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# The role of stress mindset in shaping cognitive, emotional, and physiological responses to challenging and threatening stress

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**ABSTRACT**

**Background and objectives**: Prior research suggests that altering situation-specific evaluations of stress as challenging versus threatening can improve responses to stress. The aim of the current study was to explore whether cognitive, physiological and affective stress responses can be altered independent of situation-specific evaluations by changing individuals' mindsets about the nature of stress in general.

**Design**: Using a $2 \times 2$ design, we experimentally manipulated stress mindset using multi-media film clips orienting participants ($N = 113$) to either the enhancing or debilitating nature of stress. We also manipulated challenge and threat evaluations by providing positive or negative feedback to participants during a social stress test.

**Results**: Results revealed that under both threat and challenge stress evaluations, a stress-is-enhancing mindset produced sharper increases in anabolic ("growth") hormones relative to a stress-is-debilitating mindset. Furthermore, when the stress was evaluated as a challenge, a stress-is-enhancing mindset produced sharper increases in positive affect, heightened attentional bias towards positive stimuli, and greater cognitive flexibility, whereas a stress-is-debilitating mindset produced worse cognitive and affective outcomes.

**Conclusions:** These findings advance stress management theory and practice by demonstrating that a short manipulation designed to generate a stress-is-enhancing mindset can improve responses to both challenging and threatening stress.

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Pioneering studies by Lazarus and Folkman (1984) highlighted the importance of cognitive appraisal in determining the stress response. This research proposed that individuals first appraise the degree to which the situation is demanding (primary appraisal) and then appraise whether or not they have adequate resources to cope with the situation (secondary appraisal). More recently, researchers have elaborated on these stages and highlighted that the stress response is determined by the balance of perceived resources (e.g., knowledge, skills) and perceived demands (e.g., danger, uncertainty) and have identified physiological concomitants of these challenge and threat evaluations (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003; Gaab, Rohleder, Nater, & Ehlert, 2005; Seery, 2011; Tomaka, Blascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997; Wirtz et al., 2007). Simply put, a situation is deemed *threatening* when the individual evaluates the environmental demands to outweigh their resources or ability to cope. Physiologically, threat evaluations are associated with lower cardiovascular efficiency, heightened hormonal responses, negative affect, and poorer cognitive performance (Kassam, Koslov, & Mendes, 2009; Mendes, Blascovich, Hunter,

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Lickel, & Jost, 2007). A situation is considered *challenging* when the individual perceives that they have sufficient resources to meet the environmental demands. Challenge evaluations are typically associated with increased cardiac efficiency and hormonal responses related to thriving and growth, preparing the body for action and signaling approach motivation as well as increases in cognitive performance (Kassam et al., 2009; Mendes et al., 2007).

While the distinction between "threat" and "challenge" evaluations is important, there are a few critical limitations to practically applying threat and challenge theory to improve stress responses. First, given that the components of demands include danger and uncertainty, there are times in which it may be impossible to reduce the demands of a situation; for example, facing an unpredictable stressor such as a pop-quiz in a difficult class or receiving an unexpected cardiac-related health diagnosis. Second, since the elements of resources include knowledge and abilities, there are instances where trying to increase resources may be futile, particularly in the short-term; for instance, cramming in new material two minutes before a pop-quiz or researching all possible cardiac-related health diagnoses. Finally, trying to minimize the experience of threat by reducing demands and increasing resources does not capitalize on the possibility that the *imbalance itself* can promote psychological and physiological growth.

In light of these limitations, two important questions arise: is it possible to acknowledge a stressor as a "threat," yet still garner adaptive physiological and behavioral outcomes? Conversely, might it be possible to appraise a stressor as a "challenge," but nevertheless experience maladaptive physiological and behavioral outcomes? In the current paper, we address these questions by examining the role one's mindset about stress plays in challenge and threat contexts. Specifically, we examine whether the extent to which one holds an adaptive mindset about stress (e.g., that stress-is-enhancing) or a maladaptive mindset about stress (e.g., that stress-is-debilitating) will alter one's physiological, cognitive, and emotional responses in the context of challenge and threat evaluations.

## Stress mindset theory

Stress mindset is conceptualized as the extent to which an individual holds the mindset that stress has enhancing consequences for various stress-related outcomes (referred to as a "stress-is-enhancing mindset") or holds the mindset that stress has debilitating consequences for outcomes such as performance and productivity, health and well-being, and learning and growth (referred to as a "stress-is-debilitating mindset") (Crum, Salovey, & Achor, 2013). There is growing evidence that mindset not only affects outcomes in domains of intelligence (Dweck, 2008) and aging (Levy & Myers, 2004), but also shapes the stress response. Preliminary studies measuring stress mindset suggest that stress mindset is related to perceived health and life satisfaction over and above aggregate measures of amounts of stress, appraisals of stress, and various coping strategies (Crum et al., 2013). Additionally, individuals who have a stress-is-enhancing mindset exhibit more adaptive physiological responses and more approach-oriented behavioral responses in the face of stress (Crum et al., 2013). Specifically, participants who rated themselves as having a stress-is-enhancing mindset experienced moderate cortisol reactivity and were more receptive to feedback than those with a stress-is-debilitating mindset when exposed to an acutely stressful situation. Stress mindset can also be altered via intervention to produce corresponding changes in self-reported health and work performance (Crum et al., 2013). In line with evidence that suggests mindsets can be changed quite readily by simply orienting people to different information (cf. Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2008; Paunesku et al., 2015; Tamir, John, Srivastava, & Gross, 2007; Walton, 2014), mindsets about stress can be changed by having individuals watch a series of three, 3-minute videos orienting them to either the enhancing or debilitating effects of stress (Crum et al., 2013). Further, prior research has demonstrated that video interventions can influence performance and well-being; participants exposed to stress-is-enhancing videos not only developed a stress-is-enhancing mindset, but also reported better work performance and improved health conditions (Crum et al., 2013). These strong effects of stress mindset video interventions are consistent with research more broadly highlighting the enduring effects of interventions using short articles or videos to alter mindset in other domains including intelligence (Blackwell et al., 2007), belongingness (Walton, 2014), aging (Levy & Myers, 2004) and emotion regulation (Tamir et al., 2007).

Taken together, the emerging body of research on mindsets suggests that one way to meaningfully influence the stress response is to change an individual's mindset about stress. The concept that stress mindset is not situation-specific and can influence the stress response regardless of challenge and threat evaluations has been argued conceptually and through structural equation modeling (see Crum et al., 2013). However, this premise has not been experimentally tested, leaving open the question of exactly how experiences of stress may differ in the context of both challenge and threat evaluations, depending on one's stress mindset.

## Distinguishing between stress mindset and threat versus challenge theories

One critical distinction between stress mindset theory and theories surrounding challenge and threat evaluations is that stress mindset does not focus on the *amount* of stress one is experiencing or the manner in which one *appraises and copes* with stress. Rather, stress mindset focuses on *the nature of stress itself* (i.e., whether stress is enhancing or debilitating). Stress mindset is distinct from stress evaluations in that it is a meta-cognitive belief about the nature of stress in general, and exists regardless of how an individual assesses demands and resources at any particular moment (Crum et al., 2013). For example, one may view a stressor (e.g., job interview) as threatening, but have a stress-is-enhancing mindset, expecting the experience of stress to result in positive outcomes (e.g., motivation to practice interviewing skills, staying cognitively focused, and ultimately improving self-esteem). Conversely, one might view the job interview as a challenge but have a stress-is-debilitating mindset, expecting the experience of stress to result in negative outcomes (e.g., energy depletion, cognitive deficits, and reduced self-esteem). In addition, mindset differs from evaluations of challenge or threat in its temporal focus: threat or challenge evaluations are an immediate assessment of one's resources to cope with the demands of the stressor while mindset assesses the long-term influence of the stressor in light of one's belief about the nature of stress.

Understanding how stress mindset operates in challenging and threatening contexts provides critical insights into *if* and *how* individuals can improve their responses to stress without relying on changing the demands of a situation (which may be difficult or impossible), or improving their immediate resources (which can be infeasible or taxing). Further, the majority of interventions intended to engender adaptive stress responses rely on altering situation-specific stress evaluations. By showing that the stress response can be altered independent of situation-specific evaluations by changing individuals' general beliefs, we advance existing literature and lay the foundation for an integrated theory that can apply to any type of stressful situation. Practically, understanding how stress mindset operates in the context of threat and challenge evaluations will offer more specific coping strategies, and more flexible options that can aid individuals in improving their stress responses in varied contexts.

## Overview of the current research

In the current study, we experimentally manipulated stress-is-enhancing and stress-is-debilitating mindsets and then exposed participants to a laboratory social stressor (adapted Trier Social Stress Task; [TSST] Kirschbaum, Pirke, & Hellhammer, 1993) designed to engender threat or challenge stress evaluations. Following the stress manipulation, we assessed participants' mood, cognitive flexibility, and attentional bias, all metrics found to be influenced by stress (Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007; Bolger, DeLongis, Kessler, & Schilling, 1989; Het & Wolf, 2007; Mogg, Mathews, Bird, & Macgregor-Morris, 1990; Plessow, Fischer, Kirschbaum, & Goschke, 2011). We also measured the catabolic hormone, cortisol, and its anabolic counterpart, dehydroepiandrosterone-sulfate (DHEAS) to test the degree to which stress-is-enhancing and stress-is-debilitating mindsets differentially promote physiological thriving when evaluating a situation as challenging or threatening (Dienstbier, 1989; Epel, McEwen, & Ickovics, 1998). We hypothesized that those evaluating the stressor as a threat (engendered through negative feedback during the social stress task) would exhibit maladaptive emotional, cognitive, and neuroendocrine responses to stress relative to those evaluating the stressor as a challenge (engendered through positive feedback during the social stress task). Specifically, we predicted that threat evaluations would be associated with greater negative emotion, diminished cognitive flexibility, heightened focus on threatening faces, and greater cortisol secretion relative to challenge evaluations. Further, we predicted an interaction between mindset and challenge and threat conditions, such that under threat, having a stress-is-enhancing mindset would be associated with more adaptive emotional, cognitive, and neuroendocrine responses than having a stress-is-debilitating mindset. Conversely, under challenge, we predicted that having a stress-is-debilitating mindset might dampen or even inhibit the cognitive, physiological, or psychological benefits of challenge evaluations.

## Method

### Participants

We recruited 124 (40.2% White, 32% Asian, 15.3% Black, 9.8% Native American, and 2.5% other) participants (65.6% female; $M_{age} = 24.1$ years; SD = 5.1) from a university study pool. Participants received $20 for their participation. A power analysis based on the average effect size ($d = .66$) found in previous stress reappraisal manipulations (e.g., Jamieson, Mendes, Blackstock, & Schmader, 2010; Jamieson, Nock, & Mendes, 2012; Tomaka et al., 1993) led to a targeted sample of 30 participants per condition.

### Procedure

Participants were scheduled to participate for 90 minutes during afternoon hours (between 2:30 pm and 5 pm). Participants were instructed to refrain from drinking caffeine or eating yogurt for a minimum of two hours prior to their scheduled time and from engaging in strenuous exercise, drinking alcohol, smoking, or taking non-prescription medication immediately before their appointment. During the consent process, the experimenter asked participants if they had complied with these instructions, and collected information on the number of hours participants slept the night prior, if they felt sick, and for females, the date of their last menstrual cycle. Following informed consent procedures, participants completed questionnaires assessing their mood and stress mindset and provided the first saliva sample. Stress mindset was then induced by randomly assigning participants to watch a 3-minute video that either emphasized the enhancing properties of stress (stress-is-enhancing condition) or the deleterious properties of stress (stress-is-debilitating condition). The videos were comprised of words, music, and corresponding images related to the effects of stress on cognitive performance (Crum et al., 2013).[1] Following the videos, participants again completed the stress mindset measure (SMM).

Participants then engaged in a modified version of the TSST, which was described as a "mock job interview." During the interview, participants were instructed to give an 8-minute speech, followed by a 5-minute question and answer period in which they discussed their dream job and described their strengths and weaknesses in front of two interviewers (one white male and one white female) (Akinola & Mendes, 2008). We selected a public speaking/verbal task rather than a math/cognitive task as we wanted to create a motivated performance situation that would allow participants to receive explicit positive and negative verbal feedback on their performance and consistent with evidence that both public speaking/verbal interaction tasks and math/cognitive tasks can result in heightened HPA activation (Dickerson & Kemeny, 2004).

On the basis of previous research, we manipulated challenge and threat evaluations by randomly assigning participants to receive either positive or negative feedback during the interview (Akinola & Mendes, 2008; Kassam et al., 2009). Approximately 30 seconds into the interview, participants assigned to the positive feedback condition received positive verbal and nonverbal feedback from the interviewers who nodded, smiled, leaned forward, and gave explicit positive feedback (e.g., "You are very clear and manage to put your personality across. You are very self-assured and authentic, really great job"). In the negative feedback condition, interviewers expressed negative nonverbal feedback by furrowing their brows, shaking their heads, and crossing their arms throughout the interview. They also gave explicit negative feedback (e.g., "I felt that you could be much clearer and more articulate. Think about what you are saying before you say it"). The entire interview task, including preparation time, speech, and Q & A lasted approximately 20 minutes.

Immediately following the interview, participants completed demand and resource evaluations and reported their emotions. They then provided a second saliva sample (timed approximately 30 minutes after the onset of the social stress task) after which they engaged in two[2] cognitive performance tasks assessing attentional bias (timed approximately 40 minutes after the onset of the social stress task) and cognitive flexibility (timed approximately 45 minutes after the onset of the social stress task). Finally, participants provided a third and final saliva sample (timed approximately 60 minutes after the onset of the social stress task). At the end of the study, participants were debriefed, paid, and thanked.

## Measures

### Stress mindset

Stress mindset was assessed prior to and following the video manipulation using the SMM (Crum et al., 2013). Participants rated how strongly they agreed with eight statements (e.g., the effects of stress are positive and should be utilized, the effects of stress are negative and should be avoided) on a 0 (*strongly disagree*) to 4 (*strongly agree*) scale with numbers equal to or above two reflecting a stress-is-enhancing mindset ($\alpha_{\text{baseline}} = .85$, $\alpha_{\text{post-video}} = .94$).

### Threat vs. challenge evaluations

After the speech task, participants evaluated the demands of the situation (e.g., the task was very demanding) and their resources (e.g., I had the abilities to perform well on the task) on a 1 (strongly disagree) to 7 (strongly agree) scale (Akinola & Mendes, 2013). Demand ($\alpha = .80$) and resource ($\alpha = .75$) evaluations were averaged separately and a "'threat ratio'" (demands/resources) was created. In line with previous research (Akinola & Mendes, 2008; Kassam et al., 2009), ratios above 1 indicated threat evaluations and below 1 indicated challenge evaluations.

### Positive and negative affect

We assessed self-reported emotions at five time-points: (1) upon arrival (baseline), (2) after watching the stress mindset videos, (3) after receiving speech task instructions, (4) after the speech task (during the social stress task), and (5) after the question and answer component of social stress task, using the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988). Participants rated their feelings on 20 emotional states (10 positive; 10 negative) on a 1 (not at all) to 5 (a great deal) scale. Positive ($\alpha$s range from.89 to .92) and negative ($\alpha$s range from.80 to .85) emotion scales were calculated. Because we were primarily interested in examining changes in positive affect and negative affect in anticipation of and during the social stress task, we focused our analyses the three key time-points: (1) baseline, (2) pre-speech, and (3) post-speech. For ease of interpretation, we report results from only these three time-periods, however, analyses using all five times periods followed similar linear and quadratic trends.

### Attentional bias

To assess visual attention to positive and negative stimuli, participants engaged in a computerized dot-probe task (MacLeod, Mathews, & Tata, 1986). Black and white pictures of white male faces identical to those used in Bradley, Mogg, Falla, and Hamilton (1998) served as stimuli. The emotions displayed in the pictures varied such that there were 16 angry faces, 16 happy faces, and eight neutral faces. Each trial began with a fixation cross in the middle of the screen for 500 ms, followed by 200 ms of blank screen. Stimulus pairs were then presented, consisting of angry/neutral, happy/neutral, or neutral/neutral-face pairings, displayed horizontally, side by side on the screen. Face pairs were presented for 1500 ms after which one of the pictures was replaced by the visual probe (a small dot). Participants were instructed to press one of two keys indicating the side, right or left, of the probe's appearance. Reaction time to the probe was used to assess participants' attentional bias. Facial expression of the stimuli (happy, angry, or neutral) and dot position (right or left of fixation) were randomized across all 80 trials presented and the computer recorded latencies. Response latencies above 2000 milliseconds and below 200 milliseconds were removed from the data, as were all incorrect responses (less than 5% of total responses) (Koster, Crombez, Verschuere, & De Houwer, 2004). Attentional bias scores were calculated separately for happy and angry faces by subtracting participants' mean log-transformed dot-detection latency for the happy or angry-face location trials from their mean log-transformed dot-detection latency for the neutral-face location trials (cf. Richeson & Trawalter, 2008). Greater bias scores indicate greater attention to the happy (or angry) faces.

### Cognitive flexibility

Participants engaged in the Alternative Uses Task (Guilford, 1967) in which they were asked to generate as many creative uses for a newspaper as possible within two minutes. Because of the time constraints on this task, participants must utilize cognitive flexibility to avoid perseveration and come up with multiple uses for the newspaper before the time for the task expires. Uses were coded for fluency (total number of responses), elaboration (amount of detail for each response), flexibility (number of different categories used), and originality (uniqueness of the responses). Two independent judges, unaware of condition, scored the four categories. Final scores were computed by taking the average of the two coders' scores (inter-coder reliability ranged from.80 to .90).

### Neuroendocrine measures: DHEAS and cortisol

Saliva samples were obtained at three time-periods: (1) before the social stress task (T1), (2) approximately 30 minutes after the onset of the social stress task but before the cognitive tasks (T2), and (3) approximately 60 minutes after the onset of the social stress task, immediately following the cognitive tasks (T3). At each time point, 1 mL of saliva was collected using the passive drool method. Because DHEAS levels are known to vary depending on flow rate, the time it took for participants to complete each 1 mL sample was recorded by the experimenter. Upon completion of the study, saliva samples were immediately frozen until they were shipped overnight on dry ice to a laboratory in College Park, PA. Saliva samples were assayed for cortisol and DHEAS using a highly sensitive enzyme immunoassay (Salimetrics, PA). Intra- and inter-assay coefficients were less than 10%. Flow rates for each time period for DHEAS were calculated as 1mL divided by the time it took for each sample to be collected and DHEAS levels multiplied by the flow rate so as to express the results as a function of time (pg/min). Finally, because DHEAS and cortisol levels were positively skewed, they were log-transformed prior to analysis.

### Data analysis strategy

To test our prediction that stress mindset would differentially influence affective, cognitive, and neuroendocrine responses depending on the type of stress (i.e., challenge or threat) experienced, we conducted 2 (mindset: stress-is-enhancing vs. stress-is-debilitating) × 2 (feedback: negative/threat vs. positive/challenge) ANOVAs for all dependent variables. For positive affect, negative affect, DHEAS, and cortisol (all of which were collected at multiple time-points) we conducted repeated measures ANOVAs with time as a within-subjects variable and mindset and feedback conditions as between subjects variables. Gender and stress mindset at baseline were included as covariates in all analyses. Hours of sleep and menstrual cycle phase were also included as covariates for the neuro-endocrine measures.[3] In cases where Mauchly's test of sphericity was violated, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

## Results

### *Participant attrition*

Eleven participants were excluded from the analyses, five due to recognition of the evaluators (confederates), four to equipment malfunction, and two because they did not complete the entire study. Data from the remaining 113 participants were used in all analyses. Varying degrees of freedom reflect the data loss across variables. Means and standard deviations are reported for all key outcome variables in Table 1.

### *Manipulation checks*

Changes in stress mindset from baseline were measured to assess whether the videos engendered stress-is-enhancing and stress-is-debilitating mindsets. Participants in the stress-is-enhancing condition experienced increases on the SMM reflecting a more enhancing stress mindset ($M = 2.48$); $t(53) = 7.99$, $p < .001$, while those in the stress-is-debilitating condition experienced decreases on the SMM reflecting a more debilitating stress mindset ($M = 1.13$); $t(53) = -7.63$, $p < .001$ (Figure 1(a)).

We then examined the threat ratio created from the cognitive evaluations following the speech task. As intended, the negative feedback condition resulted in a higher threat ratio ($M = 1.44$) than the positive feedback condition ($M = .95$), $t(111) = 4.82$, $p < .001$ (Figure 1(b)), indicating that we successfully manipulated threat and challenge evaluations.

**Table 1.** Means and standard deviations (in parentheses) for key outcome variables as a function of mindset and feedback conditions.

| | Positive feedback (challenge appraisal) | | Negative feedback (threat appraisal) | |
|---|---|---|---|---|
| Variable | Stress-is-enhancing | Stress-is-debilitating | Stress-is-enhancing | Stress-is-debilitating |
| Positive affect (1–5) | | | | |
| Baseline | 2.99 (0.81) | 2.91 (0.75) | 3.10 (0.66) | 3.04 (0.80) |
| Pre-speech | 3.11 (0.66) | 2.69 (0.83) | 2.96 (0.87) | 2.80 (0.96) |
| Post-speech | 3.51 (0.81) | 2.99 (0.86) | 2.80 (0.77) | 2.58 (0.91) |
| Negative affect (1–5) | | | | |
| Baseline | 1.42 (0.37) | 1.55 (0.57) | 1.52 (0.47) | 1.58 (0.56) |
| Pre-speech | 1.86 (0.57) | 1.97 (0.70) | 2.02 (0.59) | 2.10 (0.75) |
| Post-speech | 1.35 (0.35) | 1.48 (0.41) | 2.06 (0.67) | 2.14 (0.76) |
| Attentional bias | | | | |
| Happy faces | 19.08 (33) | −0.84 (45) | −1.81 (45) | 5.17 (45) |
| Angry faces | 0.78 (33) | 3.09 (50) | −11.34 (50) | −21.16 (37) |
| Cognitive flexibility | 6.34 (2.03) | 5.12 (2.21) | 4.63 (2.19) | 5.06 (2.30) |
| Cortisol (pg/ml) | | | | |
| Baseline | 17.76 (13.07) | 10.75 (5.08) | 16.61 (7.15) | 12.56 (6.17) |
| Post-social stress task | 23.97 (12.26) | 21.49 (18.36) | 25.87 (14.07) | 23.92 (25.63) |
| Post-cognitive tasks | 16.67 (9.35) | 16.65 (13.09) | 21.59 (13.52) | 16.87 (13.65) |
| DHEAS (pg/min) | | | | |
| Baseline | 2550.74 (2219) | 2752.41 (2108) | 2633.98 (1972) | 2992.33 (3674) |
| Post-social stress task | 3804.08 (3750) | 2479.32 (2045) | 6541.92 (9487) | 2686.07 (2291) |
| Post-cognitive tasks | 1952.50 (1175) | 2459.07 (2192) | 2671.21 (1736) | 3032.96 (2084) |

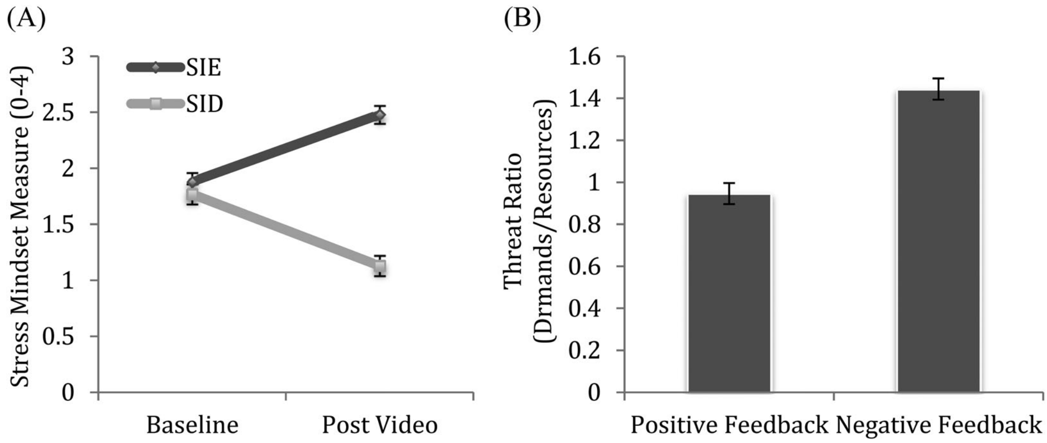


**Figure 1.** Means and standard errors for SMM pre- and post-mindset video (a) and Threat ratio post-speech (b).
Note: SIE = stress-is-enhancing and SID = stress-is-debilitating.

Importantly, the stress mindset manipulation did not significantly alter evaluations of the speech task in either the positive ($F$(1, 55) = 0.29, $p$ = .593, $\eta^2$ = .005) or negative ($F$(1, 56) = 0.09, $p$ = .763, $\eta^2$ = .007) feedback conditions. This finding supports the theory that mindsets and threat versus challenge evaluations are distinct constructs and therefore could be examined independently.

### *Positive and negative affect*

For positive affect, we observed a significant time × feedback condition effect $F$(2, 202) = 18.29, $p$ < .001, $\eta^2$ = .153 such that participants in the positive feedback (challenge evaluation) condition experienced increases in positive affect over time relative to those in the negative feedback (threat evaluation) condition, who experienced decreases in positive affect over time. We also found a significant time × mindset condition effect $F$(2, 202) = 3.63, $p$ = .020, $\eta^2$ = .035 such that participants in the stress-is-enhancing condition experienced increases in positive affect over time relative to those in the stress-is-debilitating condition, who experienced decreases in positive affect over time. The three-way interaction between mindset, feedback, and time was not statistically significant $F$(2, 202) = 0.73, $p$ > .482, $\eta^2$ = .007. However, simple-effects tests (illustrated in Figure 2) demonstrated that while there were no differences between the four conditions in positive affect at baseline $F$(3, 112) = 0.322, $p$ = .810, $\eta^2$ = .009 or prior to the speech $F$(3, 110) = 1.35, $p$ = .262, $\eta^2$ = .037, there was a significant difference between conditions following the speech $F$(3, 112) = 5.47, $p$ = .002, $\eta^2$ = .131, such that participants who had a stress-is-enhancing mindset and were in the positive feedback (challenge evaluation) condition had significantly more positive affect after the speech task than participants in the other three conditions.

For negative affect, we observed a significant time × feedback condition effect, $F$(1.84, 186) = 19.63, $p$ < .001, $\eta^2$ = .163. Simple-effects tests within each time period (Figure 2) indicated that there were no differences in negative affect between the positive feedback (challenge evaluation) condition and the negative feedback (threat evaluation) condition at baseline $F$(1, 106) = 2.37, $p$ = .126, $\eta^2$ = .023, or pre-speech $F$(1, 107) = 0.90, $p$ = .345, $\eta^2$ = .007. However, there were significant differences between conditions following the speech $F$(1, 107) = 37.99, $p$ < .001, $\eta^2$ = .271, such that negative affect remained higher for participants in the negative feedback (threat evaluation) condition compared to participants in the positive feedback (challenge evaluation) condition. Neither the time × mindset condition effect nor the three-way interaction between mindset, feedback, and time were significant [$F$(1.84, 186) = 0.02, $p$ = 978, $\eta^2$ = .000 and $F$(1.84, 186) = 0.036, $p$ = .965, $\eta^2$ = .000, respectively].

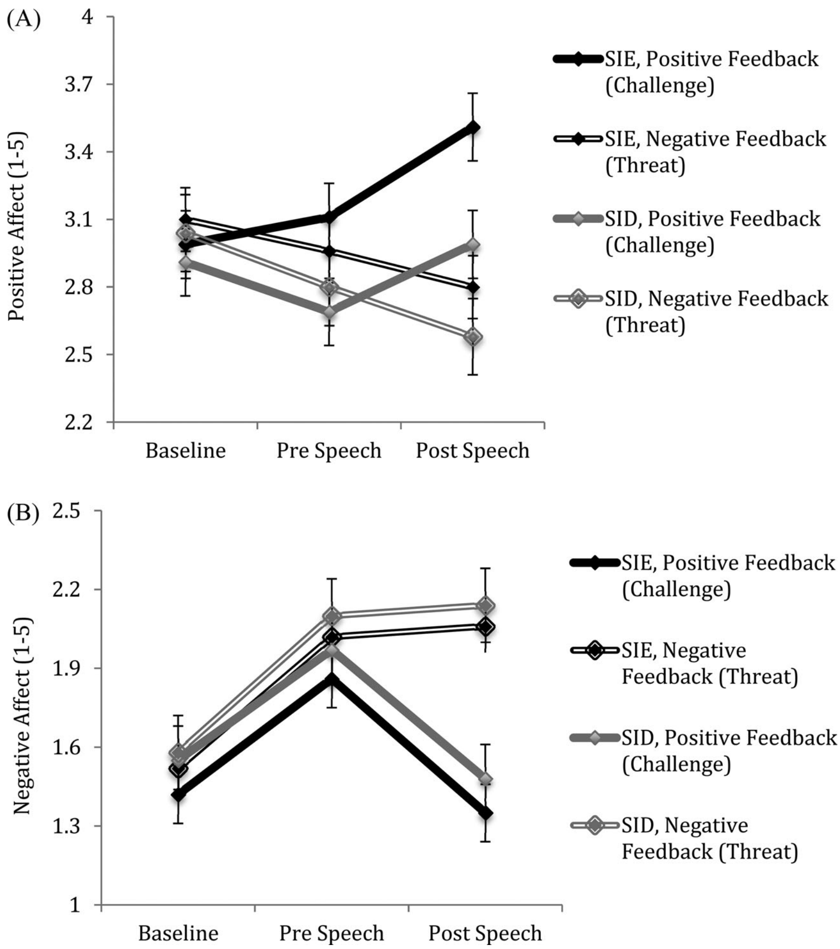


**Figure 2.** Mean positive affect (a) and negative affect (b) ratings as a function of mindset and feedback condition over three time-periods.

Note: SIE = stress-is-enhancing and SID = stress-is-debilitating; Error bars show standard errors.

## *Attentional bias*

Results for attentional bias for happy faces showed a similar pattern as our positive affect findings in the positive feedback condition. There were no main effects of mindset or feedback condition on attentional bias, however there was a significant mindset × feedback condition interaction, $F(1, 95) = 4.48$, $p = .037$, $\eta^2 = .047$. Simple-effects tests showed that, in the positive feedback (challenge evaluation) condition, bias towards happy faces was significantly higher for those with a stress-is-enhancing mindset relative to those with a stress-is-debilitating mindset, $F(1, 46) = 4.40$, $p = .042$, $\eta^2 = .091$, again suggesting that a stress-is-enhancing mindset only boosted attentional bias towards happy faces when participants were in the positive feedback (challenge stress evaluation) condition. In contrast, in the negative feedback (threat evaluation) condition, there was no difference in bias toward happy faces between mindset conditions, $F(1, 48) = 0.88$, $p = .354$, $\eta^2 = .019$ (Figure 3(a)). With respect to attentional bias toward angry faces on the Dot Probe task, we observed a marginally significant effect of feedback condition, $F(1, 95) = 3.46$, $p = .066$, $\eta^2 = .037$, such that those in the negative feedback (threat evaluation) condition showed greater attentional bias away from angry faces than those in the positive feedback (challenge evaluation) condition (Figure 3(b)).

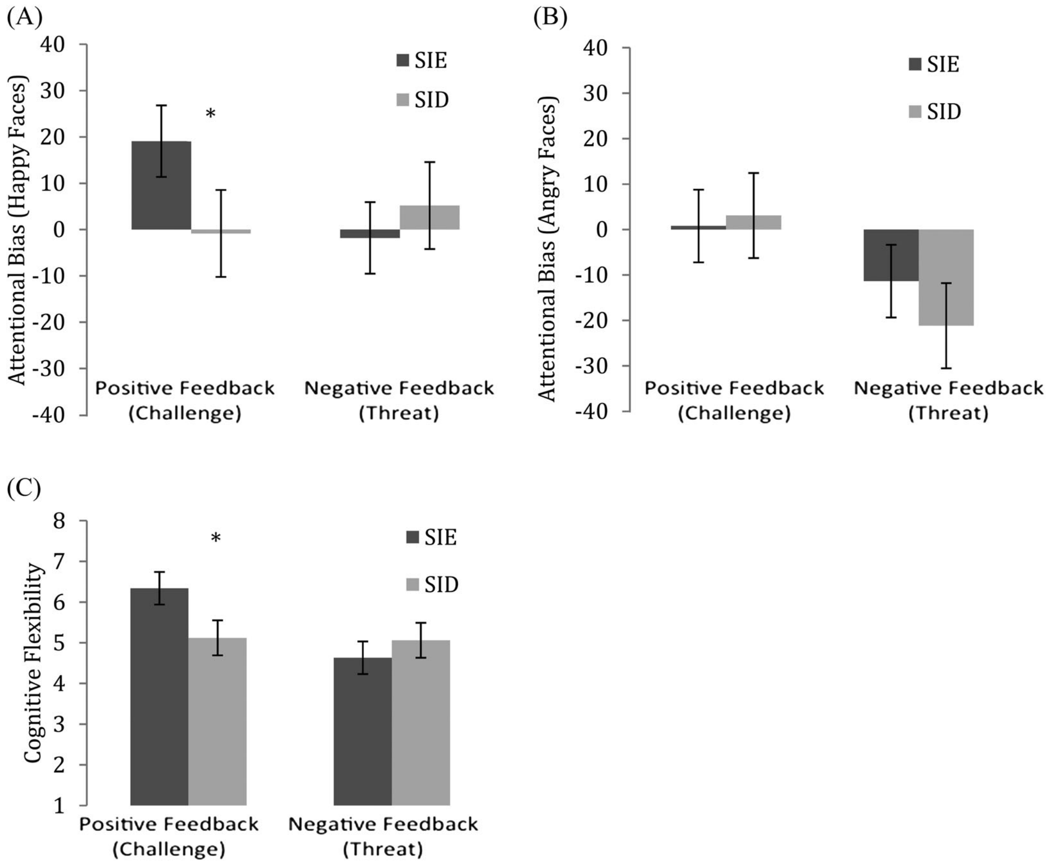


**Figure 3.** Attentional bias scores for happy faces (a), attentional bias scores for angry faces (b), and creativity scores (c) as a function of mindset and feedback conditions.

Note: SIE = stress-is-enhancing and SID = stress-is-debilitating; Error bars show standard errors;*$p < .05$.

### *Cognitive flexibility*

For flexibility, while there was no main effect of mindset, we observed a significant main effect of feedback condition $F(1, 105) = 4.64$, $p = .033$, $\eta^2 = .044$, such that participants in the positive feedback (challenge evaluation) condition received higher cognitive flexibility scores than those in the negative feedback (threat evaluation) condition. This main effect was qualified by a marginally significant interaction, $F(1, 105) = 3.63$, $p = .060$, $\eta^2 = .035$. Consistent with our attentional bias findings, participants who were in the positive feedback (challenge evaluation) condition and held a stress-is-enhancing mindset received higher flexibility scores than those who held a stress-is-debilitating mindset, $F(1, 52) = 4.22$, $p = .045$, $\eta^2 = .079$ (Figure 3(c)). Aligned with the aforementioned effects, this suggests that a stress-is-enhancing mindset only generated creative flexibility when participants were in the positive feedback (challenge evaluation) condition. In contrast, in the negative feedback (threat evaluation) condition, there was no difference in flexibility between mindset conditions, $F(1, 52) = 0.21$, $p = .648$, $\eta^2 = .004$. In other words, whereas stress-is-enhancing and stress-is-debilitating mindsets significantly differed from each other in cognitive flexibility in the positive feedback condition, they did not differ in the negative feedback condition.

In summary, for each of the cognitive performance categories, we observed differential performance for participants with a stress-is-enhancing mindset relative to those with a stress-is-debilitating mindset, but mainly in the positive feedback (challenge evaluation) condition.

### *Neuroendocrine responses: DHEAS and cortisol*

For DHEAS, we observed a significant time × mindset condition effect, $F(2, 108) = 6.62$, $p = .002$, $\eta^2 = .109$. Within-subjects contrasts revealed that this effect was quadratic in nature, $F(1, 54) = 12.32$, $p = .001$, $\eta^2 = .186$, such that that relative to participants in the stress-is debilitating condition, participants in the stress-is-enhancing condition experienced significantly sharper increases in DHEAS between baseline (T1) and the end of the social stress task (T2), $F(1, 54) = 10.65$, $p = .002$, $\eta^2 = .165$, followed by significantly sharper decreases in DHEAS between the end of the social stress task (T2) and the end of the cognitive tasks (T3), $F(1, 55) = 7.73$, $p = .007$, $\eta^2 = .123$. Simple-effects tests within each time period (illustrated in Figure 4(a)) indicated that there were no differences in DHEAS between the stress-is-enhancing and stress-is-debilitating mindset conditions at baseline (T1), $F(1, 60) = 0.29$, $p = .595$, $\eta^2 = .005$ or following the cognitive tasks (T3), $F(1, 61) = 0.04$, $p = .845$, $\eta^2 = .001$, but that DHEAS was higher for participants in the stress-is-enhancing mindset condition compared to participants in the stress-is-debilitating mindset condition following the speech task (T2), $F(1, 61) = 4.07$, $p = .048$, $\eta^2 = .068$. Neither the time × feedback condition effect nor the mindset × feedback × time effects were significant for DHEAS [$F(2, 108) = 1.17$, $p = .316$, $\eta^2 = .021$ and $F(2, 108) = 0.27$, $p = .764$, $\eta^2 = .005$, respectively].

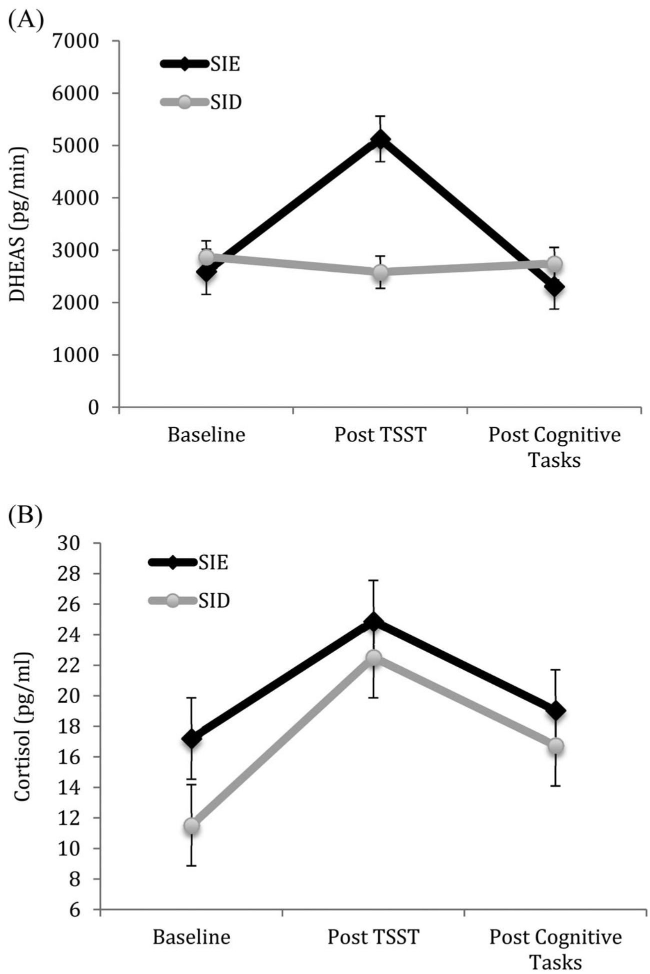


**Figure 4.** Changes in DHEAS (a) and cortisol (b) over time as a function of mindset.

Note: SIE = stress-is-enhancing and SID = stress-is-debilitating; Error bars show standard errors at each time period.

For cortisol, the time × mindset condition was not significant $F(1.22, 67.13) = 0.41$, $p = .665$, $\eta^2 = .007$. Further, aligned with our DHEAS findings, neither the time × feedback condition effect nor the time × mindset × feedback effects were significant for cortisol [$F(1.22, 67.13) = 0.13$, $p = .878$, $\eta^2 = .002$ and $F(1.22, 67.13) = 0.367$, $p = .694$, $\eta^2 = .002$, respectively].

### *Exploratory analyses*

In line with research suggesting that both DHEAS (e.g., Morgan et al., 2004; Shields, Lam, Trainor, & Yonelinas, 2016; Sripada et al., 2013) and cortisol (e.g., Gagnon & Wagner, 2016; Het, Ramlow, & Wolf, 2005; Shields, Bonner, & Moons, 2015) can influence cognitive functioning, we examined the relationship between our neuroendocrine measures and cognitive performance scores using the AUC increase measure for both DHEAS and cortisol. In order to analyze these correlations, we conducted area under the curve increase analysis (AUC; Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003) using the following formula: (((HormoneTime1 + HormoneTime2) * 60)/2) + (((HormoneTime2 + HormoneTime3) * 20)/2) – (HormoneTime1 * 80), with 60 representing the time between the first and second saliva samples, 20 representing the time between the second and third saliva samples, and 80 representing the time from saliva sample one to saliva sample three. These results indicated no significant correlations between our neuroendocrine measures and our cognitive performance measures (all $ps > .510$).

## Discussion

The goal of this study was to examine how stress mindset would moderate emotional, cognitive, and neuroendocrine responses in the context of challenge and threat evaluations. Consistent with extant theory, we predicted that threat evaluations would produce poorer emotional, cognitive, and neuroendocrine outcomes relative to challenge evaluations. However, we also predicted that threat and challenge evaluations would be moderated by stress mindset such that having a stress-is-enhancing mindset would improve responses in the context of threat evaluations and having a stress-is-debilitating mindset would worsen responses in the context of challenge evaluations.

Our results revealed that adopting a stress-is-enhancing mindset was indeed beneficial as it relates to positive emotion and DHEAS secretion; participants with a stress-is-enhancing mindset experienced greater increases in DHEAS and greater increases in positive emotions relative to those with a stress-is-debilitating mindset in both the positive feedback (challenge) and negative feedback (threat) conditions. The boost to positive emotions and DHEAS-amplifying effect of a stress-is-enhancing mindset is particularly noteworthy as it contributes to stress management theory and practice by showing that adaptive outcomes don't solely ensue from acknowledging a stressor as challenging, but can also ensue from acknowledging a stressor as threatening if accompanied by an enhancing mindset. Importantly, having a stress-is-enhancing mindset may not make stressful situations feel any less emotionally difficult (as negative affect was still high) or any less physiologically taxing (as cortisol levels were still high). However, our results suggest that having a stress-is-enhancing mindset can promote physiological thriving as evidenced by the heightened DHEAS we observed under both challenge and threat evaluations. The anabolic and antiglucocorticoid effects of DHEAS (Morgan et al., 2004), particularly when combined with its ability to promote physiological resilience (Charney, 2004) and positive mood (Frye & Lacey, 1999), may foster resilience under stress, facilitating one's ability to endure future stressors.

With respect to cognitive responses, we found that a stress-is-enhancing mindset produced greater attentional bias towards happy faces, and more cognitive flexibility, than a stress-is-debilitating mindset for participants receiving positive feedback (challenge evaluation). In other words, although mindset did moderate the effects of stress differentially depending on whether challenge or threat evaluations were evoked, the majority of the cognitive benefits of a stress-is-enhancing mindset occurred primarily under challenge evaluations. In contrast, those with a stress-is-debilitating mindset experienced worse cognitive flexibility and less bias to happy faces despite facing a seemingly manageable stressor (i.e., positive feedback). The finding that adopting a stress-is-debilitating mindset under challenge evaluations produced similar outcomes as those under threat may help explain why even small everyday stressors can have negative effects (McIntyre, Korn, & Matsuo, 2008), sometimes evoking worse somatic outcomes than more threatening life events (Almeida, 2005; DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982). Moreover, the amplifying cognitive flexibility effect we observed of having a stress-is-enhancing mindset under challenge evaluations is particularly interesting as it is consistent with literature showing that the experience of positive emotions can broaden individuals' thought–action repertoires, building enduring physical, intellectual, social, and psychological resources and producing flexible, creative, and novel thinking (Amabile, Barsade, Mueller, & Staw, 2005; Fredrickson, 2001; Tugade & Fredrickson, 2004).

It is important to note that the interpretation of our attentional bias findings remains unclear as there is significant debate regarding whether the dot-probe measures a heightened vigilance *toward information* or an inability to *disengage from information* (e.g., Fox, Russo, Bowels, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Koster et al., 2004; Salemink, van den Hout, Kindt, 2007). In light of this debate, our finding that under challenge evaluations, bias towards happy faces was significantly higher for those with a stress-is-enhancing mindset relative to those with a stress-is-debilitating mindset could suggest that either those in the stress-is-enhancing condition had heightened vigilance to happy faces or couldn't disengage from happy faces. Regardless of the interpretation, our finding nonetheless represents the concept that participants who believe stress is enhancing spend more time attending to happy faces than those who believe stress is debilitating.

Taken together, the results of this study suggest that while having a stress-is-enhancing mindset increased positive mood, cognitive flexibility, attention to happy faces (under challenge evaluations), and DHEAS responses (under both threat and challenge evaluations), it did not seem to reduce negative emotional reactions to the stress in either the challenging or threatening conditions. Thus, adopting a stress-is-enhancing mindset in the face of both challenging and threatening situations may be beneficial, not necessarily because of its ability to make the stress *feel* less negative or threatening, but rather, by recruiting and magnifying cognitive, emotional, and physiological attributes that may contribute to adaptive responses over the long-run. Importantly, these finding do not suggest that adopting a stress-is-enhancing mindset is a panacea for all stressful situations. Under threat, the only adaptive response we observed was the boost in DHEAS. Boosts in cognitive flexibility and attentional bias were only found under challenge evaluations, suggesting that, whenever possible, people should still attempt to evaluate stressors as challenging (as opposed to threatening). Moreover, the finding that there were no effects of mindset or threat vs. challenge evaluation on cortisol in this study serves as an important reminder that some of the responses to stress may be independent of both evaluations of the stressor and mindsets about the nature of stress in general.[4]

Several additional limitations should be acknowledged and addressed in future research. First, our stress task was designed to focus on the relative effects of mindset under threat (negative feedback) and challenge (positive feedback) evaluations, and therefore did not include a control group (e.g., no feedback from evaluators), which by nature would be lower arousal (Dickerson & Kemeny, 2004). As a result, our study is constrained in that we have little insight into how mindset influences challenge and threat evaluations relative to lower arousal situations, and we cannot examine if confounding variables related to our feedback manipulations may have affected our results. However, given that prior research has found that the neuroendocrine, emotional, and cognitive effects of no feedback social stress control conditions typically fall in the middle of the effects seen in negative (threat) and positive (challenge) feedback conditions (Akinola & Mendes, 2008; Kassam et al., 2009), and that mindset effects under low stress engender similar neuroendocrine results as we observed in this study (Crum et al., 2013), we can speculate that a stress-is-enhancing mindset in a lower arousal situation would produce results that were less pronounced than those in the positive (challenge) condition, but more pronounced than those seen in the stress-is-debilitating mindset negative (threat) condition. Nonetheless, future research is needed that explores the effect of mindset in lower arousal, more ambiguous, even naturally occurring stressful situations, to better tease apart the processes through which stress mindsets exert psychological, physiological, and behavioral effects.

Second, we explored mindset effects as they relate to acute short-term stressors. Of considerable interest are the duration of stress mindset effects and the longitudinal sequence of emotional, cognitive, and neuroendocrine outcomes triggered by approaching stress in a stress-is-enhancing mindset relative to a stress-is-debilitating mindset under situations of chronic stress. Third, there is evidence that both DHEAS and cortisol have cognitive effects (Gagnon & Wagner, 2016; Het et al., 2005; Shields et al., 2015, 2016; Sripada et al., 2013), however, these cognitive effects were not observed in our study. It is possible that the type of cognitive tasks we used in this study (alternative uses and dot probe) may not be representative of the types of tasks that are influenced by neuroendocrine changes, such as episodic recall tasks or measures of decision-making competence. Future studies should consider broadening the range of cognitive tasks used to further our understanding of the types of cognitive tasks for which stress mindset manipulations may be particularly beneficial. Finally, as is common with laboratory research, our sample consisted of young and healthy undergraduate and graduate students living in the United States, and did not include a no-stress control group as we were primarily interested in the relative benefit of stress mindset in challenging and threatening contexts. Additional research is needed to examine whether the benefits of adopting a stress-is-enhancing mindset extend to different populations and settings, such as among individuals with anxiety disorders, in contexts with no stress or more extreme levels of stress, and in cultures where mindsets about stress and anxiety are different from those in the United States (Tweed, White, & Lehman, 2004).

Stress is an undeniable part of everyday reality for most individuals. Our findings advance stress theory by highlighting the relative benefit of stress mindset in the context of both threat and challenge evaluations. Taken together, these results do not refute or question the powerful role of threat and challenge evaluations in shaping the stress response. Rather, they enrich the literature by demonstrating some important nuances regarding how mindsets and evaluations interact. Specifically our results suggest that the cognitive and affective benefits of challenge evaluations many only be present when approached through in a stress-is-enhancing mindset and, furthermore, that a stress-is-enhancing mindset may also help improve physiological responses in both challenging and threatening stress by boosting DHEAS. Although much remains to be explored, these results lay the foundation for an integrated theory demonstrating that altering general beliefs about stress can change situation-specific stress evaluations. In doing so, this research provides a hopeful possibility that individuals can improve their responses to stress – both in the face of manageable stressors as well as in the face of threatening stressors – by adopting more enhancing mindsets about stress that are not specific to the stressor at hand, but can generally apply to any stressful situation.

## Notes

1. The videos used in this study are available upon request from the first author.
2. Participants also completed a third cognitive interference task; however, we do not report on this measure as it not the theoretical focus of the current research.
3. Although we controlled for menstrual cycle variation in women by controlling for the time since last menstruation, we were not able to control for inevitable variation in menstrual cycles between women. That said, it is unlikely that such cycle variation would meaningfully affect the results given that variability in menstrual cycle is likely randomly distributed across conditions.
4. It is important to note that although changes in cortisol were not observed in this study, the effects of mindset and challenge/threat evaluations on cortisol responses remain unclear. There is evidence that the effects of mindset on cortisol are moderated by individual reactivity (as compared to a baseline day) (Crum et al., 2013). Additional research is needed to further our understanding of how cortisol responses may be differentially altered depending the person, their mindset, and the context.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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