LOOKING AT THE POSITIVE: THE STRESS-BUFFERING ROLE OF COGNITIVE REAPPRAISAL ABILITY ON RISK FACTORS FOR DISEASE

by

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ABSTRACT

SARA JOAN SAGUI. Looking at the positive: The stress-buffering role of cognitive reappraisal ability on risk factors for disease. (Under the direction of DR. SARA M. LEVENS)

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 high body mass index (BMI) and (2) if this buffering effect persists against the indirect influences of stress reactivity on type 2 diabetes. Participants completed an online cognitive reappraisal ability (CRA) task, self-report measures of perceived stress reactivity, height, weight, and type 2 diabetes diagnosis. Results revealed that CRA significantly interacted with perceived stress reactivity to predict BMI, which indirectly predicted type 2 diabetes. Individuals who perceived elevated levels of stress reactivity yet had higher CRA, exhibited lower BMI and lower incidence of type 2 diabetes than individuals with higher perceived stress reactivity and lower CRA. Interestingly, higher CRA appeared to not be protective in those who have lower levels of perceived stress reactivity. Findings from this study suggest that emotion regulation interventions can be developed to indirectly target type 2 diabetes and similar obesity-related illnesses and must be designed according to the individual given the context-dependent nature of our results.

DEDICATION

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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). However, people vary in their response to a stressor, with individuals higher in perceived stress reactivity (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 reactivity negatively impacts the development of obesity-related chronic diseases. For example, prolonged stress reactivity has been associated with increased body mass index (BMI; Steptoe & Wardle, 2005), which in turn increases an individual's risk for developing type 2 diabetes (Bays, Chapman, & Grandy, 2007; Centers for Disease Control and Prevention [CDC], 2013b). With the prevalence of type 2 diabetes rising (CDC, 2013a), it is important to consider potential buffers against the detrimental impact of stress on the development and progression of this disease. Thus, the overarching goal of the present study was to investigate whether the emotion regulation strategy of cognitive reappraisal has the potential to buffer against the negative effects of perceived stress reactivity.

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, a strategy that involves reinterpreting an appraisal of an emotion-eliciting situation to change its emotional impact (Gross, 1998, 2002; 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; Mauss, Cook, Chang, & Gross, 2007; Thayer & Brosschot, 2005). Because the use of reappraisal has the capacity to reduce negative emotions by reframing a negative event in a more positive light, an individual's ability to implement reappraisal may represent their capacity to reduce their own stress response. The ability to lower maladaptive reactions to stress could 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). High reappraisal ability, therefore, may offer protection against high BMI and the subsequent development of type 2 diabetes.

The present study sought to investigate a moderated mediation model examining whether cognitive reappraisal ability acts as a stress-buffer against high BMI, and whether this buffering effect persists against the indirect influences of perceived stress reactivity on type 2 diabetes. We hypothesized that individual differences in the ability to use cognitive reappraisal to down-regulate negative emotions would moderate the relation between perceived stress reactivity and BMI, such that individuals with higher reappraisal ability would be protected from higher BMI despite having higher levels of perceived stress reactivity. Further, we hypothesized that perceived stress reactivity would confer indirect influences on type 2 diabetes via BMI differentially for individuals with higher versus lower reappraisal ability.

METHOD

Participants

Adults between the ages of 18 and 65 were recruited through Amazon's Mechanical Turk (MTurk), a commonly used participant recruitment website that is open to a worldwide population. MTurk samples have been found to be more demographically diverse and representative of the national population than standard American college samples and other Internet samples (Buhrmester, Kwang, & Gosling, 2011). The sample was restricted to individuals living in the United States. Participants were excluded from analyses if they failed the two manipulation checks for the cognitive reappraisal ability (CRA) task (see Measures section), reducing the initial sample of $n = 224$ size by 68 participants.[1] One additional participant was excluded due to an extreme BMI value (see Measures section), and listwise deletion was used to account for missing data, yielding a final sample size of $n = 150$.

The mean age of participants (54% female) was 40.38 years ($SD = 12.42$). The sample was 78% White, 9.3% African American, 6% Hispanic or Latino, 4.7% Asian, 1.3% Native American, and 0.7% identified as other. Regarding educational attainment, 16.7% held a graduate degree, 43.3% completed college, 26% completed some college, 12.7% held a high school diploma, 0.7% completed some high school, and 0.7 % completed junior high school. Finally, income levels for this sample were as follows: 10.7% < $10,000, 18.7% $10,000-24,999, 31.3% $25,000-49,999, 21.3% $50,000-74,999, 9.3% $75,000-99,999, 8.7% > $100,000.

Procedure

Upon selecting the study on MTurk, participants were provided a link to the survey using Qualtrics survey software. Participants were asked to complete the study in a quiet room free from distractions. Prior to beginning the study, all participants provided informed consent according to the regulations of the University of North Carolina at Charlotte Institutional Review Board.

Participants first completed a series of questionnaires, followed by the CRA task, followed by a final set of questionnaires. The presentation order of the questionnaires before and after the CRA task was counterbalanced. This format was chosen to reduce participant fatigue and maximize performance and engagement with the questionnaires and task. The CRA task took around 15 minutes to complete and the entire online session lasted approximately 45 minutes. Upon completion, participants were compensated with $1.75, a rate consistent with other behavioral MTurk studies of similar length and difficulty. The findings reported here were part of a larger study examining stress, reappraisal, and physical health. More information can be found in the supplemental material.

Measures

Demographics**.** Participants reported their age and gender. For racial and ethnic background, participants reported the group that best represented themselves from preselected options (i.e., White, African American, Hispanic or Latino, etc.). Educational background was assessed by asking respondents the highest level of education they had completed on a six-point scale (1 = *less than seven years*, 6 = *graduate or professional training*). Income was assessed by asking participants the range that best described their pre-tax household income in the last year on a seven-point scale (1 = *less than $10,000*, 7 = *more than $100,000*).

Perceived Stress Reactivity. Perceived stress reactivity was assessed via the Perceived Stress Reactivity Scale (PSRS; Schlotz et al., 2011), a 23-item questionnaire developed to assess an individual's typical response style across different stressful situations in daily life. Participants were asked to indicate their general reactions to psychologically stressful situations, such as, "when I fail at a task," and, "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. Higher scores indicate higher perceived stress reactivity. The PSRS has been validated against objective assessments of stress reactivity (e.g., higher scores were associated with steeper cortisol responses to psychosocial stress; Schlotz, Hammerfald, Ehlert, & Gaab, 2011). This measure demonstrated strong internal consistency reliability in our sample (α = .93).

Body Mass Index (BMI). BMI is a fairly reliable indicator of body fatness for most people (CDC, 2011). BMI was calculated from participant self-reports of height and weight. One participant was deemed to be an outlier because of an extreme BMI value (66.6 kg/m^2), which was more than 5 standard deviations above the mean in this sample, and thus was excluded from the current analyses.

Type 2 Diabetes. Participants responded to a yes or no question asking if a medical doctor had ever diagnosed them with type 2 diabetes. Participants were coded as 0 if they had never been diagnosed with type 2 diabetes and 1 if they had.

Cognitive Reappraisal Task. A modified version of a previously validated and published emotion regulation task was used to assess CRA and emotional reactivity (see

Troy, Wilhelm, Shallcross, & Mauss, 2010 for more detail). For the CRA task, participants viewed four short film clips. After each clip ended, participants rated the greatest amount of emotion they experienced to 13 emotion prompts (e.g., sadness, fear, happiness, amusement, etc.). To induce a neutral mood at the beginning of the task, the first of the four film clips was a 3-minute emotionally neutral film depicting nature scenes. Next, participants were presented with three film clips pretested to induce moderate amounts of sadness. Using film clips as opposed to still photos is a widely used and more ecologically valid method to induce emotions (Fredrickson & Levenson, 1998; Rottenberg, Ray, & Gross, 2007). Although stress likely encompasses several different emotions, this task was designed to measure an individual's ability to reduce negative emotions using reappraisal. Thus, sadness served as the negative emotion of interest in this task. The film clips were approximately two minutes long and depicted two people discussing an emotional event. Films that induce moderate amounts of sadness were chosen because they are more ecologically valid and reduce ceiling or floor effects, which helps to maximize the variability in sadness ratings, and ultimately CRA scores (Troy et al., 2010).

A within-subject repeated measures design was employed to avoid habituation or regression to the mean. The order that the film clips were presented were the same, but the instructions differed for the two groups to which participants were randomly assigned. Each group passively watched the first sad film and this rating served as participants' baseline sadness. During the first sad film clip, participants were told to watch carefully. During the second or third film clips, participants were instructed to reappraise the situation in a more positive way in order to decrease the emotional impact of the film. Group 1 was instructed to reappraise the second sad film clip and watched the third clip carefully, while Group 2 watched the second clip carefully and reappraised the third film clip. Reappraisal instructions were developed by Troy et al. (2010) and were based on clinical research techniques that encourage participants to reframe a stressful situation in a positive way.

Two manipulation checks were employed to verify engagement with the CRA task. First, the Qualtrics survey software used in this study allowed us to record the amount of time each participant stayed on the pages playing the video clips. Participants were excluded if they did not stay on the page for at least 75% of the neutral film and 100% of all three sad films. Second, after watching each film clip, participants were asked questions about the film's content; participants were excluded if they answered the questions incorrectly.

Cognitive Reappraisal Ability and Emotional Reactivity Scores. Post film clip self-reported sadness ratings were used to calculate CRA and emotional reactivity. Participants rated, on a nine-point Likert scale (1 = *not at all*, 9 = *extremely*), the greatest amount of 13 different emotions that were experienced during the film. Because the reappraised film was not the same for all participants, sadness ratings were *z*-scored for each film clip so that score differences could be compared across Group 1 and 2 participants.

To assess CRA, change scores were calculated by subtracting sadness ratings given after the reappraised film clip from sadness ratings given after the baseline sad film. Thus, a greater score indicates greater CRA. 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 on this covariate indicated more emotional reactivity from the neutral to baseline film clips.

Reappraisal Use. As a theoretically distinct construct from reappraisal ability (Troy et al., 2010), we included reappraisal use as a covariate in our analyses. A subset of six questions that form the cognitive reappraisal subscale in the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) was used to measure general use of the reappraisal strategy. Higher scores indicate more reappraisal use. This measure demonstrated strong internal consistency reliability in our sample (α = .91).

Depressive Symptoms. Prior literature associates depressive symptoms with stress reactivity (Felsten, 2004) and CRA (Troy et al., 2010); therefore, it was included as a covariate. 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. Higher scores indicate greater depressive symptoms. This measure demonstrated strong internal consistency reliability in our sample (α = .89).

Statistical Analysis

The moderated mediation model was examined using hierarchical multiple regression and path analysis. The hypothesized model examined the effects of perceived stress reactivity on type 2 diabetes through BMI and the moderating influence of CRA on the relation between perceived stress reactivity and BMI (see Figure 1). Existing literature (Cohen, Doyle, & Baum, 2006; Kudielka, Buske-Kirschbaum, Hellhammer, & Kirschbaum, 2004; Tang, Chen, & Krewski, 2003; Troy et al., 2010) associates age, gender, education, income, emotional reactivity, frequency of reappraisal use, and current depressive symptoms with the predictor and outcome variables. Therefore, we controlled for these variables in all paths of this model. Analyses were carried out in SPSS (Version 20).

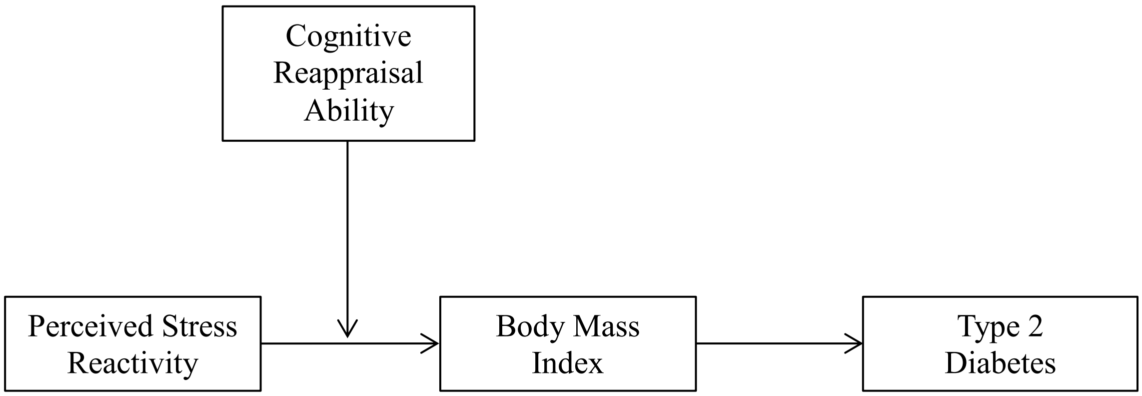

Figure 1: Proposed moderated mediation model for the stress-buffering influence of cognitive reappraisal ability on body mass index and downstream incidence of type 2 diabetes.

To examine our first hypothesis regarding the stress-buffering effects of CRA on BMI, a moderated regression analysis was conducted with BMI as the criterion. To enhance the interpretability of the first order coefficients (i.e., to show main effects), all variables, including BMI and the final outcome type 2 diabetes, were transformed to z-scores (except for CRA and emotional reactivity scores which were calculated from standardized sadness ratings). This allows for the unstandardized partial regression coefficient for each term to be interpreted as the average amount of SD change in the criterion per SD change in the predictor (or equivalently, as the standardized change in Y per SD change in X for the person with average CRA). An interaction term was computed as the product of the z-scored perceived stress reactivity and CRA scores. Using hierarchical regression, control variables were introduced as predictors in step one, and perceived stress reactivity and CRA as predictors in step two. In step three, the interaction term was added as a predictor to determine if these two variables have an interactive effect above and beyond the variables by themselves (Cohen, Cohen, West, & Aiken, 2003).

To assess our second research question regarding the extension of the stress-buffering effects of CRA to type 2 diabetes, the moderated mediation model was analyzed via path analysis. Following the procedures described by Cohen et al. (2003), the direct effect of perceived stress reactivity on BMI was estimated as the partial regression coefficient for the impact of perceived stress reactivity on BMI at three levels of CRA. Similarly, the direct effect of BMI on type 2 diabetes was estimated as the partial regression coefficient for the impact of BMI on type 2 diabetes. To assess the indirect impact of perceived stress reactivity on type 2 diabetes via BMI at each level of CRA, the path weight leading BMI to type 2 diabetes was multiplied by each simple slope from the moderation, yielding three indirect effects. Because our goal was to estimate the indirect impact of perceived stress reactivity via BMI at varying levels of CRA, rather than maximizing the prediction of being diagnosed with type 2 diabetes, we used linear regression for all analyses. Using logistic regression, while common for computing an odds ratio coefficient that represents the percent change in odds of being diagnosed with type 2 diabetes per unit change in the independent variable, would result in a coefficient that would not align with the first half of the model. Therefore, using this analysis would prevent the accurate calculation of indirect effects (see Hellevik 1984, 2009 for more detail on the appropriate use of linear versus logistic regression).

RESULTS

Descriptive Statistics

Descriptive statistics and Pearson correlations for all focal variables are presented in Table 1. Consistent with prior research (Bays et al., 2007; CDC, 2013b), BMI and type 2 diabetes were positively correlated ($r = .35$, $p < .01$). No statistically significant associations were found between perceived stress reactivity and CRA, or between BMI and either CRA or perceived stress reactivity.

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

Variables	*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	26.75	7.02	.03	-.05	.07	.02	.03	--	
7. Type 2 Diabetes	.09		.13	-.03	-.01	.03	-.01	.35*	--

Note. $n = 150$. *$p < .01$. 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. Cronbach's alpha reliabilities are reported on the diagonal.

Moderated Regression Results

In step one (see Table 2), the combination of control variables explained 9% of the variance in BMI ($R^2 = .09$, $p = .05$), demonstrating a moderate, but not statistically significant, effect size. In step two, the individual predictors did not explain a statistically significant or meaningful amount of variance beyond the first model (R^2 = .09, ΔR^2 = .00, *p* > .25) with neither perceived stress reactivity nor CRA (*b* = .01, *p* > .25 and *b* = .06, *p* > .25, respectively) significantly predicting BMI, while holding controls constant. This indicates that there is no overall main effect for either focal predictor. In step three, however, the interaction term (*b* = -.29, *p* = .001, 95% CI [-.45, -.12]) incrementally predicted BMI (R^2 = .16, ΔR^2 = .07, *p* = .001) indicating that together, perceived stress reactivity and CRA have an interactive effect that increases the predictive validity beyond the second model. Specifically, the interaction term was able to predict an additional 7% of the variance in BMI.

Table 2: Summary of Moderated Regression Analysis for Variables Predicting Body Mass Index

Variable	Step 1		Step 2		Step 3	
	b	*S.E.*	*b*	*S.E.*	*b*	*S.E.*
(Intercept)	-.03	.08	-.03	.08	-.06	.08
Age	.23**	.08	.24**	.08	.25**	.08
Female	-.12	.07	-.12	.08	-.08	.07
Education	-.06	.08	-.06	.08	-.04	.08
Income	-.12	.08	-.12	.08	-.12	.08
Emotional Reactivity	.03	.06	.02	.07	.00	.06
Reappraisal Use	-.09	.08	-.09	.09	-.07	.08
Depressive Symptoms	.06	.08	.06	.11	.05	.11
PSR			.01	.12	-.01	.11
CRA			.06	.09	.10	.09
PSR*CRA					-.29**	.08
R^2	.09		.09		.16**	
ΔR^2			.00		.07**	

Note. *n* = 150. **p* < .05. ***p* < .01. *b* = unstandardized beta weight; *S.E.* = standard error. PSR = Perceived Stress Reactivity. CRA = Cognitive Reappraisal Ability. Dependent variable = Body Mass Index. Because all continuous variables were z-scored before analysis and categorical variables were weighted effects coded, the unstandardized beta weights reflect standardized estimates.

Because step three of the hierarchical analysis revealed a statistically significant interaction between stress reactivity and CRA on BMI, the simple slopes were plotted following the procedures outlined by Cohen et al. (2003). That is, we used the standardized values reflecting the mean and +/- 1 SD on both stress reactivity (z-scored) and CRA and solved the equations using the unstandardized beta weights.

The simple slopes (see Figure 2) revealed an interesting disordinal interaction between stress reactivity and CRA. Specifically, when an individual has lower CRA, higher perceived stress reactivity predicts higher BMI (simple slope for stress reactivity at -1 SD of CRA, $b = .27$, CI [.19, .35]); however, when CRA is higher, higher perceived stress reactivity predicts *lower* BMI (simple slope for stress reactivity at +1 SD of CRA, $b = -.29$, CI [-.38, -.20]). In other words, CRA acts as a buffer against the negative influence of higher perceived stress reactivity. Upon examining levels of BMI at varying levels of perceived stress reactivity, another interesting pattern emerged. At high levels of perceived stress reactivity, individuals with higher CRA had lower BMI (BMI = -0.26); however, at low levels of perceived stress reactivity those with higher CRA exhibited the highest BMI (BMI = 0.33). This indicates that higher CRA is protective against the detrimental impact of *high* stress reactivity on BMI, but appears to not be beneficial when perceived stress reactivity is lower.

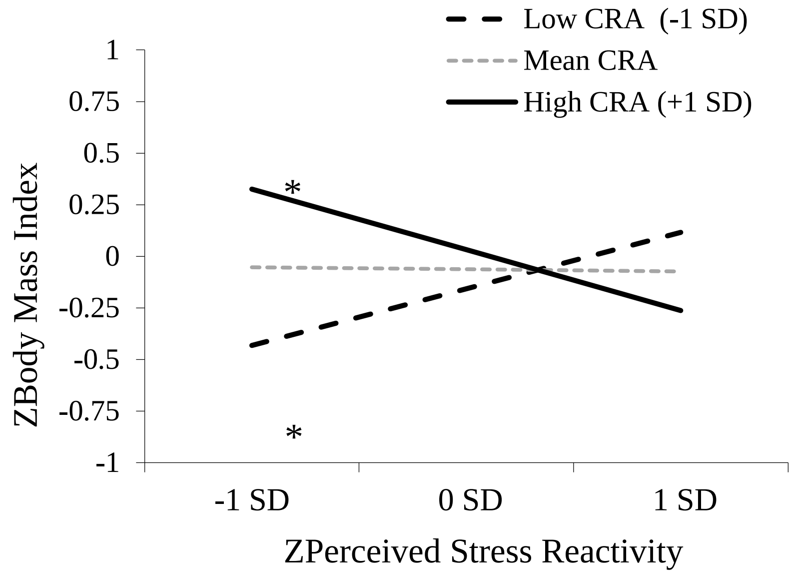

Figure 2: Interactive effect of perceived stress reactivity and cognitive reappraisal ability (CRA) on body mass index. Analyses controlled for age, gender, education, income, emotional reactivity, reappraisal use, and depressive symptoms. The simple slopes representing those with lower (-1 SD, *b* = .27) and higher (+1 SD, *b* = -.29) CRA levels yielded confidence internals that exclude zero and are statistically significant. The line representing those with mean CRA levels did not significantly differ from zero.

Moderated Mediation Results

A summary of the direct and indirect effects are presented in Table 3. Because there is evidence of moderation, this implies the mediated effects will be moderated as well (i.e., the indirect effect will be different at different levels of CRA). First, the direct effects of perceived stress reactivity on BMI were calculated at three levels of CRA. In support of our first stress-buffering hypothesis, at lower CRA, the impact of perceived stress reactivity on BMI was .27, while at higher CRA, the impact of perceived stress reactivity on BMI was -.29. In other words, for individuals with lower CRA, a 1 SD increase in perceived stress reactivity will result in a .27 SD *increase* in BMI; whereas for individuals with higher CRA, a 1 SD increase in perceived stress reactivity will result in a .29 SD *decrease* in BMI. In support of the latter portion of our model, BMI ($b = .34$, $p < .001$) had a unique direct effect on type 2 diabetes, indicating that a 1 SD increase in BMI will result in a .34 SD increase in the likelihood of having type 2 diabetes.

In support of our second hypothesis, perceived stress reactivity was found to indirectly impact type 2 diabetes via BMI differentially for individuals with higher versus lower CRA. At lower levels of CRA, the indirect effect of perceived stress reactivity on BMI was .09, indicating that an increase in perceived stress reactivity will result in an *increase* in the incidence of type 2 diabetes. However, at higher levels of CRA, the indirect effect of perceived stress reactivity on BMI was -.10, indicating that an increase in perceived stress reactivity will result in a *decrease* in the incidence of type 2 diabetes. The magnitudes of the indirect effects constitute a small effect size and indicate that the buffering impact of CRA extends beyond BMI to predict a lower incidence of type 2 diabetes when perceived stress reactivity is higher.

The total effect for perceived stress reactivity on type 2 diabetes can be also calculated at each level of CRA by summing the direct and indirect effect for that level. For example, at higher levels of CRA, the total effect of perceived stress reactivity on type 2 diabetes would be -.39. Similarly, at lower levels of CRA, the total effect of perceived stress reactivity on type 2 diabetes would be .36. In sum, higher CRA appears to mitigate the impact of higher perceived stress reactivity on type 2 diabetes.

Table 3: Summary of Effects (Standardized Units) for the Moderated Mediation Model

	Outcomes	
	BMI	Type 2 Diabetes
Perceived Stress Reactivity		
Direct Effect		
At High CRA	-.29*	--
At Average CRA	-.01	--
At Low CRA	.27*	--
Indirect Effect		
At High CRA	--	-.10
At Average CRA	--	.00
At Low CRA	--	.09
BMI		
Direct Effect	--	.34**
Indirect Effect	--	--

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

DISCUSSION

This study provides evidence that CRA may act as a stress buffer against obesity-related health conditions. Our first hypothesis regarding the moderating effect of higher CRA was confirmed—when a person perceives themselves to be highly stress reactive, greater CRA levels protects him/her against higher BMI. Our second hypothesis was also confirmed as the buffering effect of CRA was extended to a chronic disease outcome, whereby having higher CRA mitigated the influence of higher perceived stress reactivity on type 2 diabetes. While cognitive reappraisal more broadly (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Gross & John, 2003), and specifically as an ability (Troy et al., 2010; Troy, Shallcross, & Mauss, 2013), has been linked with better psychological health, this is the first study to show a relationship between reappraisal ability, BMI, and type 2 diabetes. These findings highlight the importance of considering cognitive reappraisal as a way to adaptively regulate stress to promote better physical health.

The observed interaction between CRA and perceived stress reactivity also illustrates two important findings regarding the contextual nature of using reappraisal to promote physical health. First, cognitive reappraisal ability is most beneficial for those perceive themselves as highly stress reactive individuals. The ability to reappraise negative events and lower stress appraisals in highly stress reactive individuals may help reduce maladaptive psychophysiological stress responses and engagement in health compromising behaviors, such as poor diet or physical inactivity. This finding suggests that reappraisal interventions can be developed to help highly reactive individuals reduce their stress to enhance their health. Indeed recent research has begun systematically investigating the impact of emotion regulation and reappraisal training interventions to improve psychological health (Denny & Ochsner, 2014; Quoidbach, Mikolajczak, & Gross, 2015). Our results suggest that not only should reappraisal interventions be examined to improve obesity-related health outcomes, such as type 2 diabetes, but also that these interventions should target those who perceive themselves as highly stress reactive individuals.

Second, results from the moderation suggest that higher CRA is not universally protective. Overall higher CRA was found to mitigate the impact of elevated perceived stress reactivity on type 2 diabetes; however, individuals with lower perceived stress reactivity and greater CRA exhibited higher BMI, indicating that reappraisal ability may be maladaptive in certain contexts. Although extensive research has examined the negative impact of higher stress reactivity on health (e.g., Cohen et al., 2007; Cohen & Manuck, 1995), emerging literature suggests that abnormally low levels of stress reactivity can also be detrimental (Lovallo, 2010; Phillips, Roseboom, Carroll, & de Rooij, 2012). Negative stress reactions motivate behavioral change (Ekman, 1993); therefore, low stress reactive individuals may be less likely in general to change their behavior in the face of a stressor. When a low stress reactive individual uses reappraisal to down-regulate already low negative emotions, higher CRA may be detrimental by reducing the low stress response and removing the motivational benefit of optimal stress reactivity. In the context of health, individuals who have higher reappraisal ability and lower stress reactivity may be removing the motivation to engage in healthier behavior, which then leads to higher BMI and greater incidence of type 2 diabetes.

Although the present study substantially contributes to our understanding of the relation between perceived stress reactivity, emotion regulation and health, there are a number of study limitations that warrant discussion and further investigation. First, future research should be conducted that verifies the current findings using non self-report measures, including psychosocial stress testing with physiological assessments of reactivity and waist circumference or triceps and subscapular skinfold thicknesses to measure body fat. In addition, self-reported diagnosis of type 2 diabetes was low and should be assessed in future studies using more objective measures such as fasting plasma glucose.

Second, the cross-sectional nature of the study precludes assumptions of causality; therefore, future longitudinal research should be conducted to test if CRA prospectively buffers against obesity-related health outcomes. Additionally, questions were not asked that would allow researchers to assess the mechanisms through which CRA interacts with perceived stress reactivity to affect BMI (such as diet). Therefore, future research should investigate the pathways by which CRA affects health, such as health behaviors or psychophysiological stress responses.

In addition, the present study only assessed reappraisal ability via changes in sadness ratings to video clips. We were conservative in our administration of the CRA task as this was first time it was conducted online—we used previously tested sad inducing film clips and included a number of manipulation checks to confirm task attention and performance. When the full sample was included in analyses, the interaction remained significant, suggesting that tasks such as these can be effectively administered online. Therefore, future research should adapt the task to investigate how CRA could reduce other negative emotions such as anger and fear, as well as increasing positive emotions that may buffer against stress.

Despite noted limitations, the present results contribute to the burgeoning research on the stress-buffering effects of emotion regulation on physical health processes. Our findings demonstrate reappraisal as an important protective factor against obesity and the development of type 2 diabetes in those who perceive themselves to be highly stress reactive. In addition, we found that the ability to use reappraisal to down-regulate negative emotions is not universally beneficial. CRA may be maladaptive in individuals who perceive lower levels of stress reactivity by removing the motivational benefits of optimal stress reactivity. This pattern of findings supports current research on emotion regulation flexibility, suggesting that the adaptiveness of a strategy depends on the context it is used in. Thus, future research should examine if adaptive emotion regulation promotes positive physical health outcomes varies as a function of underlying stress reactivity styles. Although 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 emotion regulation plays in the relationship between perceived stress reactivity and health, and highlight how adaptive cognitive reappraisal has the capacity to buffer against obesity-related health outcomes.

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APPENDIX A: HEALTH BEHAVIOR ANALYSES INTRODUCTION

Heart disease is the leading cause of death for both men and women in the United States, claiming about 600,000 lives each year—or one in every four deaths (Centers for Disease Control and Prevention [CDC], 2013). While there has been substantial research identifying a variety of biological, behavioral, and social factors that contribute to the development of CVD (National Heart, Lung, and Blood Institute [NHLBI], 2014), prospective research provides considerable support that *psychological* stress—a strained feeling that occurs when a person perceives that external demands exceed his or her coping abilities (Cohen, Janicki-Deverts, & Miller, 2007)—also contributes to CVD morbidity and mortality (Kivimäki et al., 2006; Krantz, & McCeney, 2002; Rozanski, Blumenthal, Kaplan, 1999).

Importantly, people vary in their response to a stressor, with individuals higher in stress reactivity (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). One pathway by which stress reactivity negatively impacts the onset and progression of CVD is through behavioral mechanisms, whereby higher stress reactivity contributes to more engagement in health-compromising behaviors (Rozanski et al., 1999; Wiebe & McCallum, 1986). Indeed higher levels of stress reactivity are associated with physical inactivity (Muhsen, Garty-Sanalon, Gross, & Green, 2010), unhealthy dietary choices (Oliver, Wardle, & Gibson, 2000), greater tobacco use (Slopen et al., 2012) and poor sleep quality (Charles et al., 2011; National Sleep Foundation, 2001).

Importantly, the National Heart, Lung, and Blood Institute (2012a) has identified low levels of physical activity (i.e., less than 150 minutes of moderate-intensity activity per week), a diet high in saturated fat, and smoking as behavioral risk factors for heart disease. Evidence also suggests that poor sleep quality contributes to increased blood pressure and hypertension (Ayas et al., 2003; Croix & Feig, 2006; Wang, Xi, Liu, Zhang, & Fu, 2012). Additionally, these health behaviors contribute to obesity-related conditions (NHLBI, 2012b) including stroke and Type 2 diabetes, which are also among the leading causes of death in the U.S. (CDC, 2010). Therefore, critical investigation of the modifiable factors linking stress reactivity to CVD is an important step in developing preventative strategies for reducing the incidence of this detrimental disease. Furthermore, investigating potential buffers against the adverse effects of stress reactivity on the engagement in harmful health behaviors could prove relevant for broader disease prevention efforts.

Several buffering factors against the pathogenic influences of stress reactivity have been identified, including positive emotions (Dockray & Steptoe, 2010; Pressman & Cohen, 2005; Steptoe, Dockray, & Wardle, 2009), and social support (Cohen & Wills, 1985). In addition, recent findings have highlighted the importance of emotion regulation in the adaptive behavioral responses to a stressor (Giuliani, Calcott, & Berkman, 2013; Magar, Phillips, & Hosie, 2008). Emotion regulation (ER) encompasses cognitive, behavioral, and physiological processes that are used to influence the occurrence, intensity, duration, and expression of an emotion (Campbell-Sills, Ellard, & Barlow, 2014). Both adaptive and maladaptive ER is involved in cardiovascular health. Epidemiological studies have found that maladaptive ER strategies, which are either unsuccessful at reducing an unwanted emotion or have costs that are too great relative to the benefits (Campbell-Sills et al., 2014), are associated with hypertension (Mund &

Mitte, 2012) and adverse cardiac events in patients with coronary heart disease (Denollet, Gidron, Vrints, & Conraads, 2010; Denollet, Pedersen, Vrints, & Conraads, 2006; Denollet et al., 1996). Alternatively, adaptive strategies, which successfully reduce subjective distress and enable an individual to maintain the necessary abilities to pursue a relevant goal (Campbell-Sills et al., 2014), are positively associated with life satisfaction, interpersonal functioning, and well-being (Gross & John, 2003). Additionally, adaptive strategies are related to increases in heart rate variability (Denson, Grisham & Moulds, 2011), lower blood pressure and fewer cardiac symptoms in people who had previously experienced a heart attack (Willmott, Harris, Gellaitry, Cooper, & Horne, 2011). Collectively, these findings suggest that the ability to effectively regulate emotions may be a protective factor that helps individuals deal with stress and contributes to better cardiovascular health.

In determining which emotion regulation strategies are effective, it is important to consider a major component of emotions—that an appraisal of a situation must be made in order to perceive the event as stressful and subsequently experience an emotion. Beyond our physiological capabilities to handle stress, “we differ in the psychological filters through which we perceive the stressors in our world,” (Sapolsky, 2004, p. 269). For example, two people experiencing the same event—getting stuck in traffic on the way home, having a big deadline approach, public speaking—may differ dramatically in the way they psychologically perceive the event (Sapolsky, 2004). Indeed, Lazarus and Folkman’s (1984) psychological appraisal theory suggests that a person’s appraisal of a situation, as opposed to the “objective” event itself, precedes an emotion which triggers the physiological and behavioral stress response. Given the importance of subjective appraisals, an ER strategy that targets and attempts to alter these appraisals should be effective in promoting positive outcomes.

Cognitive reappraisal is a widely studied ER strategy that involves reinterpreting the initial appraisal of an emotion-eliciting situation in a positive light to change its emotional impact (Gross, 1998, 2002; Gross & John, 2003). Laboratory studies have found that participants who are told to cognitively reappraise an emotional film clip experience both more positive and less negative emotion than those who are told to use another ER strategy or passively watch the film (Dandoy & Goldstein, 1990; Gross, 1998). Studies employing self-report trait measures of cognitive reappraisal have also found that individuals who frequently use reappraisal experience less negative emotion in emotional situations and have higher life satisfaction, self-esteem, and optimism (Gross & John, 2003; Mauss, Cook, Cheng, & Gross, 2007). Additionally, a recent meta-analysis examining adaptive and maladaptive ER strategies in relation to psychopathology found that frequent reappraisers demonstrate positive outcomes over time (e.g., negatively associated with depression, anxiety, eating and substance-related disorders; Aldao, Nolen-Hoeksema, & Schweizer, 2010). This research shows that cognitive reappraisal use has many benefits and raises the question of whether this strategy is useful as a way to reduce the impact of psychological stress on health-compromising behaviors. Specifically, cognitive reappraisal may be a protective factor in the relation between stress and behavioral risk factors by promoting positive appraisals that enable individuals to effectively down-regulate negative emotions.

While the majority of prior research has examined the physiological impact of cognitive reappraisal on cardiovascular health (i.e., more adaptive cardiovascular stress responses; Denson et al., 2011; Jamieson, Nock, & Mendes, 2012; Mauss et al., 2007; Thayer & Brosschot, 2005), much less research has examined the behavioral impact associated with reappraisal. Recent evidence suggests that the craving to smoke cigarettes and consume desired foods can be cognitively regulated (Hollmann et al., 2012; Kober, Kross, Mischel, Hart, & Ochsner, 2010; Siep et al., 2012). In one study, participants instructed to use a cognitive reappraisal strategy when viewing pictures of desirable “junk” food (e.g., chocolate, cookies, and ice cream) were able to reduce their cravings for these items (Giuliani et al., 2013). Using measures of self-reported cognitive reappraisal use, other studies have demonstrated that reappraisal is negatively associated with smoking status and age of smoking initiation in young adults (Magar et al., 2008) and frequent adult reappraisers have weaker expectations that smoking will alleviate negative emotions (Fucito, Juliano, & Toll, 2010).

Another way that cognitive reappraisal can impact healthy behavioral adjustment to stress is by promoting the experience and expression of positive emotions. Research examining both experimentally induced cognitive reappraisal and self-reported trait reappraisal has shown that this strategy can generate positive affect, particularly during stressful circumstances (Fredrickson, 2001; Gross & John, 2003). In turn, positive emotions are believed to encourage the habituation of healthy behaviors, including physical activity (Bruijn, Rhodes, & Osch, 2012; Peterson et al., 2013) and healthy dietary choices (Cohen, Doyle, Turner, Alper, & Skoner, 2003) and are negatively associated with poor sleep quality (Baglioni, Spiegelhalder, Lombardo, & Riemann, 2010). Overall, evidence suggests that cognitive reappraisal is negatively associated with engagement in harmful health behaviors, both directly and through positive emotions.

Understanding this modifiable stress-buffer has important implications for CVD preventative efforts.

In conjunction with the theoretical appraisal perspective and the view that psychological stress is a subjective experience, a model emerges in which individual differences in the use of cognitive reappraisal may be an important moderator of the relationship between stress and behavioral risk factors. A study conducted by Troy, Wilhelm, Shallcross, and Mauss (2010) found support for the cognitive reappraisal stress-buffering theory in the context of depression. Troy and colleagues developed a novel multi-method laboratory paradigm to examine a person's *ability* to cognitively reappraise (known as cognitive reappraisal ability (CRA)). To measure CRA, participants were shown a series of negative emotion-eliciting film clips and asked to rate their emotions after each clip. On one of the three emotional film clips, participants were asked to reappraise their reaction to the situation in a more positive way. Their emotional reactions were measured through self-reported emotion ratings and skin conductance levels. Troy and colleagues (2010) found that CRA significantly moderated the relation between perceptions of stressful life events and depressive symptoms, such that at high levels of stress, participants higher in CRA showed less depressive symptoms than those lower in CRA. These results suggest that CRA is an important moderator in the relation between stress and mental health. Critically, CRA has never been examined in the context of stress and health-compromising behaviors.

The Present Study

Current evidence suggests that cognitive reappraisal is negatively associated with engagement in harmful health behaviors that place a person at-risk for CVD. In this context, cognitive reappraisal may help individuals positively alter their stress appraisals so they don't feel the need to engage in adverse health behaviors. Because CRA has only been examined with characteristics of mental health, the goal of the present study is to expand Troy and colleague's (2010) reappraisal stress-buffering model by applying it in the context of behavioral risk factors. Examining other outcomes related to stress is an important next step in determining the predictive validity of CRA in different contexts and the strong operationalization and valid measurement of this construct is important to ensure quality research on this topic (Troy et al., 2010). Multiple theories and models have been developed to change unhealthy behavior (see Schwarzer, 2011 for a review); therefore, the identification of a modifiable stress-buffer that can be taught as a cognitive tool (see Denny & Ochsner, 2014) and used to decrease engagement in health-compromising behaviors could further our understanding of heart disease prevention and intervention with broad implications for health behavior research.

To test the role of CRA in the relation between perceived stress and behavioral risk factors, participants will complete a modified version of the CRA experiment developed by Troy and colleagues (2010) as well as an extensive survey on psychosocial factors related to health. We hypothesize that people who are more effective at down-regulating their negative emotions using cognitive reappraisal are going to engage in less harmful health behaviors. Specifically, we predict that CRA will moderate the relationship between stress reactivity and behavioral risk factors, such that at high levels of stress, participants with high CRA will be more physically active, consume a diet lower in saturated fat, not smoke tobacco, and get sufficient sleep, compared to those with low CRA.

APPENDIX B: PHYSICAL ACTIVITY

Hypothesis 1 – Physical Activity

Cognitive reappraisal ability (CRA) will moderate the relation between perceived stress reactivity and physical activity.

Measure

Physical activity was measured via the 31-item International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) that asks about specific types of activities undertaken for work, transportation, domestic and garden, and leisure-time at three levels of activity (walking, moderate, and vigorous). A well-known physiologic effect of physical activity is that it 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 are calculated by summing the total walking, moderate, and vigorous MET-minutes per week for the different types of activities. These three domain scores are summed to yield a total physical activity score which is represented as median MET-minutes per week. Extensive reliability and validity testing has indicated that his measure has acceptable psychometric properties and is suitable for national population-based studies of participation in physical activity (Brown, Trost, Bauman, Mummery, & Owen, 2004; Craig et al., 2003).

Statistical Analysis

A moderated multiple regression analysis was conducted with physical activity as the criterion. First, the stress reactivity and CRA score variables were mean centered then multiplied together to create an interaction term. Centered and weighted effects coded control variables were introduced as predictors in step one, and stress reactivity (centered) and CRA (centered) as predictors in step two. In step three, the interaction term was added as a predictor to determine if these two variables have an interactive effect above and beyond the variables by themselves (Cohen, Cohen, West, & Aiken, 2003).

Results

Descriptive Statistics

Please refer to the main document for demographic and descriptive information about this sample. The average level of physical activity was 6620.89 (*SD* = 7488.09) median MET minutes per week. Levels of total physical activity showed an associated with age ($r = -.19$, $p < .05$), but was not correlated with any other measure.

Moderated Regression Results

In step one, the combination of control variables did not explain a significant amount of variance in physical activity ($R^2 = .07$, $F(142) = 1.64$, $p = .13$). In step two, the individual predictors did not explain a significant amount of variance beyond the first model ($R^2 = .08$, $\Delta R^2 = .01$, $p = .55$) with neither stress reactivity ($b = -68.91$, $p = .43$) nor CRA ($b = -578.43$, $p = .42$) significantly predicting physical activity, while holding controls constant. In step three, the interaction term ($b = -14.22$, $p = .83$) did not incrementally predicted physical activity ($R^2 = .08$, $\Delta R^2 = .00$, $p = .83$) indicating that together, stress reactivity and CRA do not have an interactive effect that increases the predictive validity beyond the second model.

Conclusion

Hypothesis 1 was not supported. CRA does not appear to moderate the relation between perceived stress reactivity and physical activity.

APPENDIX C: DIET HIGH IN SATURATED FAT

Hypothesis 2 – Diet High in Saturated Fat

Cognitive reappraisal ability (CRA) will moderate the relation between perceived stress reactivity and a diet high in saturated fat.

Measure

Diet was measured via a modified subscale of the Paffenbarger Physical Activity Questionnaire (PPAQ; Paffenbarger et al., 1993), which assesses the frequency of various foods eaten. Respondents indicated how often they eat certain types of foods on a six-point Likert scale (0 = *almost never*, 6 = *6+ times per day*). Analyses focused on the frequency of consumption of eight foods known to be high in saturated fat (e.g., eggs, whole milk, low fat milk, cream, cheese, ice cream, butter, and sweet desserts; National Cancer Institute, 2013). Scores range from 0-48 and are summed, with higher scores indicating a diet higher in saturated fat. This measure demonstrated low reliability in our sample (α = .51).

Statistical Analysis

A moderated multiple regression analysis was conducted with diet as the criterion. First, the stress reactivity and CRA score variables were mean centered then multiplied together to create an interaction term. Centered and weighted effects coded control variables were introduced as predictors in step one, and stress reactivity (centered) and CRA (centered) as predictors in step two. In step three, the interaction term was added as a predictor to determine if these two variables have an interactive effect above and beyond the variables by themselves (Cohen et al., 2003).

Results

Descriptive Statistics

Please refer to the main document for demographic and descriptive information about this sample. Mean levels of diet indicated that, on average, individuals in this sample consumed 11.86 (*SD* = 4.79) servings of food high in saturated fat per week. Our measure of diet was not correlated with any other measure.

Moderated Regression Results

In step one, the combination of control variables did not explain a significant amount of variance in diet ($R^2 = .06$, $F(142) = 1.30$, $p = .26$). In step two, the individual predictors did not explain a significant amount of variance beyond the first model ($R^2 = .08$, $\Delta R^2 = .02$, $p = .22$) with neither stress reactivity ($b = -.00$, $p = .97$) nor CRA ($b = .78$, $p = .09$) significantly predicting diet, while holding controls constant. In step three, the interaction term ($b = .05$, $p = .21$) did not incrementally predicted physical activity ($R^2 = .09$, $\Delta R^2 = .01$, $p = .21$) indicating that together, stress reactivity and CRA do not have an interactive effect that increases the predictive validity beyond the second model.

Conclusion

Hypothesis 2 was not supported. CRA does not appear to moderate the relation between perceived stress reactivity and a diet high in saturated fat.

APPENDIX D: POOR SLEEP QUALITY

Hypothesis 3 – Poor Sleep Quality

Cognitive reappraisal ability (CRA) will moderate the relation between perceived stress reactivity and a poor sleep quality.

Measure

Poor sleep quality was measured 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 are combined to form seven component scores (e.g., sleep quality, durations, disturbance, efficiency), each weighted equally on a scale from 0 to 3 (0 = *no difficulty*, 3 = *severe difficulty*). The component scores are summed to yield one global PSQI score ranging from 0 to 21, with higher scores indicating poorer sleep quality. This scale demonstrated acceptable reliability in our sample (α = .75).

Statistical Analysis

A moderated multiple regression analysis was conducted with poor sleep quality as the criterion. First, the stress reactivity and CRA score variables were mean centered then multiplied together to create an interaction term. Centered and weighted effects coded control variables were introduced as predictors in step one, and stress reactivity (centered) and CRA (centered) as predictors in step two. In step three, the interaction term was added as a predictor to determine if these two variables have an interactive effect above and beyond the variables by themselves (Cohen et al., 2003).

Results

Descriptive Statistics

Please refer to the main document for demographic and descriptive information about this sample. Mean sleep quality was 6.35 (*SD* = 3.61). Considering the highest level of poor sleep quality was 21, the standard deviation for this variable suggests a restricted range (i.e., limited variability in the distribution). Poor sleep quality was correlated with gender ($r = .28$, $p < .01$), reappraisal use ($r = -.20$, $p < .05$), depressive symptoms ($r = .53$, $p < .01$), and stress reactivity ($r = .44$, $p < .01$). There was a trend in the relation between poor sleep quality and CRA ($r = -.16$, $p = .05$). Poor sleep quality was not correlated with BMI or type 2 diabetes.

Moderated Regression Results

In step one, the combination of control variables explained a significant amount of variance in poor sleep quality ($R^2 = .36$, $F(142) = 11.20$, $p < .01$). In step two, the individual predictors did not explain a significant amount of variance beyond the first model ($R^2 = .36$, $\Delta R^2 = .00$, $p = .60$) with neither stress reactivity ($b = .03$, $p = .35$) nor CRA ($b = -.08$, $p = .78$) significantly predicting poor sleep quality, while holding controls constant. In step three, the interaction term ($b = -.03$, $p = .32$) did not incrementally predicted poor sleep quality ($R^2 = .36$, $\Delta R^2 = .00$, $p = .32$) indicating that together, stress reactivity and CRA do not have an interactive effect that increases the predictive validity beyond the second model.

Conclusion

Hypothesis 3 was not supported. CRA does not appear to moderate the relation between perceived stress reactivity and poor sleep quality.

APPENDIX E: TOBACCO USE

Hypothesis 4 – Tobacco Use

Cognitive reappraisal ability (CRA) will moderate the relation between perceived stress reactivity and tobacco use.

Measure

Tobacco use was assessed using questions adapted from the National Social Life, Health, and Aging Project (Drum et al., 2009). Respondents were asked if they currently smoke cigarettes (yes/no) and if so how long they have been smoking and how many cigarettes on average they smoke per day. Participants were coded as 0 if they did not currently smoke cigarettes and 1 if they did.

Statistical Analysis

A moderated logistic regression analysis was performed on smoking behavior (0 = *does not smoke,* 1 = *smokes*) using stress reactivity, CRA, and a product term that multiplies the two variables by one another as predictor variables. Before conducting the analysis and computing the product term, the two predictors were mean centered. Centered and weighted effects coded control variables were entered in step one, the two predictors in step two, and the product term in step 3. The exponent of the logistic coefficient of stress reactivity was interpreted as the predicted odds change of being a smoker given a 1-unit increase in stress reactivity, holding controls constant. The same interpretation was made for CRA. The change in pseudo R^2 from step two to step three was inspected for practical and statistical significance.

Results

Descriptive Statistics

Please refer to the main document for demographic and descriptive information about this sample. Twenty-two percent of participants reported currently smoking cigarettes. Tobacco use was negatively correlated with gender (*r* = -.17, p < .05) and depressive symptoms (*r* = -.17, *p* < .05).

Moderated Logistic Regression Results

In step one, the combination of control variables explained 13% of the variance in tobacco use, constituting a large effect size (Nagelkerke pseudo-R^2 = .13). In step two, the individual predictors did not explain a meaningful amount of variance beyond the first model (Nagelkerke pseudo-R^2 = .14), with neither stress reactivity (*b* = -.01, O.R. = .99, *p* = .70, 95% CI [.93, 1.05]) nor CRA (*b* = -.18, O.R. = .83, *p* = .43, 95% CI [.53, 1.31]) significantly predicting the odds of being a smoker, while holding controls constant. In step three, the interaction term (*b* = -.01, O.R. = .99, *p* = .56, 95% CI [.95, 1.03]) did not incrementally predict the odds of being a smoker (Nagelkerke pseudo-R^2 = .14) indicating that together, stress reactivity and CRA do not have an interactive effect that increases the predictive validity beyond the second model.

Conclusion

Hypothesis 4 was not supported. CRA does not appear to moderate the relation between perceived stress reactivity and tobacco use.

APPENDIX F: HEALTH BEHAVIOR ANALYSES CONCLUSION

The present study sought to examine if people who are more effective at down-regulating their negative emotions using cognitive reappraisal would engage in less harmful health behaviors. Specifically, we predicted that CRA would moderate the relationship between stress reactivity and health compromising behaviors. These hypotheses were not confirmed in the current study. An individual's ability to cognitively reappraise did not moderate the relation between stress reactivity and physical activity, diet, sleep, or tobacco use.

These findings could have resulted from the way we measured the four health compromising behaviors. Physical activity was assessed using a well-validated scale, however, these analyses only took into account an individual's total amount of physical activity per week across four domains: work, transportation, domestic and garden, and leisure-time. Because leisure-time activity would likely be the domain most impacted by high levels of stress, as opposed to commuting to work, future research should examine how stress reactivity and CRA functions in this domain of activity compared to the other domains. In contrast, our measure of diet was not assessed with a well-validate scale and may not have been sensitive enough to assess dietary choices. This measure was taken from a larger physical activity questionnaire; however, the decision to simply total the frequency of eight food items known to be high in saturated fat was made to specifically test our hypothesis but may not have been appropriate. Due to the complexity of eating behaviors and choices, future research should consider a more sensitive and well-validated measure of diet.

Poor sleep was assessed using a well-validated scale; however, similar to the measure of physical activity, perhaps the interaction between CRA and stress reactivity is more relevant for some aspects of poor sleep (e.g., sleep latency), as opposed to a total sleep score. Future research should examine these relationships in specific domains of sleep to see if any patterns emerge. Finally, tobacco use was assessed with a simple yes/no question asking respondents if they currently smoke cigarettes. This assessment excludes individuals who formerly smoked, potentially accounting for the fact that only 22% of the sample reported currently smoking. Future research may consider testing these relationships in a larger sample of smokers. Further, a more accurate measure of tobacco use involves calculating an individual's smoking pack years, by multiplying the number of packs of cigarettes smoked per day by the number of years smoked. Future research should explore this measure as a health behavior outcome in order to more accurately gauge participants' smoking habits and levels of tobacco use.

Despite the issues with assessing complex health behaviors such as physical activity, diet, sleep, and smoking behavior, this study yielded a finding that was in line with the CRA stress-buffering hypothesis. CRA interacted with stress reactivity to buffer against high BMI, which extended to protect against type 2 diabetes, an obesity-related health condition. Specifically, when a person is highly stress reactive, CRA protects them against high BMI. In addition, the buffering effect of CRA extended to a chronic disease outcome, whereby having higher CRA mitigated the influence of high stress reactivity on type 2 diabetes. In addition, results from the moderation suggest that high CRA is not universally protective. While high CRA was found to mitigate the impact of high stress reactivity on type 2 diabetes, individuals with low stress reactivity and high reappraisal ability exhibited higher BMI, indicating that reappraisal ability may be maladaptive in certain contexts. While the four proposed hypotheses were not supported by the data, the pattern of findings with BMI and type 2 diabetes was consistent with the proposed hypotheses: CRA interacts with stress reactivity to buffer against negative health outcomes. In sum, findings from the present study advance our understanding of the role that emotion regulation plays in the relation between stress reactivity and health, and highlight how adaptive cognitive reappraisal has the capacity to buffer against obesity-related health outcomes.

APPENDIX G: SUPPLEMENTARY HEALTH BEHAVIOR ANALYSES REFERENCES

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FOOTNOTE

1. When the 68 participants who did not pass the manipulation checks were included in analyses, the reported data patterns did not change from the reported sample (n = 150) analyses. The interaction between CRA and perceived stress reactivity remained significant using the full sample. In step two, the individual predictors did not explain a significant amount of variance beyond the first model of control variables (R^2 = .09, ΔR^2 = .00, p > .25). Neither perceived stress reactivity nor CRA (b = .02, p > .25 and b = .03, p > .25, respectively) significantly predicted BMI, while holding controls constant. In step three the interaction term (b = -.15, p = .01, 95% CI [-.27, -.03]) incrementally predicted BMI (R^2 = .12, ΔR^2 = .03, p = .01) indicating that together, perceived stress reactivity and CRA have an interactive effect.