10-2012

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Recommended Citation

Carlson, J. M., Dikecligil, G. N., Greenberg, T. & Mujica-Parodi, L. R. (2012). Trait reappraisal is associated with resilience to acute psychological stress. Journal of Research in Personality, 46(5), 609-613. http://dx.doi.org/10.1016/j.jrp.2012.05.003

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Article *in* Journal of Research in Personality · October 2012

DOI: 10.1016/j.jrp.2012.05.003

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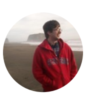

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Journal of Research in Personality xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Journal of Research in Personality

journal homepage: www.elsevier.com/locate/jrp

Brief Report

Trait reappraisal is associated with resilience to acute psychological stress

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Reappraisal
Emotion
Regulation
Stress
Skydive
Anticipation
Cortisol

ABSTRACT

Life is full of stressful events. However, while some individuals are negatively affected by stress, others are more resilient to its effects. The factors that contribute to variability in stress resilience are not fully understood. Here, we tested the hypothesis that trait reappraisal would be associated with greater stress resilience to a first-time tandem skydive. Specifically, we expected measures of "anxiety" to be lower and measures of "euphoria" to be higher in high trait reappraising individuals. Our findings that trait reappraisal is negatively correlated with stress reactivity as measured by cortisol, heart rate, and self-report state anxiety, but positively correlated with self-report state euphoria suggest that individuals high in trait reappraisal are more stress resilient.

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1. Introduction

In our day-to-day life we encounter a variety of stressful events. In addition to dealing with these stressors as they occur, we also anxiously anticipate or worry about them before they happen. Excessive levels of worry and stress can adversely affect individuals' emotional well-being and health (Krantz, Grunberg, & Baum, 1985); however, some individuals are resilient to these adverse effects. Resilience to stress can be thought of as a decrease in negative emotional responding coupled with a relative increase in positive emotion. Understanding the factors that contribute to variability in resilience may help successful coping.

One's ability to regulate their emotional response, both before and during a stressful event, can help attenuate its effect. Cognitive reappraisal, or thinking about an event in a manner that modifies its affective impact, is a common emotion regulation strategy aimed at modulating the emotional response before it fully manifests (Gross, 1998). Therefore, one's tendency to reappraise may contribute to individual differences in stress resilience. Research has demonstrated that instructing participants to reappraise negative emotional stimuli decreases reported emotional experience, behavioural expression, physiological responses, and neural activation in emotional structures such as the amygdala and insula (for review see Gross, 2002; Ochsner & Gross, 2005). Across individuals there appears to be significant variability in one's natural disposition to use reappraisal in daily life to regulate emotional responding. Based on questionnaire data, higher levels of trait reappraisal are associated with reduced experience and expression of negative emotions, but increased experience and expression of positive emotions (Gross & John, 2003). Similarly, during experimentally induced anger provoking situations individuals high in trait reappraisal experience less anger and demonstrate reduced blood pressure and adaptive cardiovascular responding (Mauss, Cook, Cheng, & Gross, 2007; Memedovic, Grisham, Denson, & Moulds, 2010). Furthermore, high trait reappraisers have reduced amygdala reactivity to threatening stimuli (Drabant, Mcrae, Manuck, Hariri, & Gross, 2009) and reduced anterior insula activation during anxious anticipation (Carlson & Mujica-Parodi, 2010). Overall, findings suggest that both instructed and habitual uses of cognitive reappraisal are associated with reduced negative emotional responding and increased positive emotional responding, and may therefore be beneficial to overcoming the detrimental effects of stress.

In the current investigation we assessed the extent to which natural tendencies towards reappraisal predict stress resilience. We utilised a controlled testing protocol outside the laboratory to test the hypothesis that individual differences in dispositional reappraisal would be positively associated with resilience to a first-time tandem skydive. Specifically, we predicted that self-report levels of anxiety would be lower, while self-report levels of euphoria would be higher in high trait reappraising individuals. Additionally, we collected cortisol and heart rate measures, which are well-established physiological measures of stress reactivity and can easily be measured in the field. Elevated cortisol levels are indicative of an individual's hypothalamic–pituitary–adrenal neuroendocrine response to stress, while heart rate is reflective of the cardiovascular stress response. We expected that these measures would be negatively associated with trait reappraisal.

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0092-6566/$ - see front matter Published by Elsevier Inc.
http://dx.doi.org/10.1016/j.jrp.2012.05.003

2. Methods

2.1. Participants

Twenty-one (9 female) healthy consenting adults ($M = 23.52$, $SD = 5.79$, 18–43) participated in the study. Participants were recruited from individuals who independently contacted a local skydiving school to complete their first tandem skydive (Skydive Long Island, Calverton, NY). This study is comprised of a subset of individuals participating in a larger investigation of individual variability in physiological stress reactivity. The Institutional Review Board of Stony Brook University approved this study.

2.2. Procedure

A skydive exposes participants to an environment with potentially fatal consequences and has previously been shown to elicit a strong physiological stress response (Chatterton, Vogelsong, Lu, & Hudgens, 1997). However, skydiving is also an activity that some individuals find enjoyable. Typically, individuals are most anxious during the anticipatory period leading up to the jump and are most euphoric upon landing (see results). This multifaceted emotional response is ideally suited to test the hypothesis that trait reappraisal is associated with reduced negative affect and increased positive affect.

Testing took place over two time-matched days (minimising diurnal and other potential time-related confounds). During one day participants completed the skydive. The other day took place at the Stony Brook University Hospital General Clinical Research Center (GCRC) and served as a baseline. On both days, participants arrived at the GCRC at 7:30 am and ate a standardised breakfast, after which they did not eat or drink (other than water) until the completion of cortisol acquisition. Fourteen participants completed the skydive day first[1]. Participants boarded the plane at 10:15 am, ascended for 15 min until an altitude of 4 km/13,000 feet, and then jumped at 10:30 am. Free-fall lasted for one full minute, which was followed by a four minute decent under an open parachute. Participants landed at 10:35 am.

After the acquisition of physiological data on the control day, participants completed the Emotion Regulation Questionnaire (ERQ; Reappraisal: $M = 4.90$, $SD = 0.98$, Suppression: $M = 3.33$, $SD = 1.05$, on a 1 (low usage) to 7 (high usage) scale, Gross & John, 2003) and the Trait Anxiety Inventory (TAI; $M = 31.86$, $SD = 6.70$; Spielberger, Gorsuch, & Lushene, 1970). Reliability was good for the TAI ($\alpha = 0.80$) and ERQ-Reappraisal ($\alpha = 0.80$), but questionable for ERQ-Suppression ($\alpha = 0.67$).

2.2.1. Cortisol

Ten 6 cc saliva cortisol samples were collected in 15 min intervals occurring both prior to skydive (9:15 am, 9:30 am, 9:45 am, and 10:00 am) and after landing (10:45 am, 11:00 am, 11:15 am, 11:30 am, 11:45 am, and 12:00 pm). To control for diurnal variability baseline cortisol samples were collected at identical timepoints. Acquisition of cortisol samples was obtained using the passive drool method (Saliva Collection Handbook; Salimetrics, LLC). Samples were frozen at −20°F and subsequently assayed as singles by the GCRC Core Lab via radioimmunoassay with a Coat-A-Count Cortisol Kit (Siemens Medical Solutions Diagnostics, Los Angeles, CA). Based on separate quality control samples the intra-assay variation was 3% and the inter-assay variation was 9%. The lower limit of detection was 0.7 nmol/L. For one individual, skydive samples 6–10 contained excessive mucus and were therefore not analysed (i.e., cortisol $N = 20$).

2.2.2. Heart rate

At both the airfield and the GCRC, an Aria Digital Holter Monitor (Del Mar Reynolds Medical, Irvine, California) was attached at approximately 9:00 am and remained on until 3:30 pm. Two electrodes were attached to the chest over the left sixth rib and one just right of the xiphoid process of the sternum. A reference electrode was placed on the manubrium of the sternum. The ECG signal was sampled at a rate of 128 samples/s. The Impresario Holter Analysis System (Del Mar Reynolds Medical, Irvine, California) was used for initial automated data processing. The ECG was manually reviewed to check for any misclassifications or errors. Cubic spline was used to generate a heart rate (HR) signal with a sampling frequency of 1 Hz. To assess the effect of acute stress on HR participant's ECGs were initially segmented relative to landing as follows: 9:45–9:55 am, 9:55–10:10 am, 10:10–10:25 am, 10:25–10:30 (jump), 10:30–11:00 am, 11:00–11:30 am, 11:30 am–12:00 pm, 12:00–12:30 pm, 12:30–1:00 pm, 1:00–1:30 pm. Due to equipment malfunction, all skydive HR data for four individuals were lost (i.e., HR $N = 17$).

2.2.3. Self-report state measures

Participants reported their state anxiety (Marteau & Bekker, 1992; six-item short-form) and euphoria (lab constructed; see Supplementary Appendix) levels at six time points both before (9:00 am and 10:25 am, which occurred immediately prior to jumping out of the plane) and after (10:45 am, 11:15 am, 1:00 pm, and 3:30 pm) the time of the skydive on both days (Cronbach's $\alpha = 0.61$ and $\alpha = 0.68$, respectively[2]).

2.3. Statistical analyses

To assess the effect of the skydive, as an acute stressor, we conducted separate two-way (Day × Time) repeated measures Analyses of Variance (ANOVA) with cortisol (2 × 10), HR (2 × 10), state anxiety (2 × 6), and state euphoria (2 × 6) as dependent variables[3]. When assumptions of sphericity were violated the Greenhouse–Geisser correction was applied. Follow-up pairwise comparisons were Bonferroni adjusted for multiple comparisons. Given our relatively small sample size/limited statistical power and to limit type-one error, we restricted our correlation analyses to a single reactivity measure for each dependent variable. To ensure that reactivity–reappraisal correlations were not driven by baseline–reappraisal correlations, we used standardised Skydive–Control regression residuals as our measures of reactivity. To test the hypothesis that higher levels of trait reappraisal would be associated with reduced physiological stress reactivity we performed single-tailed Pearson correlations on average reactivity measures for HR (i.e., averaged from 9:55–10:30 am) and cortisol (averaged across the10:00 am, 10:45 am, and 11:00 am samples), which included the anticipatory period most proximal to the skydive and the peak response to the skydive itself (see Fig. 1a and b). Note that the selected anticipatory cortisol samples account for the 20–30 min time lag associated with the bioavailability of salivary cortisol (Kirschbaum & Hellhammer, 1989). Also note that this late-anticipation-to-landing time frame is intuitively the most anxiety/stress inducing time frame of the skydive. This is supported by participants self-report state anxiety values (see results). The association between reappraisal and state anxiety was assessed at 10:25 am immediately

[1] Baseline measures were unaffected by order (all $ps > 0.1$).

[2] Alphas were only calculated for participants' first state measure on the control day.

[3] Heart rate reactivity did not correlate with cortisol ($r = 0.03$, $p > 0.1$), state anxiety ($r = 0.09$, $p > 0.1$), or state euphoria ($r = -0.17$, $p > 0.1$) reactivity. Cortisol reactivity positively correlated with state anxiety ($r = 0.72$, $p < 0.05$), but not euphoria ($r = -0.14$, $p > 0.1$). A negative correlation between state anxiety and euphoria approached significance ($r = -0.33$, $p = 0.07$).

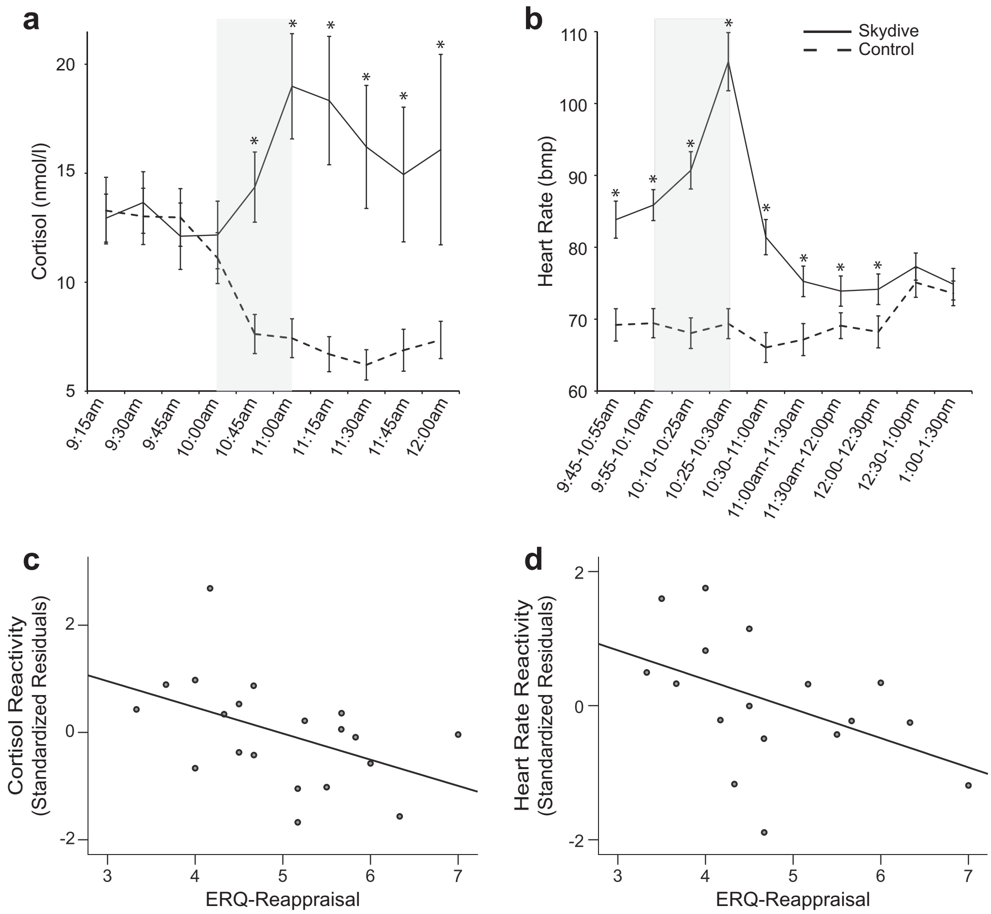

Fig. 1. (a) Cortisol and (b) heart rate were elevated in response to skydiving. Note participants landed at 10:35 pm. Also note there is a 20–30 min time lag in the bioavailability in salivary cortisol (Kirschbaum & Hellhammer, 1989). Negative correlations with trait reappraisal were found for (c) cortisol and (d) heart rate reactivity averaged across the shaded timeframe. Reactivity was calculated as the difference between the skydive – control days for both measures.

before jumping out of the plane, which was the peak response and best corresponds to the average reactivity measures used for HR and cortisol (see Fig. 2a). Given that high trait reappraisal has previously been associated with higher levels of positive affect (Gross & John, 2003), we expected that state euphoria would be positively associated with ERQ-Reappraisal scores. We tested this relationship at the 10:45 am landing time when euphoria was at its highest (Fig. 2b).

3. Results

3.1. Effects of the skydive

Participants' levels of cortisol (Day × Sample: $F(9,162) = 7.85$, $p = 0.001$, $\eta^2_{partial} = 0.30$) were elevated by the skydive. As can be seen in Fig. 1a, differences between the two days were significant from 10:45 am to 12:00 pm. Similarly, HR (Day × Segment: $F(9,153) = 43.43$, $p < 0.001$, $\eta^2_{partial} = 0.72$) was elevated by the skydive from 9:45 am to 12:30 pm (see Fig. 1b). State anxiety ($F(5,65) = 6.61$, $p < 0.001$, $\eta^2_{partial} = 0.34$)[4] and euphoria ($F(5,65) = 5.74$, $p < 0.001$, $\eta^2_{partial} = 0.31$) were also elevated in response to skydiving with state anxiety peaking immediately prior to jumping and euphoria peaking at landing (see Fig. 2a and b).

3.2. Negative associations with trait reappraisal

As predicted, cortisol ($r = -0.46$, $p < 0.05$; see Fig. 1c), HR ($r = -0.47$, $p < 0.05$; see Fig. 1d), and state anxiety ($r = -0.46$, $p < 0.05$; see Fig. 2c) reactivity were all negatively correlated with ERQ-Reappraisal. To ensure that these associations between ERQ-Reappraisal and stress reactivity were not driven by trait anxiety[5] or gender, we ran partial correlations controlling for these variables. The correlations with ERQ-Reappraisal and cortisol ($r_{partial} = -0.51$, $p < 0.05$), HR ($r_{partial} = -0.47$, $p < 0.05$), and state anxiety ($r_{partial} = -0.58$, $p < 0.05$) remained significant. ERQ-Suppression did not correlate with cortisol ($r = -0.20$, $p > 0.1$), HR ($r = -0.09$, $p > 0.1$) or state anxiety ($r = -0.16$, $p > 0.1$). In sum, we found that HR, cortisol, and state anxiety all revealed a consistent negative correlation with ERQ-Reappraisal in anticipation of skydiving.

3.3. Positive associations with trait reappraisal

There was a positive correlation between state euphoria and trait reappraisal ($r = 0.43$, $p < 0.05$; see Fig. 2d), which remained significant when trait anxiety and gender were accounted for ($r_{partial} = 0.50$, $p < 0.05$). ERQ-Suppression correlated with state euphoria ($r = 0.40$, $p < 0.05$), but not when controlling for trait anxiety and gender ($r = 0.20$, $p > 0.1$).

[4] In an alternate model including gender, females displayed a greater increase in reported state anxiety prior to skydiving at 9:00am (+5.6) and 10:25 am (+7) compared to males (+.3 and +1.1, respectively; $F(5,65) = 3.25$, $p < 0.05$). There were no gender effects on heart rate, cortisol, or euphoria.

[5] In alternate partial correlations using Neo-Neuroticism the association with HR was marginally significant ($r = -0.41$, $p = 0.06$), while cortisol and self-report correlations with reappraisal were significant (p's < 0.05).

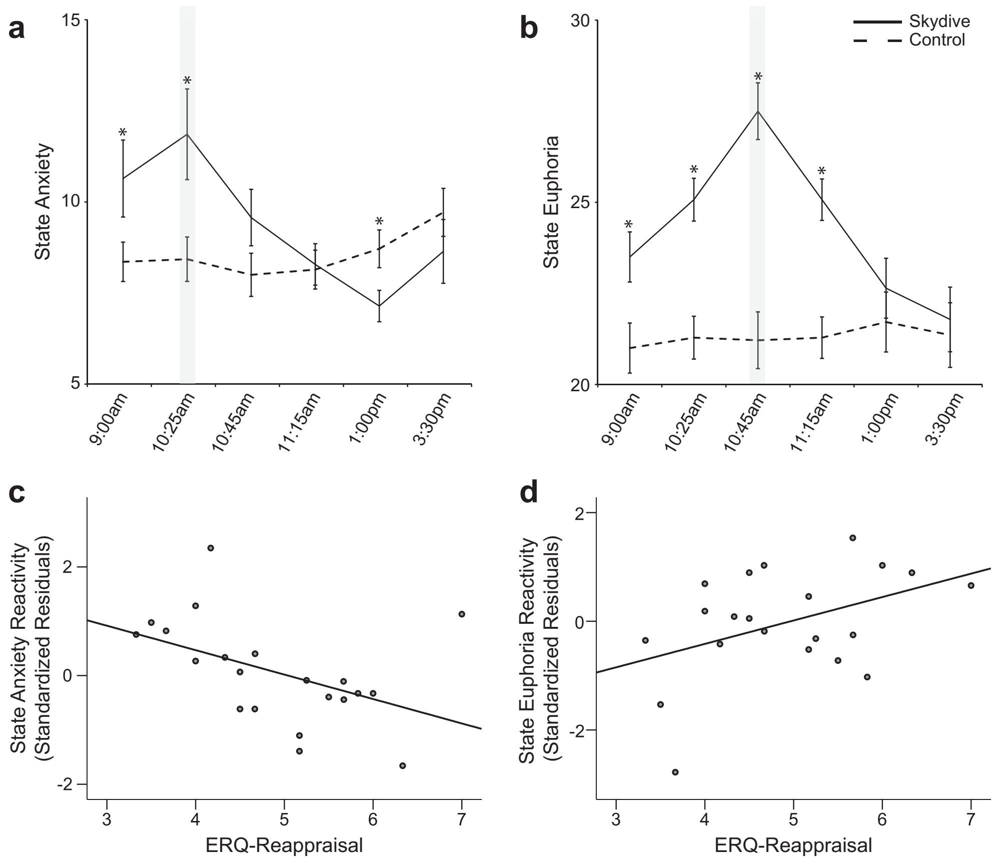

Fig. 2. (a) State anxiety and (b) state euphoria were elevated in response to skydiving. Note participants landed at 10:35 pm. A negative correlation with trait reappraisal was found for (c) state anxiety reactivity prior to jumping. Conversely, reappraisal was positively associated with (d) state euphoria reactivity at landing. Reactivity was calculated as difference between the skydive – control days for each measure.

4. Discussion

The first-time tandem skydive elicited a robust physiological and experiential stress response across cortisol, heart rate (HR), and self-report measures (see Figs. 1a and b and 2 a and b). As predicted, we found that trait reappraisal was negatively correlated with cortisol, HR, and state anxiety (see Figs. 1c and d and 2c and d), and positively correlated with state euphoria in response to skydiving. These associations between trait reappraisal and stress reactivity cannot be explained by gender or individual differences in trait anxiety. Furthermore, cortisol, HR, and self-report reactivity to skydiving were not associated with one's tendency to use suppression as an emotion regulation strategy. Together, these results provide evidence that trait reappraisal is uniquely associated with a reduction in the negative stress-inducing aspects of skydiving, while at the same time correlating with an increased positive skydiving experience. This pattern of results suggests that individuals who habitually use cognitive reappraisal techniques in their daily lives are more likely to be stress resilient.

Individuals high in trait reappraisal have reduced blood pressure and adaptive cardiovascular reactivity during emotionally taxing situations (Mauss et al., 2007; Memedovic et al., 2010). Similarly, neuroimaging research has shown that variability in insula and amygdala reactivity is negatively associated with dispositional reappraisal (Carlson & Mujica-Parodi, 2010; Drabant et al., 2009). This down-regulation in physiology may be mediated by inhibitory regulation of the amygdala by dorsolateral prefrontal cortex (Drabant et al., 2009; Ochsner & Gross, 2005). Thus, a disposition to reappraise may decrease both neural reactivity in emotion-related regions and peripheral physiological reactivity. The current results support this observation and further indicate that reappraisal-related decreases in physiological responding, including neuroendocrine and cardiovascular responses, occur during real-life stress. Collectively, these findings suggest that trait reappraisal is robustly associated with a reduction in stress physiology across endocrine, cardiovascular, and neural measures.

Our self-report measures of state anxiety and euphoria revealed that individuals high in trait reappraisal were both less anxious in anticipation of skydiving and more euphoric after skydiving. These differential associations are consistent with prior findings of lower levels of negative affect (Gross & John, 2003; Mauss et al., 2007; Memedovic et al., 2010) and higher levels of positive affect in individuals high in trait reappraisal (Gross & John, 2003). Importantly, we demonstrate that this negative association with state anxiety is accompanied by a reduced physiological stress response to an extreme acute real-world stressor. This is important because prolonged exposure to cortisol is thought to directly contribute to stress-induced health-related diseases and the regulation of this physiological response is likely necessary for resilience (Feder, Nestler, & Charney, 2009). Further research is needed to understand the long-term effects of cognitive reappraisal on stress resilience. In sum, it appears that individuals who tend to reappraise emotional events in their daily lives have less stress and experience greater joy-a combination that seems aptly suited for resilience to life stress.

Our finding of a reduced stress response is consistent with prior studies using self-report and neuroimaging measures. In contrast to these results, a recent study using a speech stressor found increased cortisol release in high trait reappraisers (Lam, Dickerson, Zoccola, & Zaldivar, 2009). It is unclear whether these differences are associated with the nature of the stressor, the level of stress/cortisol elicited by each method, or the time frame of the stress response (i.e., anticipation of stress vs. recovery from stress). Further work is needed to better understand this relationship.

Although our results inform the relationship between resilience and reappraisal, there are several limitations of the study and areas for future research. Due to weather-related constraints and ethical considerations with respect to recruitment our sample size was relatively small. Thus, replication in a larger sample is warranted. The generalizability of our results to a non-self-selected sample is unclear. However, given the potency of our stressor and the fact that people often knowingly put themselves in stressful situations, we suspect that these findings are relevant to the larger population. It should be noted that we did not instruct individuals to reappraise; thus, it is unclear if cognitive reappraisal was explicitly used. Nevertheless, these findings suggest that individuals high in trait reappraisal were more resilient to an extreme real-world stressor.

Trait suppression was not associated with physiological or self-report stress reactivity. Prior work has shown that instructed suppression strategies may actually result in an increased physiological response (Gross, 1998). However, similar to our results, Memedovic et al. (2010) reported no association between trait suppression and reduced emotional physiological reactivity. Thus, as previously proposed, habitual usage of reappraisal appears to be more effective in reducing the emotional experience and physiological response associated with the stress-inducing challenges of everyday life.

In conclusion, we found that skydiving was an effective stressor that increased cortisol, HR, and self–report anxiety. Importantly, we demonstrated that even without instruction to reappraise, individuals high in trait reappraisal experienced less anxiety assessed by both physiological and self-report measures and enhanced euphoria during a skydive, which suggests they may be more resilient to real-life stressors.

Acknowledgments

We thank the GCRG staff for assistance in processing the cortisol samples and Dan DeDora for programming the computerised questionnaires. Funding for this study was provided by the Office of Naval Research #N0014-04-1-005 (LRMP) and the National Institutes of Health # 5MO1-RR-10710 (GCRC).

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jrp.2012.05.003.

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