indicating that together, perceived stress reactivity and DRN reappraisal have an interactive effect which predicted an additional 5% of the variance in systolic blood pressure.

The simple slopes (see Figure 8; Hayes & Matthes, 2009) revealed an interesting dis-ordinal interaction between perceived stress reactivity and DRN reappraisal ability that aligns with the interaction predicting physical risk factors. When an individual has lower DRN ability, higher perceived stress reactivity intuitively predicts higher systolic blood pressure ($\beta = .32$, 95% CI [-.06, .70]; however, when DRN ability is higher, higher perceived stress reactivity predicts *lower* systolic blood pressure ($\beta = -.36$, 95% CI [-.79,

.07]. In other words, DRN ability acts as a buffer against the negative influence of higher perceived stress reactivity. Interestingly, those with lower levels of perceived stress reactivity yet higher DRN ability exhibited higher systolic blood pressure (119.5 mmHg) compared to those with lower DRN ability (110.5 mmHg). Further, those with higher perceived stress reactivity yet higher DRN ability exhibited lower systolic blood pressure (110.5 mmHg) than those with lower DRN ability (118.5 mmHg). This pattern of findings highlights that higher DRN ability may be protective against the detrimental impact of *higher* perceived stress reactivity on systolic blood pressure; however, the ability to DRN emotions using reappraisal appears to be harmful when perceived stress reactivity is lower.

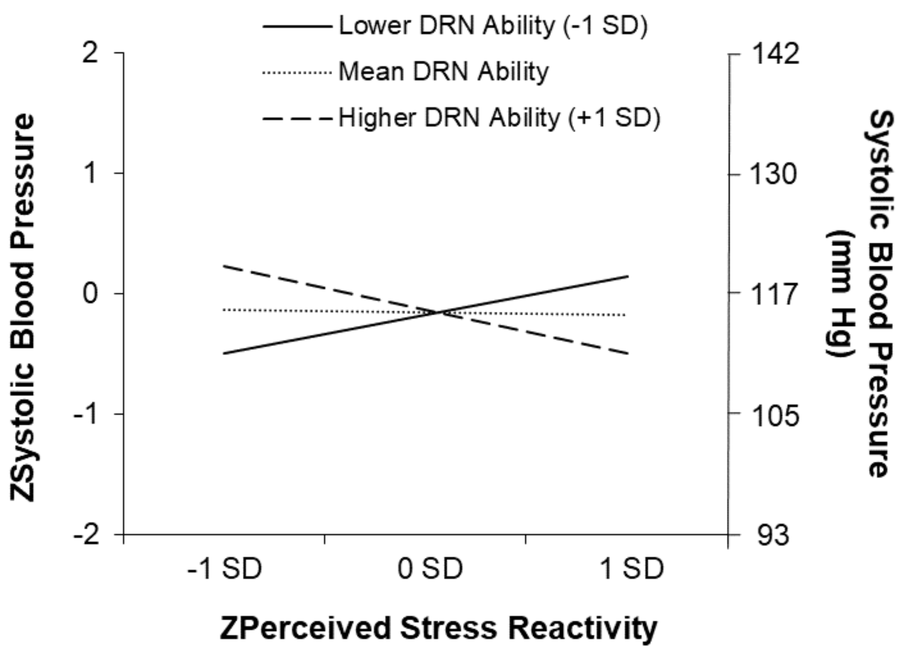

Figure 8. Interactive effect of perceived stress reactivity and down-regulate negative (DRN) reappraisal ability on systolic blood pressure (left axis is z-scored and right axis is raw values). Analyses controlled for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability. The lines representing the mean and +/-1 SD DRN Ability levels do not significantly differ from zero.

Table 11
Summary of Hypothesis 2c – Moderated Multiple Regression Analyses for the Interaction Between Perceived Stress Reactivity and DRN Reappraisal Ability Predicting Systolic Blood Pressure

	Step 1		Step 2		Step 3			
	β	*S.E.*	β	*S.E.*	β	*S.E.*	R^2	ΔR^2
Fully Adjusted								
(Intercept)	-.23[†]	.12	-.23[†]	.12	-.16	.12		
Age	.03	.11	.04	.11	.01	.11		
Female	-.14[c]	.03	-.14[c]	.03	-.13[c]	.03		
Subjective Social Status	-.21[†]	.12	-.21[†]	.12	-.19	.12		
Emotional Reactivity	-.00	.09	.01	.10	.01	.09		
Reappraisal Use	.07	.11	.06	.12	.07	.12		
Depressive Symptoms	-.26	.16	-.26	.16	-.25	.16		
Anxiety Symptoms	.30[†]	.16	.31[†]	.17	.30[†]	.17		
Social Desirability	-.05	.11	-.04	.12	-.07	.11	.22[a]	
Physio Stress Reactivity			.02	.14	-.02	.14		
DRN Reappraisal Ability			-.07	.13	.02	.14	.23[a]	.00
Physio*DRN					-.34[a]	.15	.27[a]	.05[a]

Note. n = 83. [†]$p < 0.10$, [a] $p < .05$, [b] $p < .01$, [c] $p < .001$. Dependent variable = Systolic Blood Pressure; β = standardized beta weight; *S.E.* = standard error; DRN = Down-Regulate Negative; PSR = Perceived Stress Reactivity. The interaction term is the product of the z-scored Perceived Stress Reactivity and DRN Reappraisal Ability variables.

The second exploratory moderated regression tested the interaction between *perceived* stress reactivity and DRN reappraisal ability with diastolic blood pressure as the criterion ($n = 83$; see Table 12). In step one, the combination of control variables (age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability) did not explain a significant amount of variance in diastolic blood pressure ($R^2 = .12$, $p = .30$). In step two, neither perceived stress reactivity ($\beta = .04$, $p = .78$) nor DRN reappraisal ability (β = 07, $p = .61$) significantly predicted diastolic blood pressure ($R^2 = .12$; $\Delta R^2 = .00$, $p = .82$). This indicates there was no overall main effect for either focal predictor. In step three, the interaction term (β = -.34, p < .05) incrementally predicted diastolic blood pressure (R^2 = .17, ΔR^2 = .05, p < .05) indicating that together, perceived stress reactivity and DRN reappraisal have an interactive effect which predicted an additional 5% of the variance in diastolic blood pressure.

The simple slopes (see Figure 9; Hayes & Matthes, 2009) revealed an interesting dis-ordinal interaction between perceived stress reactivity and DRN reappraisal ability that aligns with the interaction predicting physical risk factors and systolic blood pressure. When an individual has lower DRN ability, higher perceived stress reactivity intuitively predicts higher diastolic blood pressure (β = .35, 95% CI [-.06, .75]; however, when DRN ability is higher, higher perceived stress reactivity predicts *lower* diastolic blood pressure (β = -.34, 95% CI [-.79, .12]. In other words, DRN ability acts as a buffer against the negative influence of higher perceived stress reactivity. Interestingly, those with lower levels of perceived stress reactivity yet higher DRN ability exhibited higher diastolic blood pressure (71.48 mmHg) compared to those with lower DRN ability (67.12 mmHg). This pattern of findings highlights that the ability to DRN emotions using reappraisal may be harmful when perceived stress reactivity is lower.

Table 12
Summary of Hypothesis 2c – Moderated Multiple Regression Analyses for the Interaction Between Perceived Stress Reactivity and DRN Reappraisal Ability Predicting Diastolic Blood Pressure

	Step 1		Step 2		Step 3			
	β	*S.E.*	β	*S.E.*	β	*S.E.*	R^2	ΔR^2
Fully Adjusted								
(Intercept)	-.01	.13	-.01	.13	.06	.13		
Age	.24[a]	.11	.24[a]	.11	.21[†]	.11		
Female	-.01	.03	-.02	.04	-.02	.04		
Subjective Social Status	.05	.13	.04	.13	.05	.13		
Emotional Reactivity	.04	.10	.02	.10	.02	.10		
Reappraisal Use	.02	.12	.04	.13	.05	.13		
Depressive Symptoms	-.03	.17	-.02	.17	-.01	.17		
Anxiety Symptoms	.25	.17	.22	.18	.21	.18		
Social Desirability	.19	.12	.19	.12	.16	.12	.12	
Physio Stress Reactivity			.04	.15	.01	.14		
DRN Reappraisal Ability			.07	.14	.16	.14	.12	.00
Physio*DRN					-.34[a]	.16	.17	.05[a]

Note. n = 83. [†]$p < 0.10$, [a] $p < .05$, [b] $p < .01$, [c] $p < .001$. Dependent variable = Diastolic Blood Pressure; β = standardized beta weight; *S.E.* = standard error; DRN = Down-Regulate Negative; PSR = Perceived Stress Reactivity. The interaction term is the product of the z-scored Perceived Stress Reactivity and DRN Reappraisal Ability variables.

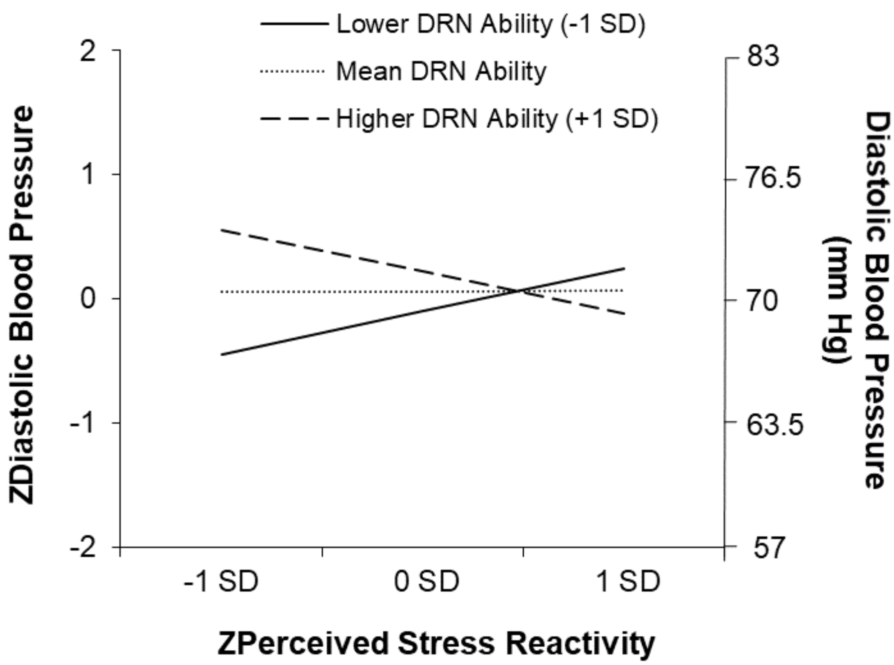

Figure 9. Interactive effect of perceived stress reactivity and down-regulate negative (DRN) reappraisal ability on diastolic blood pressure (left axis is z-scored and right axis is raw values). Analyses controlled for age, sex, subjective social status, emotional reactivity, reappraisal use, depressive symptoms, anxiety symptoms, and social desirability. The lines representing the mean and +/-1 SD DRN Ability levels do not significantly differ from zero.

H2d: Stress Reactivity and URN Ability Interact to Predict Physical Risk Factors

The eleventh moderated regression tested the interaction between *physiological* stress reactivity and URN reappraisal ability with physical risk factors as the criterion (n = 63). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical risk factors (R^2 = .04, p = .51). In step two, neither physiological stress reactivity (β = .09, p = .68) nor URN reappraisal ability (β = .28, p = .14) significantly predicted physical risk factors (R^2 = .07, ΔR^2 = .03, p = .33). This indicates there was no main effect for either focal predictor. In step three, the interaction term (β = -.03, p = .93) did not incrementally predict physical risk factors (R^2 = .07, ΔR^2 = .00, p = .93) indicating that together, physiological stress reactivity and URN reappraisal ability do not have an interactive effect that predicts physical risk factors.

The twelfth moderated regression tested the interaction between *perceived* stress reactivity and URN reappraisal ability with physical risk factors as the criterion (n = 71). In step one, the combination of control variables (age, sex, and emotional reactivity) did not explain a significant amount of variance in physical risk factors (R^2 = .05, p = .32). In step two, neither perceived stress reactivity (β = .15, p = .28) nor URN reappraisal ability (β = .22, p = .18) significantly predicted physical risk factors (R^2 = .09, ΔR^2 = .04, p = .25). This indicates there was no main effect for either focal predictor. In step three, the interaction term (β = -.04, p = .86) did not incrementally predict physical risk factors (R^2 = .09, ΔR^2 = .00, p = .86) indicating that together, perceived stress reactivity and URN reappraisal ability do not have an interactive effect that predicts physical risk factors.

H3: Relation Between Behavioral and Physical Risk Factors

A hierarchical linear regression with physical risk factors as the criterion tested the association between the behavioral and physical risk factors (n = 72). In step one, the combination of control variables (age and sex) did not explain a significant amount of variance in physical risk factors (R^2 = .07, p = .098). In step two, neither physical activity (β = .05, p = .82) nor sleep quality (β = -.00, p = .99) predicted physical risk factors.

5.5. DISCUSSION

The present study sought to better understand the behavioral and physiological adaptiveness of health-focused emotion regulation for individuals differing in levels of stress reactivity. Because reactions to stress are posited as causal mechanisms in the development of disease with maladaptive health outcomes associated with both high and low stress reactions, this study first explored the curvilinear relation between stress reactivity and behavioral and physical risk factors for cardiometabolic disease. Building on prior investigations, a conceptual model was also tested in which the ability to up- and down-regulate negative emotions modulates the influence of stress reactivity to promote reduced biobehavioral disease risk (see Figure 3). The present study addressed several limitations of prior research by utilizing a novel health-focused ERA task, a social evaluative stress task with psychophysiological measurements, and assessments of behavioral and physical health. Combining these variables with additional assessments of psychological, emotional, and behavioral health, as well as health beliefs and health-related motivation, a larger database was created that will allow for future investigations of the way stress and emotions interact to influence health. This discussion first addresses considerations around the study procedures and zero-order associations among the focal variables, then discusses the three specific aims, and ends with implications for future research.

Study Recruitment

Using a simple quota sampling method, 89 individuals participated in the present study who fell into three BMI weight status categories that approximated the general U.S. population weight status distribution (37% normal BMI, 37% overweight BMI, 26%

obese BMI). Due to the strict exclusion criteria used to increase the internal validity of the study, including weight minimums and maximums, use of a variety of medications, and presence of several mental and physical health conditions, it was challenging to recruit and schedule participants. To date, our research team has screened 771 individuals who expressed interest in participating but were disqualified for one or more of the exclusion criteria. The largest reason for disqualification was prescription medication use (243 individuals disqualified), specifically anti-depressant use (130 individuals disqualified). Although we only ran 89 participants through the experimental procedure thus far, approximately 400 individuals who expressed interest in participating were eligible for the study. However, these people could either not be contacted after expressing interest (approximately 70 individuals), they were undergraduate psychology students who only participated in the Part 1 online survey and did not intend on completing the entire study (approximately 75 individuals), or they reported a BMI in the normal weight status range when we were targeting overweight and obese BMI weight categories. Thus, approximately 50% of the people interested in the study were eligible, but only 22% of those individuals met the recruitment needs for our quota sampling method and completed the study.

A strength of the sampling and recruitment methods used was the enrollment of a diverse sample with respect to age, sex, and race/ethnicity. The sample ranged in age from 18-58 years old with a mean age of 28 years and 61% identified as female. Further, 47% of the sample identified as non-White. This indicates that the study advertisements and methods for enrolling not only undergraduate students, but also faculty, staff, and Charlotte community members, were successful in recruiting individuals from diverse backgrounds. These demographic proportions are close to, or more diverse than, the general U.S. population (51% female, 27% non-White; U.S. Census Bureau, 2016a, b), which increases the study's external validity and generalizability of the findings and allows a better understanding of how these processes function in people of differing backgrounds. By using the same quota sampling techniques, inclusion/exclusion criteria, and recruitment methods, we are continuing to enroll participants through 2018, with a final sample size goal of 130 participants. We plan to expand the sample while maintaining the strong internal and external validity captured in the preliminary sample of 89 participants.

Stress Reactivity Measurement

The present study measured stress reactivity with the Perceived Stress Reactivity Scale (PSRS; Schlotz et al., 2011) to replicate previous findings and through psychophysiological assessment to extend prior work and explore the autonomic pathways through which emotion regulation may influence health. This also allowed for an exploration of the differential impact of perceived and physiological stress reactivity in the context of emotions and health. For the physiological assessment, electrocardiography was used to measure participants' HRV during a three-minute baseline paced breathing exercise and while they completed a five-minute standardized social stress task. HRV reflects the changes in time between consecutive heartbeats and is an indirect index of autonomic function sensitive to acute stress (Berntson et al., 1997). Time- and frequency-domain measurements of HRV are metrics used to quantify autonomic function, with time-domain measurements estimating the amount of variability in measurements of the interbeat interval, and frequency-domain measurements quantifying the distribution of absolute or relative power into frequency bands (Shaffer & Ginsberg, 2017).

Simple time-domain variables are calculated by detecting each QRS complex and determining the intervals between adjacent QRS complexes (Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology, 1996). The RMSSD is a commonly used time-domain measure that estimates short-term HF variations in heart rate with lower RMSSD values indicating lower HRV and a greater experience of acute stress. Alternately, frequency-domain assessments decompose the HRV wave form into its constituent frequencies, with the LF component mediated by both the vagus (parasympathetic) and cardiac sympathetic nerves and the HF component primarily mediated by the vagus nerve. The present study used a ratio of LF-to-HF power to capture sympatho-vagal balance where a higher ratio reflects SNS dominance and a lower ratio reflects PNS dominance.

Regarding the use of ECG during the experiment, only four participants (4.5%) had to be excluded from analyses due to experimenter error. All other files were able to be cleaned, processed, and used in analyses, indicating that the experimental protocol was well-developed and adhered to. However, there is some methodological concern over interpreting the frequency-domain metrics used in analyses because of the mean differences in the LF/HF ratio between conditions. The average ratio during the final one-minute bin of baseline was 11.88 ms^2 (SD = 9.10 ms^2), while the ratio during the 30-second bin of peak reactivity was 3.06 ms^2 (SD = 3.04 ms^2). According to this metric, this indicates that participants' autonomic nervous system was, on average, under more SNS dominance during the baseline period than during peak stress reactivity. It is possible that the serial subtraction task was not stressful to participants; however, verbal and non-verbal indications from participants suggest they perceived the task as stressful and the RMSSD between conditions indicates that the stress task did influence HRV in the expected way. The RMSSD during the final one-minute bin of baseline was 63.81 ms, while the RMSSD during the 30-second bin of peak reactivity was 3.25 ms, suggesting that participants did have a greater experience of acute stress during the stress task as compared to baseline.

Frequency-domain measures are thought to capture broader variations in other autonomic indices, including body temperature and respiration, and the SNS contribution to the LF component of the LF/HF ratio can vary considerably with posture and testing conditions. One possibility is that participants remained stationary during the baseline condition but changed their posture during the stress task. The chair that participants sat in during the experiment was a doctor’s office table with a reclining back adjusted so participants were upright but not quite at a 90-degree angle. During the baseline condition, participants watched a paced breathing geometric shape on a laptop and were instructed to follow the shape with their breath (inhaling as the shape expanded for 5 seconds, exhaling as the shape contracted for 5 seconds). Participants likely felt comfortable during this task and remained in the reclining position (approximately 110-degree angle). However, some of our experimental session notes indicate that participants may have sat up in a more upright 90-degree angle during the stress task. As they are sitting up, they could have experienced a short SNS burst and increase in heart rate, followed by a quick and large PNS activation to help balance the change in blood pressure. This may account for the PNS dominance during peak reactivity experienced by some participants during the stress task.

Another more likely explanation for the lower LF/HF ratio during the stressor is the difference in respiration rate between the baseline and stress task conditions. Due to the unavoidable nature of the stress task where participants are verbally counting backwards, the effects of respiration on cardiac output during the stressor will be much greater than the effects during the breathing task. For future analyses with the larger database, the RMSSD metric may be a better way to assess HRV in this study. Further, to make the conditions more equal in future research, I would consider using a standard slow breathing task for baseline that is not paced or use a stressor that was non-verbal, such as anticipatory stress paradigms (e.g., Waugh, Panage, Mendes, & Gotlib, 2010). I could also use a respiration band concurrently with continuous ECG measurements and control for respiration rate in the future. Finally, I could use RMSSD values as opposed to the LF/HF ratio or utilize repeated measures analyses to look at trajectories of stress reactivity *and* recovery instead of examining a basic percent change from baseline to peak reactivity.

It is also interesting to note that in this study perceived and physiological stress reactivity were not correlated. Although initial work with the PSRS indicated that higher scores on this measure were associated with greater cortisol reactivity (Schlotz et al., 2011), other research has found dissociated response patterns between the PSRS and cortisol responses to a laboratory stress task (Jackowska, Fuchs, & Klaperski, 2018), and dissociation between psychological and acute physiological stress responsivity more generally (Campbell & Ehlert, 2012). This is the first study to our knowledge to test the association between the PSRS and HRV reactivity to a standardized stressor. The serial subtraction exercise used as the stress task in this study was an artificial, standardized acute stressor which lasted for a short time period, whereas the PSRS asks about stressful real-life scenarios which vary in length and situational context. Thus, the autonomic response systems that react to acute stressors may be different than the appraisal- and emotion-based stress responses captured by the PSRS.

In addition, in follow-up analyses we found that values on the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) were positively associated with physiological stress reactivity ($r = .22$, $p < .05$, $n = 81$). The PSRS includes several items, such as “When I’m wrongly criticized by others…I am normally annoyed for a long time; I am annoyed for just a short time; or In general I am hardly annoyed at all,” that may reflect stress recovery processes in addition to reactivity. This potentially suggests that the PSS may capture general reactivity to stressors, whereas the PSRS may capture both perceived reactivity to and recovery from a stressor. In future analyses with these data, we will test this hypothesis by assessing the association between physiological stress reactivity and items that reflect reactivity and recovery from the PSRS. In addition, because we assessed HRV during a five-minute recovery period, in future analyses we also plan to assess PSRS associations with stress recovery.

Another interesting consideration regarding the lack of association between perceived and physiological stress reactivity involves the concept of response coherence. In theories of emotion, coherence refers to an alignment between subjective, behavioral, and physiological responses during strong emotional episodes, such as experiences of distress (Levenson, 1994). The coordination between perceptions and physiology is thought to promote successful coping attempts and be adaptive and functional (Sze, Gyurak, Yuan, & Levenson, 2010); however, coherence between subjective, behavioral, and physiological responses is not consistently found. Moreover, when coherence is found, it varies greatly across individuals, with some people showing no coherence and others showing perfect coherence (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). One explanation of coherence differences could be to see each assessment as a unique prediction error signal. The concept of prediction error is grounded in reward learning and decision-making research and occurs when the brain's prediction of what will happen in a certain situation differs from the actual brain signal from that situation (Schultz, Dayan, & Montague, 1997). From this perspective, non-coherence may reflect meaningful differences in prediction error. Times of non-coherence would be more likely to occur in new situations and would be important for resolving expectations based on prediction errors in the brain as learning occurs.

Although this study measured more trait-like perceived stress reactivity as opposed to perceptions of reactivity during the experimental stress task, the lack of correlation between perceived and physiological stress may indicate that these response systems did not cohere for at least some individuals in this study. Future research could use these data to explore both within- and between-person variation in coherence between perceptions and physiology as predictors of cardiometabolic health and emotional coping processes.

Regarding the zero-order associations among stress reactivity and biobehavioral health, both perceived and physiological stress reactivity were negatively associated with sleep quality as expected (National Sleep Foundation, 2001); however, neither measures were associated with physical activity nor any physical cardiometabolic risk factors. This suggests that although stress reactivity may act more directly on sleep quality due to the bi-directional stress-sleep cycle and influence of stress reactions on sleep duration and disturbances, stress reactivity may influence physical activity and physical risk factors through more indirect pathways, such as health-related motivation, self-efficacy, and neuroendocrine responses. The larger database created as part of this research will allow us to test health belief and motivation processes as mediators and moderators in the relation between stress reactivity and biobehavioral health.

Emotion Regulation Ability Task

A novel contribution of the present study to the emotion regulation and health literature was the use of a health-focused ERA task that assessed participants' ability to up- and down-regulate negative emotions towards weight-related stimuli. The task was developed in Study Two of this dissertation (Sagui-Henson & Levens, *in preparation*) and implemented during the in-person experimental lab session with concurrent ECG measurement. Only five participants (5.6%) were excluded from ERA analyses due to equipment error, suggesting that the task, which had previously been administered online to a national sample, was successfully implemented in a laboratory setting. Although not presented in the current study, the ability to examine variations in HRV during different emotion regulation conditions in the larger database represent a substantial potential contribution to the field of emotion regulation.

Regarding the inter-task correlations, higher DRN reappraisal ability was associated with lower URN reappraisal ability, replicating the Study Two task development findings (Sagui-Henson & Levens, *in preparation*). These results suggest that, on average, individuals have the capacity to either up- or down-regulation negative emotions, but do not have high ability in both. The effect size of the correlation was small-to-medium (r = -.27) and replicates the effect sizes found in Study Two of this dissertation (rs = -.26 to -.31). This indicates that there is variability in the association between DRN and URN reappraisal ability across individuals and has implications for emotion regulation flexibility research. Future research should explore emotion regulation phenotypes (e.g., high in both abilities, low in both abilities, high in one ability and not the other) and their associations with biobehavioral health.

The ERA task also demonstrated unique associations with other variables in the present study. Physiological stress reactivity demonstrated a trending negative correlation with URN reappraisal ability and no association with DRN ability, while perceived stress reactivity demonstrated a significant positive correlation with DRN reappraisal ability and no association with URN ability. Although research linking emotion regulation ability with stress reactivity are limited, prior research has found that the voluntary down-regulation of negative emotions, compared to the up-regulation of negative emotions, was associated with decreased heart rate reactivity during an emotional picture task (Driscoll et al., 2009). However, this study only assessed heart rate response magnitude, as opposed to HRV, and compared cardiovascular changes during the actual emotion regulation attempt instead of a validated stress task. Although it is outside the scope of the current study, it will be important to examine changes in HRV *during* the emotion regulation conditions as a function of regulatory instruction and level of ability. It is possible that HRV will decrease during URN conditions and increase during DRN conditions as posited by prior research.

It is also possible that health-focused ERA is associated with autonomic reactivity to a standardized social stressor (physiological stress reactivity) and perceptions of stress reactivity across a variety of social situations (perceived stress reactivity) in unique ways that have not been captured in previous studies. Because DRN and URN are negatively correlated, the pattern of findings suggests that individuals with higher stress reactivity demonstrate a greater ability to be more positive and less negative (higher ability to DRN emotions using reappraisal and lower ability to URN emotions). This could indicate that individuals in this sample have an adaptive coping ability to feel less negative under conditions of heightened stress reactivity. It could also suggest that because the associations between stress reactivity and ERA were small in effect size that these variables may interact in unique ways to promote adaptive coping and subsequent healthy outcomes, where some individuals with higher reactivity benefit from a heightened ability to feel less negative under conditions of stress, yet other individuals experience maladaptive outcomes when high stress reactivity and DRN ability are coupled.

The ERA scores also demonstrated interesting associations with biobehavioral risk factors for cardiometabolic diseases. Regarding behavioral health, higher DRN reappraisal ability was correlated with lower physical activity and the main effects for DRN ability in the Hypothesis 2 moderated regressions show trending positive associations with sleep quality. Conversely, main effects of higher URN ability in the Hypothesis 2 moderated regressions show non-significant, but directionally positive associations with physical activity and negative associations with sleep quality. This pattern of results suggests that higher DRN ability may promote better sleep quality, while higher URN ability may promote more engagement in physical activity. The ability to DRN emotions is typically accompanied by a concurrent increase in positive emotions (as evidenced by positive correlations among DRN and up-regulate positive abilities; Sagui-Henson & Levens, *in preparation*). A greater ability to feel less negative and more positive may have direct effects on sleep, where people experiencing greater positive emotions are less physiologically aroused during the day and are more likely to engage in health restorative behaviors, such as getting sufficient and high-quality sleep (Pressman & Cohen, 2005). Positive emotions may also be associated with sleep quality through stress-buffering mechanisms (Pressman & Cohen, 2005) or through bi-directional associations where individuals who sleep better are able to experience more positive emotions through emotion regulation (Armon, Melamed, & Vinokur, 2014). It will be important to confirm these results with ability scores surrounding the positive emotions assessed during the ERA task in future research.

Although some research has posited an association between positive emotions and more physical activity engagement (Bruijn, Rhodes, & Osch, 2012; Peterson et al., 2013), it is possible that the association between physical activity and a greater URN reappraisal ability in the context of obesity and weight management reflects the enhanced motivation to engage in healthier behavior that can accompany negative health-focused emotions (Ekman, 1993). Emotions, including negative emotional states, direct our attention, inform our decisions and guide our behavior (DeSteno et al., 2013). Thus, it is possible that a greater ability to see the potential negative consequences of obesity-related health stimuli spurs motivation to be more physically active.

Regarding associations among ERA task scores and physical risk factors for cardiometabolic diseases, higher DRN ability was related to higher LDL cholesterol and higher URN ability was related to higher HbA1c. Because there was an overall lack of zero-order associations with the physical risk factors, it is possible that ERA acts more directly on behavioral health yet has a more indirect influence through mediators or stress-buffering moderators on physical health. These divergent findings between the ability to up- and down-regulate negative emotions highlight the complex nature of biobehavioral health because different health-promoting behaviors and physiological indices reciprocally influence each other over time and respond to different emotional and motivational forces (DeSteno et al., 2013).

Behavioral and Physical Health Assessments

Studies One and Two of this dissertation examining stress reactivity and ERA focused on self-reported BMI as the health outcome of interest; therefore, the assessment of behavioral and physical health indices as outcomes of stress reactivity ERA interactions represented a significant expansion of previous methodologies. Physical activity and sleep quality were measured with well-validated self-report measures and social desirability was also included as a potential confounder in behavioral health analyses. These questionnaires also include physical activity and sleep quality subscales so future analyses can examine the impact of stress and emotion processes on subtypes of behavioral health, including leisure time physical activity, sleep duration, and sleep latency.

Abdominal obesity was measured with a DEXA scan, which allowed for more valid assessments of body fat percentage and provided regional analyses of the distribution of adipose tissue across the body. The Health Risk Assessment lab in the Kinesiology department served as a valuable partner in this research and only one participant was excluded from abdominal obesity analyses due to a missing DEXA scan. Blood pressure was assessed with an aneroid sphygmomanometer and three successive brachial artery readings allowed for at least two readings to be averaged for each participant with no missing data.

Cholesterol, triglycerides, and HbA1c were measured via a finger stick blood sample and point-of-care diagnostic machines. Despite a standardized protocol and regular care and maintenance of laboratory equipment, there were some issues encountered with the finger stick blood samples. The most consistent issue was not obtaining enough blood to use in the lipids point-of-care machine, even though participants pumped their fist, ran their hand under warm water, and stood up to stretch and walk around before the finger stick. Thirteen participants (14.6%) returned to the lab within two weeks of participation for a make-up finger stick when we were unable to obtain enough blood for the sample. Some participants were unable to return for another finger stick, resulting in the loss of between 9-11% of the data on the blood variables in this study. Because the finger stick occurred at the end of the Part 2 laboratory session after participants had been sitting for approximately 2 hours, future research should consider performing the finger stick procedure on a separate day or after the participant engaged in more movement to increase blood flow.

Regarding Hypothesis 3 and the associations among behavioral and physical health indices, physical activity and sleep quality were not significantly associated with each other or with the physical risk factors (apart from a negative association between sleep quality and HDL cholesterol). It is possible that we were underpowered to detect any effects due to our lower sample size. This may also be the result of the BMI quota sampling, as well as the high diversity of the sample. Our recruitment aim for this study was to obtain a sample that was more representative of the general population; therefore, while some research focuses on subpopulations and may find a greater relation between physical and behavioral risk factors, the variability in our sample may have reduced our effects. Overall, the physical risk factors appeared to be correlated in expected ways, including abdominal obesity demonstrating positive associations with diastolic blood pressure, triglycerides, and HbA1c, and a negative association with HDL cholesterol. Additionally, indices of blood pressure and glycated hemoglobin were positively associated, and HDL cholesterol and triglycerides were negatively associated.

Discussion of Specific Aims

Aim 1 (H1): Curvilinear Relation with Stress Reactivity and Health

The first aim of this study was to investigate the curvilinear relation between stress reactivity and behavioral health and physical risk factors for cardiometabolic disease. A series of polynomial regressions were conducted to test if both higher and lower stress reactivity were associated with poor health outcomes. A quadratic term for both physiological and perceived stress reactivity were used as predictors of physical activity, sleep quality, and a combined physical risk factor variable. Results revealed that neither stress reactivity variable demonstrated a curvilinear relationship with any health outcome. These analyses, coupled with zero-order correlations and main effects from the moderated regressions, suggest that both stress reactivity variables have a linear association with sleep quality. These findings support prior research (Charles et al., 2011; Jackowska et al., 2018; Schlotz et al., 2011) and may account for the lack of curvilinear relation among these variables. However, stress reactivity did not appear to share a linear or curvilinear relation with physical activity or physical risk factors.

These findings do not align with research connecting both heightened stress reactivity (e.g., Cacioppo & Berntson, 2011; Cohen & Manuck, 1995) and diminished reactivity (e.g., Lovallo, 2011; Phillips, Roseboom, Carroll, & de Rooij, 2012) to impaired biobehavioral health. However, this is the first study, to our knowledge, that examines associations among perceived stress reactivity measured via the PSRS (Schlotz et al., 2011) and cardiometabolic health outcomes, such as resting blood pressure, cholesterol, triglycerides, and HbA1c. Regarding biobehavioral health, prior research has examined associations among the PSRS and BMI (Sagui & Levens, 2016), sleep quality (Jackowska et al., 2018; Schlotz et al., 2011), endocrine reactivity (Unger, Busse, & Yim, 2014), and disordered eating (Ciarma & Matthew, 2017). Therefore, the present study attempted to expand the nomological network of perceived stress reactivity but did not find linear or curvilinear associations with physical activity or physical risk factors for cardiometabolic diseases. It is possible that perceived stress reactivity does not act directly on these health outcomes, but relates to them via mediators, such as self-efficacy, motivation, or neuroendocrine function, or moderators, such as ERA.

Physiological stress reactivity also did not demonstrate associations with many of the cardiometabolic health outcomes. Perhaps the way this variable was assessed (as a simple percent change from baseline to peak reactivity) or the frequency-domain metric of the LF/HF ratio used to quantify stress reactivity resulted in null findings. It is also possible that our analyses were underpowered to detect an association due to a small sample size. Including more participants in analyses or examining time-domain measures of HRV with repeated measures techniques that assess stress reactivity and recovery trajectories could potentially reveal associations with biobehavioral health.

Aim 2 (H2): Stress Reactivity and ERA Interact to Predict Behavioral Health

The second aim of this study was to test a conceptual model in which the ability to up- and down-regulate negative emotions in a health context moderates the influence of stress reactivity on cardiometabolic health outcomes. Although the conceptual model combines all variables of interest together, we ran separate models to assess associations with individual predictors, moderators, and outcomes. The first series of moderated regressions tested whether these variables interacted to predict physical activity and sleep quality. No significant interactions were observed with physical activity as the criterion, or with physiological stress reactivity as the predictor. However, we did observe a trending interaction between perceived stress reactivity and DRN ability and a significant interaction between perceived stress reactivity and URN ability with sleep quality as the criterion.

Although it was only trending in significance after being fully adjusted for relevant covariates ($p = .076$), the interaction between perceived stress reactivity and DRN ability (see Figure 5) suggests that individuals with lower perceived stress reactivity may experience higher quality sleep if they are higher in DRN ability. Conversely, for individuals with higher perceived stress reactivity, varying levels of DRN ability do not appear to influence levels of sleep quality. When examining the relation between perceived stress reactivity and sleep quality, these variables are unrelated for individuals lower in DRN ability, yet for people with higher DRN ability sleep quality decreases as perceived stress reactivity decreases. This indicates that in the context of sleep quality, higher DRN ability may be health-protective at lower levels of perceived stress reactivity, yet at higher levels of perceived stress reactivity it has no protective effect.

The significant interaction between perceived stress reactivity and URN ability supports a similar pattern of results (see Figure 6). This model suggests that individuals with lower perceived reactivity experience higher quality sleep if they are lower in URN ability. When examining the relation between perceived stress reactivity and sleep quality, these variables are significantly negatively associated for people with lower URN ability, yet there is a non-significant, but positive association between these variables for people with higher URN ability. This indicates that a lower ability to URN emotions may be health-protective in at lower levels of perceived stress reactivity but detrimental at higher levels.

DRN ability represents a person's capacity to decrease negative emotions (with a potential increase in positive emotions) in the context of weight-related negative stimuli. Whereas, URN ability represents one's capacity to increase health-related negative emotions (with a potential decrease in positive emotions). Therefore, the pattern of results illustrated by both models suggests that individuals who perceive themselves to have lower stress reactivity experience higher quality sleep if they possess a greater ability to regulate their emotions to be more positive (higher DRN ability and lower URN ability). The enhanced sleep quality these individuals experience potentially reflects a synergistic effect between lower perceived stress reactivity and a greater capacity to experience more positive and less negative emotions, both of which are related to better sleep (Bardwell, Berry, Ancoli-Israel, & Dimsdale, 1999; Jackowska et al., 2018). Although this does not align with the conceptual model presented in this study, the findings demonstrate that the adaptiveness of emotion regulation is inherently context dependent. In the context of sleep quality, there may not be a situation (such as being higher in DRN ability) in which more stress reactivity is associated with better behavioral health.

In general, brain regions associated with arousal activity need to slow down to enter a state of restoration (marked by PNS dominance) and achieve quality sleep (Sapolsky, 2004). Thus, while the combination of lower perceived stress reactivity and higher DRN ability and/or lower URN ability may not be beneficial for motivating obesity-related behaviors, it may be an adaptive combination for further down-regulating an individual’s stress response system, so they can sleep better. In other words, better sleep quality could be an unanticipated healthy side effect of an otherwise maladaptive stress reactivity-emotion regulation coping pattern. Individuals with higher stress reactivity may also have a greater tendency to worry or ruminate (LeMoult, Arditte, D'Avanzato, & Joormann, 2013) and the emotion regulation strategy of reappraisal (regardless of up- or down-regulating emotions) may be too cognitively effortful (Sheppes et al., 2014) when they are attempting to sleep. Even DRN reappraisal ability, which facilitates more positivity, may cause individuals to ruminate on the emotion-inducing situation at the expense of reducing arousal. A less effortful emotion regulation strategy, such as distraction, may be facilitate better quality sleep for highly stress reactivity individuals, a hypothesis that can be tested with the larger database created by this dissertation.

Aim 2 (H2): Stress Reactivity and ERA Interact to Predict Physical Risk Factors

The second series of moderated regressions used to test the conceptual model explored whether stress reactivity and ERA interacted to predict a composite physical cardiometabolic risk factor variable that combined abdominal obesity, blood pressure, cholesterol, triglycerides, and HbA1c. No significant interactions were observed with physiological stress reactivity as the predictor or URN ability as the moderator. However, we did observe a trending interaction between perceived stress reactivity and DRN ability with physical risk factors as the criterion and, in follow-up analyses, significant interactions with systolic and diastolic blood pressure as outcomes.

The dis-ordinal interaction between perceived stress reactivity and DRN ability predicting physical risk factors (see Figure 7), although only trending in significance after being fully adjusted (p = .098), suggests that DRN ability may not adaptive for people who perceive themselves to be low stress reactors. Rather, a higher DRN ability may be associated with less physical risk for cardiometabolic disease only for individuals higher in perceived reactivity, a finding that potentially supports our conceptual model. To further explore which physical risk factor was driving this relationship, follow-up analyses were conducted with the perceived stress reactivity-DRN ability interaction predicting each physical risk factor separately. No significant moderation was found when predicting abdominal obesity, cholesterol, triglycerides, or HbA1c. However, significant interactions emerged with systolic and diastolic blood pressure as criterions and these models remained statistically significant after being fully adjusted.

Regarding systolic blood pressure (see Figure 8), when a person perceives her or himself to be highly stress reactive, greater DRN ability protects her/him against higher blood pressure. Participants with this coupling of both higher perceived stress reactivity and DRN ability experienced an estimated 8 mmHg *reduction* in systolic blood pressure, compared to those with higher perceived stress reactivity and lower DRN ability. A resting systolic blood pressure less than 120 mmHg is considered healthy (AHA, 2018). Thus, higher DRN ability appears to have a stress-buffering effect at higher perceived stress reactivity because individuals with this ability had systolic blood pressure well within the health range (110.5 mmHg), while those with deficits in this ability had systolic blood pressure reaching the elevated range (118.5 mmHg).

As predicted by our model, the opposite pattern emerged for people with lower perceived stress reactivity. Participants demonstrating greater DRN ability, yet lower perceived stress reactivity, experienced an estimated 9 mmHg *increase* in systolic blood pressure, compared to those with lower DRN ability. This suggests that DRN ability is maladaptive for health at lower perceived reactivity because individuals with this ability had systolic blood pressure approaching the elevated range (119.5 mmHg), while those with less DRN ability had healthy values (110.5 mmHg). Elevated systolic blood pressure is more predictive of cardiovascular disease risk than diastolic blood pressure (Kannel, Schwartz, & Mcnamara, 1969), especially with increasing age. Therefore, although a difference of 8-9 mmHg between groups may not be clinically meaningful, it is significant that these results were observed in a healthy, relatively young (*M* age = 28 years) sample and has implications for the ways in which perceptions of stress reactivity and DRN ability interact to influence the cardiovascular system over time.

Regarding diastolic blood pressure (see Figure 9), higher DRN ability also acts as a stress-buffer against the negative influence of higher perceived stress reactivity. However, the simple slopes from this model indicate that varying levels of DRN ability relate to more divergent diastolic blood pressure values at lower perceived reactivity, compared to higher reactivity. Participants demonstrating greater DRN ability, yet lower perceived stress reactivity, experienced an estimated 4.36 mmHg *increase* in diastolic blood pressure, compared to those with lower DRN ability. This suggests that the ability to DRN emotions using reappraisal may be harmful when perceived stress reactivity is lower, yet both groups fall in the normal diastolic blood pressure range, so this difference is not clinically meaningful and should be interpreted with caution.

The pattern of results from these analyses highlights two important ideas: DRN ability is beneficial for people perceiving high stress reactivity and detrimental for those perceiving low reactivity, yet URN ability was not adaptive for low reactors, and blood pressure was the physical risk factor driving these findings, not metabolic indices.

The interactions with DRN ability in this study align with those found in Study One of this dissertation examining cognitive reappraisal ability (CRA; Sagui & Levens, 2016). Despite using different stimuli, the instructions for DRN ability and CRA are the same—they ask participants to reframe the situation in a more positive and less negative way. The fact that these abilities appear to be adaptive for people with higher perceived stress reactivity across multiple studies suggests that, in the context of blood pressure and BMI, these individuals may benefit from positive affect interventions and emotion regulation ability training programs that build skill in reducing negative emotions. Positive affect skills interventions have been shown to improve psychological and physical health across a range of populations adjusting to chronic illness and experiencing high levels of stress, including people with Type 2 diabetes (Cheung et al., 2017; Cohn, Pietrucha, Saslow, Hult, & Moskowitz, 2014; Moskowitz et al., 2017). These interventions have not been implemented specifically for people high in perceived stress reactivity but could represent an entry point in helping these individuals achieve better biobehavioral health. Emotion regulation skills trainings have also shown promise in improving psychological resilience and reducing physical symptoms and illness in adults with persistent childhood-related distress (Cameron, Carroll, & Hamilton, 2018).

These interactions also reveal that not only is DRN ability potentially maladaptive for people with lower perceived stress reactivity, but URN ability may not be an adaptive strategy for them either. Therefore, future research should explore other coping mechanisms that can improve health for low perceived stress reactors, such as mindfulness meditation. Mindfulness-based interventions train practitioners to cultivate present-moment awareness in an open and non-judgmental way (Kabat-Zinn, 1994; Shapiro & Carlson, 2009) and have been shown to improve stress biology, including systolic blood pressure (Lindsay, Young, Smyth, Brown, & Creswell, 2018). Individuals with diminished stress reactivity are thought to lack appropriate behavioral motivation and/or physiological regulation (Lovallo, 2011), potentially resulting from an avoidance of negative stimuli. Thus, the attitudes of acceptance, receptivity, and equanimity toward experiences that mindfulness-based practices afford practitioners could allow lower stress reactive people to approach their health in a more adaptive way.

Among the physical cardiometabolic risk factors tested as outcomes in follow-up analyses, only the association between perceived stress reactivity and systolic and diastolic blood pressure were influenced by levels of DRN ability. It is possible that stress reactivity and ERA act more directly on cardiovascular indices, but more indirectly on metabolic outcomes, such as through behavioral mediators, like dietary habits, or neuroendocrine mechanisms. Future research with the larger database can assess moderated mediation models testing some of these possibilities.

These findings highlight the importance of considering adaptive emotion regulation strategies for individuals low in perceived stress reactivity. An abundance of prior research has focused on the negative impact of heightened stress reactivity (Sinha & Jastreboff, 2013; Steptoe & Wardle, 2005; Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011) and coping interventions to help people who overreact. Only recent studies have shown the behavioral and physiological dysregulation associated with diminished stress reactivity (e.g., Lovallo, 2011), leaving a gap in knowledge not only for the coping and stress management strategies associated with biobehavioral health for individuals with this stress regulation pattern, but also a gap in the broader stress reactivity continuum.

This study also highlights the importance of considering the effects of different coping strategies on multiple stress-related biobehavioral health outcomes. We found that DRN ability was protective for blood pressure at higher levels of perceived stress reactivity yet was associated with better sleep quality at lower levels of perceived stress reactivity. Thus, interventions promoting stress management and coping techniques need to consider the population and tailor programs around the specific health condition. In this way, applications of the findings from basic science can be used to inform more patient-centered and individualized approaches to medicine. The present study and program of research represents an initial and important step toward explicating the emotion-focused coping strategies that may benefit individuals across the spectrum of perceived stress reactivity profiles.

Differential Impact of Perceived and Physiological Stress Reactivity

A unique aspect of the present study that represented a significant expansion from Studies One and Two of this dissertation was the measurement of both perceived and physiological stress reactivity, which allowed for a test of the differential impact of these variables on health. Physiological stress reactivity did not interact with the ERA variables to predict any health outcome, while perceived stress reactivity demonstrated unique interactions with both DRN and URN ability in the prediction of sleep quality and blood pressure. This indicates that perceptions of one's reactivity patterns across real-life stressful situations may provide unique information relevant to understanding biobehavioral health and the emotion regulation strategies that can improve it. As previously mentioned, perceived psychological reactivity and acute physiological stress responsivity may not be as closely linked as previously thought (Campbell & Ehlert, 2012). Perceptions of stress reactivity may represent a unique predictor of health with individual contributions to well-being beyond those of biological stress responses.

The predictive validity of one's subjective perceptions of her/his circumstances above and beyond objective indicators has been studied with two other constructs relevant to biobehavioral health: subjective social status and self-rated health. Subjective social status represents a person's perceived standing relative to others in a social hierarchy (Adler et al., 2000). When examining the predictive validity above and beyond objective indicators of socioeconomic position, including education, occupation, and income, a recent meta-analysis found that subjective social status demonstrated a unique cumulative association with physical health across 31 studies (Cundiff & Matthews, 2017). Self-rated health, on the other hand, refers to an individual's perception of her/his general health and is typically measured with the question, "In general, would you say your health is" with the response options "excellent," "very good," "good," "fair," or "poor" (Garrity, Somes, & Marx, 1978; Maddox, 1962). Self-rated health has also evidenced significant, independent effects on morbidity and mortality beyond objective indicators of disease risk across several populations (see Bombak, 2013 for a review and Pinquart, 2001 for a meta-analysis). These literatures may lend support for why we found that only perceptions of stress reactivity interacted with ERA to predict health and not more "objective" psychophysiological reactions.

It is also possible that perceived stress reactivity was driving the interaction with ERA to predict sleep quality because of response bias and/or common method bias. Both the PSRS (Schlotz et al., 2011) and PSQI (Buysse et al., 1989) were cross-sectional self-report assessments; thus, variations in responses could be caused by the self-report nature of the instruments instead of actual respondent characteristics on the construct. This can also be compounded by the social desirability of respondents. However, fully adjusted models controlled for social desirability, which reduces some concerns of method bias, and physiological stress reactivity not measured with a questionnaire was also associated with sleep quality. Further, perceived stress reactivity interacted with DRN ability to predict blood pressure, a finding which can not be explained by method bias. It will be important for future research to explore what the PSRS is capturing that psychophysiological assessments are not. According to Lovallo's (2011) neurophysiological model of stress reactivity, the prefrontal cortex generates cognitive reactions which are refined by the limbic system to create a more appraisal-based response system that may precede the peripheral stress response. Perceived stress reactivity may tap into this appraisal system more than HRV reactions to a stressor or represent a cognitive averaging of stress reactivity across situations.

Limitations for Aims 1 and 2

Although the present study contributes to our understanding of the ways in which stress reactivity and ERA interact to influence behavioral and physical health, there are several limitations that should be considered when interpreting the results. First, this was a cross-sectional study, which precludes any claims of causality. The statistical models tested in this study were specified based on theory and empirical rationale, but due to the bi-directional relations between stress, emotions, and health, we cannot be certain that stress reactivity is causally predicting health outcomes and there could be other potential specifications of the models that combine these variables. In the larger database we are creating, we have included a small longitudinal component in the form of a one-month follow-up survey that asks participants if they made any changes to their health or behaviors. Future analyses will be able to examine changes in these behaviors as a function of stress reactive-ERA interactions.

Future research should test these associations with a longitudinal design. Although stress reactivity is posited as a causal mechanism in the promotion of health and/or the development of cardiometabolic diseases (Carver & Vargas, 2011), biobehavioral health also influences an individual's stress and emotional response systems. For example, the hormone leptin that is secreted by fat cells stimulates SNS activity (Trayhurn & Bing, 2006), which could exaggerate a stress response, yet there is evidence that the SNS of obese individuals is less responsive to stimulation (despite higher basal SNS activity; Carroll et al., 2008). Regarding health behaviors, poor sleep quality leads to poor emotion regulation ability (e.g., Mauss, Troy, & LeBourgeois, 2013), particularly for negative emotions. To better understand how these processes develop over time and influence each other in conjunction, it would be best to employ a longitudinal design with multiple time points.

Results should also be interpreted with caution due to the small sample size. There were several factors that limited our ability to obtain a larger sample size, including time (each experimental session took approximately 3.5 hours and could only be scheduled after 11am) and sharing spaces with several other laboratories. The strict inclusion criteria used to increase the internal validity of the study may also have affected the study's external validity. However, the quota sample method enabled us to collect a sample that was more representative of the U.S. population and our initial *n* of 89 participants was sufficient to run preliminary analyses and observe trend-level and significant relations among the focal variables. Future analyses will be conducted with a larger sample size utilizing the database being created via Aim 3 of this study.

Aim 3: Develop a Larger Database and Future Directions

The third and final aim of this study was to develop a database that will allow for a larger examination of the way stress and emotions interact to influence health. Our goals with the database are to test initial hypothesized associations, as well as permit data mining. To build the larger database, we first conducted a power analysis using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2009) to determine a target sample size. Because it would be difficult to estimate a sample size for the data mining goals of this database (because power analyses are determined by the planned statistical test), we based our estimation on the tests used in the preliminary analyses of this dissertation. Therefore, assuming linear multiple regression with two primary independent variables and a several covariates (e.g., 3-9), we estimated a conservative effect size of .10 with an alpha of .05

at 90% power which yielded a targeted sample size for the database of $n = 130$. Participant recruitment and data collection will be ongoing until we reach our final sample size at the end of 2018.

The database we are creating includes assessments of psychological health and coping, emotional health, stress and experiences of trauma, physical and behavioral health, health beliefs and health-related motivation, social support, and demographic characteristics. Future analyses with this database will focus on replicating the preliminary analyses presented in this dissertation with a larger sample size and conducting follow-up analyses to explore aspects of preliminary analyses that require clarification. For example, we plan to conduct analyses with the RMSSD time-domain metric of HRV and use repeated measures analyses to investigate within- and between-person trajectories of stress reactivity and recovery, as well as interactions between these trajectories and ERA. We also have pre- and post-stress task questionnaires that assessed participants' subjective and emotional reactions to the stressor which pay provide insight into how challenging or threatening they found the stress task to be and whether challenge or threat profiles are associated with ERA and/or cardiometabolic health outcomes in unique ways. Further, we will conduct analyses with the subscales of the PSRS, particularly the social evaluation and social conflict subscales, to look at the predictive validity of these aspects of perceived stress reactivity in driving ERA interactions.

We will also utilize the larger database to answer research questions that are beyond the scope of this dissertation that will inform our understanding of how stress, emotions, coping, and health interact. We plan assess how experiences of early life adversity influence perceived and physiological stress reactivity and health and the role of other coping mechanisms in these associations, such as mindfulness, problem-focused coping, and social support. Another exciting area to explore with the database is the mediating role of health beliefs and motivation in the stress reactivity-ERA interaction. Assessments of health-specific self-efficacy, health locus of control, and motives for physical activity and healthy diet can serve as mediators in a larger model examining whether maladaptive combinations of stress reactivity and ERA are associated with dysregulated motivation as a precursor to health issues, such as higher blood pressure and BMI. Further, utilizing measures from the Transtheoretical Model of Health Behavior Change (DiClemente & Prochaska, 1982) we plan to explore how stress reactivity and ERA influence the stage of change an individual is in with regards to weight management goals. The stages of change measure was also included in the one-month follow-up survey, allowing a longitudinal investigation of the stages of behavior change as a function of stress reactivity, ERA, and participation in the study (which participants commented was helpful in spurring motivation to change their weight-related behaviors because of the personalized health results they received at the end of participation).

Conclusion

The present study sought to explore the curvilinear relation between stress reactivity and cardiometabolic health, test a conceptual model of the interaction between stress reactivity and ERA in predicting health, and develop a database that will allow for a larger examination of stress, coping, emotions, motivation, and biobehavioral health. Although no curvilinear relations between stress reactivity and health were present, a piecewise test of the conceptual model revealed that perceived stress reactivity and ERA interacted to predict sleep quality and systolic and diastolic blood pressure. These findings have implications for the stress management and coping interventions that can be recommended to individuals with different patterns of perceived stress reactivity and contributes to a better understanding of patient-centered and individualized approaches to medicine.

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CHAPTER 6: OVERALL CONCLUSION

The present doctoral dissertation began to elucidate the mechanisms through which stress reactivity and emotion regulation ability (ERA) impact cardiometabolic outcomes. This milestone project was informed by my training as a Health Psychologist and my interest in the intimate and complex connections between the psychosocial, emotional, and biobehavioral processes that interact to influence health. Research in health psychology largely focuses on core psychological processes related to well-being and illness, including coping with stress and behavioral health promotion, while integrating innovative biopsychosocial approaches with foundational scientific principles and rigorous methodology. The present study significantly contributes to this field by combining psychological theories of stress appraisals and reactions with models of emotion-focused coping to investigate how individuals can mitigate biobehavioral risks for chronic illness.

The framework regarding stress reactivity-ERA interactions that provided the rationale for this dissertation is grounded in foundational theories of psychological stress appraisals (Lazarus & Folkman, 1984), emotion regulation processes (Gross, 2008), and the physiological and behavioral health effects of emotional coping (Carver & Vargas, 2011). Specifically, coping and emotion regulation theorists have called for dynamic models of emotion-focused coping in which the person and situation interact over time to inform adaption (Bonanno & Burton, 2014). By considering an individual's level of stress reactivity and ERA in health-focused situations, this work has the potential to expand the utility and boundary assumptions of key health psychology theories. Overall, the present study promotes the importance of theory and methodological rigor in the study of emotion regulation and health processes, with the intention of clarifying the unique interactions between stress reactivity and health-specific emotional coping. Below I review and summarize my dissertation findings within my larger program of research, the skills I have gained throughout my training, and my future research interests.

My larger research program is guided by the notion that reactivity to stress is a causal mechanism in health and illness (Carver & Vargas, 2011). Although prior work has focused on the health detriments of exaggerated stress reactivity, emerging evidence suggests that markedly low stress reactions also contribute to motivational dysregulation and biobehavioral risk for obesity-related conditions (e.g., Lovallo 2011; Phillips et al., 2013). Adopting this broader view of stress in terms of dysregulated systems, my research proposes that the management, or regulation, of stress-related negative emotions can alter reactivity toward a moderate level needed for behavioral change and homeostatic balance. To test this framework, I have built a theoretically-driven research program that examines stress and emotional coping in college students and community samples of adults using behavioral, psychophysiological, and survey methodologies. The present series of studies investigates the impact of these processes on cardiometabolic health outcomes, such as body mass index (BMI), autonomic nervous system activity, lipid profiles, abdominal adiposity, physical activity, and sleep quality.

To develop this research program, I integrated a range of skills, knowledge, and experiences that I have gained throughout my doctoral training and that have prepared me for an independent research career. In Study One, I learned how to create large surveys embedded with behavioral tasks and administer them online, as well as how to analyze complex moderated mediation models. In Study Two, I established skills in emotional stimuli development and learned the value of creating a novel measurement device when your research question necessitates one instead of attempting to fit an existing device to your question. I also gained experience managing a multi-part study and working with several datasets from different populations. Study Three represented a significant expansion in my skill set. I learned how to write different types of research protocols (in-lab, Institutional Review Board, Institutional Biosafety Committee) and train and manage a large team of research assistants on these study procedures. I established partnerships with interdisciplinary research labs and developed skills in working successfully with a team of interdisciplinary collaborators. I also gained practical skills surrounding biological data collection and experimental design with methodologies like ECG, DEXA, stress testing, point-of-care blood sampling, and anthropometric measurements. Finally, I learned how to manage and analyze complex biobehavioral health data and interpret findings connecting those data to psychological and emotional processes.

The results from my dissertation highlight how different perceived stress reactivity-ERA profiles contribute to adaptive and maladaptive health outcomes, with implications for novel intervention designs that target these mechanisms to reduce disease risk. Studies One and Three suggest that the ability to down-regulate negative emotions is adaptive for individuals with higher perceived stress reactivity, as evidenced by lower BMI and systolic and diastolic blood pressure. In contrast, this ability was maladaptive for those with lower perceived stress reactivity, yet the ability to up-regulate negative emotions was not associated with better health for these people either.

The field of contemplative science has considerable applicability in this area and integrative interventions incorporating this mechanistic knowledge may be effective in empowering individuals with varying stress reactivity patterns to be more active in the promotion of their health.

For example, I would like to use the findings from this program of research to design a program that uses contemplative practices, such as mindfulness training, to improve emotion regulation ability based on patterns of stress reactivity for individuals with cardiometabolic health issues. Because emotion regulation may have the potential to alter stress responsivity, the use of contemplative practices to facilitate more adaptive emotion management may help transition explicit training into habitual implicit regulation. In my other work, I have found that cognitive reappraisal more generally is a mechanism through which trait mindfulness promotes coping with stress and improved behavioral health (Sagui-Henson, Levens, & Blevins, 2018) and would like to test if explicit training in contemplative practice can drive improvements in emotion regulation. Prior research shows that mindfulness training can facilitate the down-regulation of negative emotions using reappraisal (Garland, Gaylord, & Park, 2009) and the attitudes of acceptance and receptivity toward negative experiences that mindfulness-based practices afford practitioners could facilitate an adaptive approach orientation to health. Therefore, mindfulness training targeted toward different mechanisms may enable highly stress reactive individuals to see the positive outcomes of engaging in weight-related healthy behavior yet encourage others with lower reactivity to accept their circumstances or focus on potential consequences to increase motivation for healthy behavior.

The findings from Study Three regarding sleep quality also highlight that the adaptiveness of emotion regulation is inherently context dependent and interventions to improve health should be tailored to the specific behavior or physical condition. We found that a greater ability to down-regulate negative emotions was adaptive for lower perceived stress reactive individuals, as evidenced by better sleep quality. Thus, while the combination of lower perceived stress reactivity and a higher ability to down-regulate negative emotions may not be beneficial for motivating obesity-related behaviors, it may be an adaptive combination for further down-regulating an individual's stress response system so they can sleep better. In other words, better sleep quality could be an unanticipated healthy side effect of an otherwise maladaptive stress reactivity-emotion regulation coping pattern. To extend this aspect of my program of research in the future, I plan to investigate sleep as a behavioral pathway linking stress and emotion regulation to physical health, potentially incorporating principles of mindfulness to help people with higher stress reactivity achieve quality sleep. Through this work, I will continue to explore the conditions under which emotion regulation can be used as a tool to modulate maladaptive patterns of stress reactivity.

Another important addition to my work in the future will be consideration of nutrition and dietary habits. Although we included a basic measure of food frequency in the Study Three larger database, I plan to learn more about the complex interactions among stress, emotions, and eating behavior and incorporate healthy eating as a behavioral pathway linking stress to obesity- and cardiometabolic-related health conditions. The use of new methods, including ecological momentary assessment, may allow we me to explore how daily experiences with stress reactivity and emotion regulation contribute to health behavior change and how individuals manage the emotions surrounding cravings or other stress-related triggers that affect eating behavior.

Ultimately, the goal of my research is to better understand the psychological, emotional, and biobehavioral health patterns of different individuals so that medical decisions, practices, and interventions can be tailored to patients based on their unique responses and risk for disease. Importantly, my work also contributes to preventive medicine by focusing on modifiable health behaviors and physiological factors that comprise obesity etiology. By emphasizing predisposing mechanisms that contribute to cardiometabolic diseases, this knowledge can be used to help patients be more active in their health. The present dissertation supports these larger goals and represents a foundation upon which I will build a research program that advances preventive and patient-centered healthcare.

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APPENDIX A: DOWN-REGULATE NEGATIVE REAPPRAISAL INSTRUCTIONS

Please watch the following film clip carefully. This time, as you watch, try to think about the situation you see in a more positive light. You can achieve this in several different ways. For example, try to imagine advice that you could give to the characters in the film clip to make them feel better. This could be advice that would help them think about the positive bearing this event could have on their lives. Or, think about the good things they might learn from this experience. Keep in mind that even though a situation may be painful in the moment, in the long run, it could make one's life better, or have unexpected good outcomes. In other words, try to think about the situation in as positive terms as you possibly can. This can be difficult at times, so it is very important that you try your best. It is very important that you carefully watch the film clip, but think about it from a positive perspective.

APPENDIX B: UP-REGULATE NEGATIVE REAPPRAISAL INSTRUCTIONS

Please watch the following film clip carefully. This time, as you watch, try to think about the situation you see in a more negative light. You can achieve this in several different ways. For example, try to imagine advice that you could give to the characters in the film clip to make them take the message of the film more seriously. This could be advice that would help them think about the possible negative impact this event could have on their lives. On the other hand, you could reflect about how the clip relates to an aspect of your own life that you need to take more seriously. Keep in mind that even though a situation may be painful in the moment, the situation could become even worse with unexpected negative outcomes, and it is important to think about these potential negative outcomes so that you can be prepared. In other words, try to think about the situation in as negative terms as you possibly can. This can be difficult at times, so it is very important that you try your best. It is very important that you carefully watch the film clip but think about it from a negative perspective.

APPENDIX C: DOWN-REGULATE NEGATIVE DISTRACTION INSTRUCTIONS

Please watch the following film clip carefully. This time, as you watch, try to think about something positive that is unrelated to the situation. You can achieve this in several different ways. For example, you can think about an unrelated positive memory or funny experience, or something positive you are looking forward to. In other words, try to think about something unrelated to the situation in as positive terms as you possibly can. This can be difficult at times, so it is very important that you try your best. It is very important that you carefully watch the film clip but think about something positive.

APPENDIX D: UP-REGULATE NEGATIVE DISTRACTION INSTRUCTIONS

Please watch the following film clip carefully. This time, as you watch, try to think about something negative that is unrelated to the situation. You can achieve this in several different ways. For example, you can think about an unrelated negative memory or experience, or an expected negative event in the future that you are not looking forward to. In other words, try to think about something unrelated to the situation in as negative terms as you possibly can. This can be difficult at times, so it is very important that you try your best. It is very important that you carefully watch the film clip but think about something negative.