The Benefits of a Stress-is-enhancing Mindset in Both Challenging and Threatening Contexts

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Abstract

Decades of research have examined how the *amount* of stress (frequency, intensity, and duration) and *appraisals* of stress (e.g., as threatening or challenging) can determine whether stress will have positive or negative effects on health and performance. However, this research ignores the role that *beliefs* about the nature of stress (as enhancing or debilitating) can have on determining the effects of stress, independent of appraisals and amounts of stress. In the current paper, we examine how stress mindset—one's belief that stress is debilitating or enhancing—differentially influences cognitive, affective, and neuroendocrine responses when confronting challenge states, in which individuals perceive they have the resources to overcome the stress, and threat states, in which resources are outweighed by the demands of the stress. Participants saw videos highlighting the enhancing or debilitating nature of stress. They then engaged in a Trier Social Stress Task made to evoke challenge and threat stress states through a feedback manipulation. Following the feedback manipulation, we assessed participants' hormonal responses, mood, cognitive flexibility, and attentional bias. Results revealed that under threat, a stress-is-enhancing mindset was associated with increases in anabolic ("building up") hormones. Under challenge, a stress-is-enhancing mindset was associated with several positive benefits including greater positive affect, heightened attentional bias towards positive stimuli, and greater cognitive flexibility. There were no benefits of a stress-is-debilitating mindset under threat or challenge. These findings advance stress management theory and practice by providing a more nuanced understanding of the factors and contexts under which adaptive stress responses can ensue.

Keywords: Stress, mindset, appraisal, affect, cognitive performance, neuroendocrinology

Introduction

For over a century, stress researchers have sought to understand the effects of stress on cognitive, emotional, and physiological outcomes. As early as 1908, Yerkes and Dodson proposed that the relationship between stress and performance takes the form of an inverted U in which experiencing stress can be enhancing up to a point, after which the amount of stress (chronicity, severity, frequency) is overwhelming, and the effects of stress become debilitating (Yerkes & Dodson, 1908; see also Alpert & Haber, 1960; Holmes & Rahe, 1967). This notion that moderate amounts of stress can be innocuous or even beneficial, but extreme amounts of stress produce negative effects, has largely been eclipsed by the more nuanced perspective offered by appraisal theory which highlights that the psychosocial manner in which a person appraises and copes with stress *when it occurs* determines whether stress will have positive or negative effects (Billings & Moos, 1981; Carver, Scheier, & Weintraub, 1989; Folkman et al., 1986; Penley, Tomaka, & Wiebe, 2002). Specifically, appraisal theory argues that the cognitive, emotional, and physiological effects of stress are determined not by the stress itself, but by ones perception of the stress as a threat, in which the demands of the situation exceed ones resources to cope, or as a challenge, in which resources exceed demands (Lazarus & Folkman, 1984). Although the literature on coping and appraisal has offered a far more useful way to understand the effects of stress than simply examining the amount of stress alone, it does not take into account the fact that perceptions or beliefs about *the nature of stress itself* might influence the stress response independently of how much stress one is experiencing and how they are appraising or coping with that stressor (Crum, Salovey, & Achor, 2013). Specifically, one critically unaddressed question is: how does stress mindset—one's belief that stress is debilitating or enhancing—affect stress-related outcomes in the context of different coping or appraisal strategies?

In the current paper, we experimentally examine how stress mindset differentially influences cognitive, affective, and physiological responses when confronting two distinct types of stress states: those in which individuals perceive they have the resources to overcome the stress ("challenge" states) and those in which resources are perceived to be absent ("threat" states). To examine this question we experimentally manipulated stress mindset (using multi-media film clips orienting participants to either the enhancing or debilitating nature of stress) and appraisals (by providing unilateral positive or negative feedback in a Trier Social Stress Task). We show that individuals adopting a stress-is-enhancing mindset experienced beneficial outcomes in both challenge and threat states, while individuals adopting a stress-is-debilitating mindset experienced worse outcomes, even in challenge states. This research contributes to stress management theory in two key ways. First, it provides an important explanation for cases in which challenge states may result in deleterious outcomes (e.g., when holding a stress-is-debilitating mindset). Second, it offers evidence that a stress-is-enhancing mindset may provide some benefit in situations that are unavoidably perceived as threatening.

Threat vs. Challenge Appraisal Theory

Pioneering studies by Lazarus and colleagues in the early 1980s highlighted the importance of cognitive appraisal in determining the stress response. Specifically, Lazarus and Folkman (1984) proposed that individuals appraise stressful situations in two stages. Primary appraisal is an individual's assessment of the environment or event as stressful or impactful. Secondary appraisal is an individual's assessment of whether or not they have adequate resources to cope with the environment or event. More recently, a series of studies by Blascovich, Tomaka and colleagues have elaborated on these stages and highlighted that the stress response is determined by the balance of perceived resources (e.g., knowledge, skills, and external support) and perceived demands (e.g., danger, uncertainty, and effort) (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003; Tomaka, Blascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997). Simply put, a situation is deemed *threatening* when the individual perceives that the environmental demands outweigh their resources or ability to cope and

challenging when the individual perceives that they have sufficient resources to meet the environmental demands.

More recently, researchers have investigated the effects of challenge and threat states on psychological and physiological functioning and have found challenge states to be associated with increased cardiac efficiency and hormonal responses associated with thriving and growth, preparing the body for action and signaling approach motivation (see Blascovich & Mendes, 2010, for a review). Further, more positive affect and increases in cognitive performance are often experienced under challenge states. In contrast, threat states are characterized by less cardiovascular efficiency and maladaptive hormonal responses, preparing the body for damage or defeat (Mendes, Blascovich, Hunter, Lickel, & Jost, 2007). Additionally, poorer cognitive performance and more negative affect can ensue from threat states (Kassam, Koslov, & Mendes, 2009; Blascovich & Mendes, 2010)

While the distinction between "threat" and "challenge" states is important, there are a number of critical limitations to practically implementing challenge and threat theory. First, given that the components of demands include danger, uncertainty, and required effort (Blascovich & Mendes, 2000), there are times in which it may be impossible to reduce the demands of a situation; for example, students facing an unpredictable stressor such as a pop-quiz in a difficult class. Second, since the elements of resources include knowledge and abilities, dispositional traits, and external support (Blascovich & Mendes, 2000), 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. Finally, trying to remove 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, a key question remains: is it possible to acknowledge a stressor as "threatening," yet still have adaptive physiological and behavioral outcomes? We argue that the answer to this question lies in one's beliefs or mindset about stress. Specifically, the extent to which one holds and adaptive mindset about stress (e.g., that stress-is-enhancing) or a maladaptive mindset about stress (e.g., that stress-is-debilitating) will dictate one's response to both challenge and threat stress states.

Stress Mindset Theory

The term "mindset" has been used to describe the mental frame or lens that selectively organizes and encodes information, thereby orienting individuals toward a particular way of understanding information and guiding them toward corresponding actions and responses (adapted from Dweck, 2008). In the past 20 years, research has accumulated to demonstrate that adopting a particular mindset can profoundly influence psychological, behavioral, and physiological outcomes in a variety of domains. For example, in the domain of intelligence, students who acquire a mindset that intelligence is a malleable (as opposed fixed) trait (e.g., "I can improve my intelligence" vs. "I was born with a fixed IQ") demonstrate improvements in both behavior and attitude (e.g., greater appreciation of academics, motivation, improved GPAs, and enhanced enjoyment of learning; Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, & Dweck 2007). Further, in the domain of aging, individuals with a negative mindset are likely to engage in fewer proactive measures such as eating well, engaging in physical exercise, and visiting a physician (Levy & Myers, 2004). Furthermore, these individuals have a diminished will to live (Levy, Slade, Kunkel, & Kasl, 2002) and show reduced cardiovascular function when exposed to negative stereotypes about aging (Levy, Hausdorff, Hencke, & Wei, 2000). Moreover, they die sooner than those who had a more positive mindset (Levy et al., 2002).

Given the impact of mindset in domains such as intelligence, emotions, and health, researchers have questioned whether mindset could have a similar influence in the domain of stress. In the context of stress, one's *stress mindset* can be 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 wellbeing, and learning and growth (referred to as a "stress-is-debilitating mindset") (Crum, Salovey, & Achor, 2013).

Akin to the effects found in intelligence and aging, mindset has been found to play a strong role in shaping the effects of stress. Preliminary studies suggest that stress mindset is related to perceived health and life satisfaction over and above aggregate measures of amount of stress, appraisal of stress, and various coping strategies. That is, regardless of one's coping skills and strategies, individuals who believe that stress has enhancing properties (stress-is-enhancing mindset), have higher indices of health, performance, and well-being (Crum, Salovey, & Achor, 2013). Additionally, there is evidence that stress mindset has a significant impact on the manner in which stress is physiologically experienced and behaviorally approached. For instance, in a study examining the mechanisms that link stress mindset to health and performance outcomes, Crum and colleagues (2013) show that individuals who adopted a stress-is-enhancing mindset demonstrated a greater desire for feedback than those who adopted a stress-is-debilitating mindset, indicating an approach motivation. Furthermore, for individuals with high cortisol reactivity to stress, having a stress-is-enhancing mindset attenuated the cortisol response, indicative of a more adaptive physiological response to stress. In contrast, for individuals who had low cortisol reactivity to stress, having a stress-is-enhancing mindset increased the cortisol response. Additionally, those with a stress-is-debilitating mindset had either hyper- or hypo- cortisol reactivity, a more maladaptive physiological stress response. The results of these preliminary studies demonstrate that individuals who have a stress-is-enhancing mindset exhibit more adaptive physiological and behavioral responses to the stress.

Importantly, initial research suggests stress mindset can be altered via intervention to produce corresponding changes in self-reported health and behavior (Crum, Salovey, & Achor, 2013). Specifically, utilizing a video-priming intervention, Crum and colleagues investigated whether stress mindsets could be altered in a group of executives at a Fortune 500 company. Employees watched three videos presenting research and examples of the nature of stress over the course of one week. These videos focused participants' attention toward either the enhancing or debilitating effects of stress. After one week of this video intervention, participants in the enhancing condition developed a stress-is-enhancing mindset and reported better work performance and improved health conditions. On the other hand, participants in the debilitating condition reported no change in work performance or health over this period (Crum, Salovey, & Achor, 2013). Taken together, the emerging body of research examining stress mindset theory suggests that one way to meaningfully influence the stress response, regardless of one's motivational state, is to change an individual's stress mindset. Critical to this argument is clearly delineating between stress mindset theory and challenge vs. threat appraisal theory.

Distinguishing between Stress Mindset and Threat vs. Challenge Appraisal Theory

One critical distinction between stress mindset theory and appraisal theory 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 it is enhancing or debilitating). For example, one may view a particular stressor (e.g., an impending deadline) as highly stressful but adopt a stress-is-enhancing mindset (i.e., believes that experiencing that stress will ultimately result in positive outcomes). Conversely, a different person may also appraise the impending deadline as highly stressful, but may have a stress-is-debilitating mindset about experiencing that stress (i.e., expects the stressor to deteriorate his or her health and vitality). Stress mindset is distinct from stress appraisals 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, Salovey, & Achor, 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 appraisal in its temporal focus: appraisal is 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.

The proposition that stress mindset is a distinct construct from appraisal of stress and coping measures has been demonstrated both conceptually and through structural equation modeling (see Crum, Salovey, & Achor, 2013. However, no studies have systematically explored the role stress mindset plays in differentiating the response to challenge and threat stressors. While there have been investigations of the effects of interventions such as reappraising arousal on challenge and threat states (Jamieson et al., 2010; 2012), there are several limitations to these interventions. First, interventions instructing individuals to construe arousal as a tool to help maximize performance are most effective when individuals are in motivated performance situations that are goal-relevant and require instrumental cognitive responses; yet these are not the only contexts in which threat states can ensue (Blascovich & Mendes, 2000). For instance, one can experience threat in a more mundane context such as waiting for results from a routine doctors visit, which for many individuals is a low arousal state and does not require much thought, but for some may be considered highly demanding and therefore threatening. Second, reappraisal of arousal interventions do not fully take into consideration that there are individual differences in interoceptive accuracy, or the ability to detect physiological conditions of the body (Craig, 2002; Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004), making reappraisal of arousal potentially easier for those with good interoceptive skills (Jamieson et al, 2010). Third, the utility of this intervention is contingent on people actually experiencing increased arousal during stress, when the most commonly reported physiological symptoms of stress are not arousal, but "fatigue;" and "lack of interest, motivation, or energy" (APA, 2010). It is important to note that both stress mindset and reappraisal of arousal interventions focus on construals of the effects of stress (e.g., as physiologically arousing in the case of reappraisal interventions and as debilitating or enhancing in the case of stress mindset interventions). However, the aforementioned limitations of reappraisal of arousal interventions make it critical to further our understanding of how interventions that do not primarily rely on one's motivational state or capability to detect arousal can operate in threat and challenge states.

Additionally, understanding how stress mindset operates in challenge and threat 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), improving their immediate resources (which can be infeasible or taxing), or detecting and reappraising arousal during stress. Thus, theoretically, understanding how stress mindset theory works in concert with threat vs. challenge appraisal theory may help us understand cases in which each of these stress management strategies can be limited. Practically, understanding how stress mindset operates in the context of threat and challenge states will offer more specific coping strategies, and more flexible options for adapting to stress in various contexts, aiding individuals in improving their responses to stress. Critical to these practical implications is the need to further develop our understanding of the neuroendocrine, cognitive, and emotional responses to stress and how these responses may differ depending on one's mindset and motivational state.

Neuroendocrine, Cognitive and Emotional Responses to Stress

From a neuroendocrine perspective, when the body encounters stress, the hypothalamic pituitary adrenal (HPA) axis triggers a series of endocrine adaptations such as the release of cortisol, a catabolic or "breaking down" hormone, and dehydroepiandrosterone (DHEA), an anabolic or "building up" hormone from the adrenal glands (Dickerson & Kemeny, 2004; Selye, 1950). Cortisol is essential for

adaptation to acute stress, boosting immunity, arousal, and cognitive functioning (Dhabar & McEwen, 1996). However, the catabolic response can come at a cost; high or chronic levels of cortisol can lead to dysregulation of the HPA axis, resulting in health issues such as cardiovascular disease, stroke, ulcer, decreased immune functioning, and susceptibility to cancers (Lupien et.al, 2009; Miller & O'Callaghan, 2002). In opposition to cortisol's catabolic effects, DHEA and its sulfate derivative, DHEAS, plays a protective and regenerative role during stress and is associated with physiological thriving (Epel, McEwen, & Ickovicks, 1998). Given the opposing roles that cortisol and DHEAS play in stress, examining how stress mindset and appraisals work in concert with these neuroendocrine responses can offer greater insight into some of the adaptive and maladaptive outcomes that can ensue from changing one's beliefs about stress in the context of challenge or threat states.

From an emotional and cognitive perspective, the emotional concomitants of challenge and threat states include high-arousal positive and negative emotions, respectively (Herrald & Tomaka, 2002; see also Feldman Barrett, 2006), yet it is possible that these emotions may be differentially experienced depending on one's mindset about stress. For instance believing that stress is debilitating may enhance negative emotions, causing greater distress and fear as the stress is now perceived as bad or unwanted. Conversely, believing that stress is enhancing, even in threatening states, may boost positive emotions such as excitement, interest, or determination. Therefore, stress mindset could moderate the experience of threat states by buffering negative emotion and boosting positive emotions during stress. The experience of challenge and threat states can also have important cognitive ramifications. When the brain detects a threat to one's goal-related efforts, attention is often heightened and narrowed (Sapolsky, 1996). The focusing of attention to proposed threats is adaptive, however, *how* ones attention is focused can be a pivotal factor in determining how well an individual will adapt (Bar-Haim et al., 2007; Ohman, Flykt, & Esteves, 2001). Further, under threat states, attention can become subverted and focused on negative or threatening information resulting in positive information being missed or ignored (MacCleod, Mathews, & Tata, 1986; Mathews & MacLeod, 1994). This bias toward threatening information can reduce cognitive flexibility and enhance cognitive fixation, influencing one's ability to think creatively in the pursuit of goals and values (Hayes, 1996). Thus, an important determinant of a resilient or adaptive response under a challenge and threat state is the extent to which individuals are able to flexibly attend to information, which has the potential to be shaped by the degree to which they believe stress is enhancing or debilitating.

Taken together, there is evidence that although stress can have negative consequences on health, performance, and well-being, it can also provide the necessary catalyst for physiological toughening and psychological growth. Importantly, these effects depend on whether one is in a challenge or threat state and can be influenced by how this stress state is perceived. Therefore, one of the key goals of the present research is to understand how stress mindset and appraisals work together to influence emotional, neuroendocrine, and cognitive responses to stress in an effort to establish a more complete picture of the factors that can improve an individual's responses to stress.

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 stressor (Trier Social Stress Task; [TSST] Kirschbaum, Pirke, & Hellhammer, 1993) designed to engender threat or challenge stress states. Following the stress manipulation, we assessed participants' mood, cognitive flexibility, and attentional bias, all metrics found to be influenced by stress (e.g., Alexander et al., 2007; Bolger et al., 1989; Mogg et al., 1990). 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 under challenge and threat states (Dienstbier, 1989; Epel, McEwen, & Ickovicks, 1998). We hypothesized that those experiencing threat

states (engendered through negative feedback during the TSST) would exhibit maladaptive emotional, cognitive, and neuroendocrine responses to stress relative to those experiencing challenge states (engendered through positive feedback during the TSST). Specifically, we predicted that threat states would be associated with greater negative emotion, diminished cognitive flexibility, heightened focus on threatening faces, and greater cortisol secretion relative to challenge states. Further, we predicted an interaction between mindset and stress state, such that under threat states, having a stress-is-enhancing mindset would be associated with more adaptive emotional, cognitive, and neuroendocrine responses than having a stress-is-debilitating mindset. In contrast, under challenge states, we did not expect there to be a significant difference in cognitive, physiological, or psychological responses between those with a stress-is-enhancing mindset and those with a stress-is-debilitating mindset, given that challenge states are already associated with more adaptive responses to stress relative to threat states.

Method

Participants

We recruited 124 (40.2% White, 32% Asian, 15.3% Black, 9.8% Indian, and 2.5% other) participants (65.6% female; mean age=24.1 years; SD=5.1) from a university study pool. Participants received $20 for their participation. Sample size was determined in advance; our goal was to have approximately 30 participants per condition given the effect sizes found in previous appraisal manipulations (e.g., Jamieson et al., 2010; 2012; Tomaka et al., 1993).

Procedure

Participants were scheduled to participate for 90 minutes during afternoon hours. Following informed consent procedures, they completed questionnaires assessing their mood and stress mindset. They then provided a saliva sample that we later assayed for cortisol and DHEAS. 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). Following the videos, participants again completed the stress mindset measure.

Participants then completed a modified version of the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993)—which was a mock job interview requiring them to give a speech. Participants were randomly assigned to one of two conditions designed to activate the sympathetic nervous system and received either positive or negative feedback during the 8-minute speech (Akinola & Mendes, 2008). Participants were given 2 minutes to prepare for the speech in which they would need to discuss their dream job and describe their strengths and weaknesses in front of two interviewers. Prior to the speech task, participants completed demand and resource appraisals (Blascovich & Tomaka, 1996) and reported their emotions.

On the basis of previous research, we manipulated challenge and threat states using positive and negative feedback during the interview (Akinola & Mendes, 2008; Kassam, Koslov, & Mendes, 2009). Approximately 30 seconds into the speech, 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. They also gave explicit negative feedback during the speech (e.g., “I felt that you could be much clearer and more articulate. Think about what you are saying before you say it”).

Immediately following the interview, participants completed demand and resource appraisals and reported their emotions. They then provided a second saliva sample after which they engaged in three cognitive performance tasks. After providing a third and final saliva sample, participants were unhooked, debriefed, paid, and thanked.

Measures

Stress Mindset. Stress mindset was assessed prior to and following the video manipulation using the Stress Mindset Measure (SMM; Crum, Salovey, & Achor, 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 ($\alpha_{baseline}$ = .85, $\alpha_{post\text{-}video}$ = .94).

Threat vs. Challenge Appraisals. We assessed demand and resource appraisals following the speech task. Participants appraised 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 (α = .80) and resource (α = .75) appraisals were averaged separately and a ''threat ratio'' (demands/resources) was created. Ratios above 1 indicated a threat appraisal and below 1 indicated a challenge appraisal.

Positive and Negative Affect. We assessed self-reported emotions at three points: 1) upon arrival at the lab (baseline), 2) after receiving the speech task instructions, and 3) after the speech 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 (αs range from .89 to .92) and negative (αs range from .80 to .85) emotion scales were calculated.

Attentional Bias. To assess visual attention to positive and negative stimuli, participants engaged in a computerized dot-probe task (Macleod et al., 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 8 neutral faces. Each dot-probe trial began with a fixation cross in the middle of the screen for 500ms, followed by 200ms 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 1500ms, 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 latencies were recorded by the computer.[1]

Cognitive Flexibility. To assess cognitive flexibility, participants engaged in the Alternative Uses task (Guilford, 1967) and were asked to generate as many creative uses for a newspaper as possible within 2 minutes. 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 each of the four categories of the alternate uses task. Inter-coder reliability ranged from .80 to .90 for each subscale.

Neuroendocrine Measures: Cortisol and DHEAS. Saliva samples were obtained before and after the stress induction, as well as at the end of the study, using the passive drool method. 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%.

Results

Participant attrition

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

Manipulation checks

We first tested whether the stress mindset videos had their intended impact. Changes in SMM 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 in SMM, $t(53)=-7.99$, $p<.001$, while those in the stress-is-debilitating condition experienced decreases in SMM $t(53)=7.63$, $p<.001$ (Figure 1a).

Next we examined changes in cortisol to test whether we had created a stressful situation. Repeated measures ANOVA across the three time points (baseline, post-feedback, post-cognitive tasks) indicated a significant linear $F(2,72)=5.099$, $p=.027$, $\eta 2=.066$ and quadratic effect $F(2,72)=27.32$, $p<.001$, $\eta 2=.275$. Examining each phase separately indicated that cortisol levels increased between baseline and post stress task $F(1,72)=18.70$, $p<.001$, $\eta 2=.206$ and then decreased between stress task and post cognitive tasks $F(1,74)=28.10$, $p<.001$, $\eta 2=.275$. The same trends were found in both the positive and negative feedback conditions: quadratic effects over three time periods were $F(2,27)=33.684$, $p<.001$, $\eta 2=.555$ for negative feedback and $F(2,32)=5.284$, $p=.028$, $\eta 2=.142$ for positive feedback; linear increase between baseline and post stress was $F(1,27)=14.76$, $p=.001$, $\eta 2=.353$ for negative feedback and $F(1,32)=4.43$, $p=.043$, $\eta 2=.122$ for positive feedback and linear decrease between post stress and post-cognitive tasks was $F(1,28)=57.92$, $p<.001$, $\eta 2=.637$ for negative feedback and $F(1,33)=131.057$, $p<.001$, $\eta 2=.824$ for positive feedback.

We then examined the threat ratio created from the cognitive appraisals 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 1b), indicating that we were successfully able to manipulate threat and challenge stress states.

Data Analysis Strategy

To test our primary 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) x 2 (threat vs. challenge) ANOVAs for all dependent variables. Given that we assessed affective responses at multiple points, we conducted repeated measures ANOVAs with time as a within subjects variable and mindset and feedback conditions as a between subjects variable for our measures of positive and negative affect. Finally, although we also collected hormonal responses at multiple time points, since we were interested in understanding the total increase in cortisol and DHEAS secretion over the course of the study, we conducted area under the curve increase analysis (AUC; Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003). We employed this approach because it enabled us to account for differences in the time intervals between measurements, which were not identical in our study and because within-subjects repeated measures ANOVAs have no method to account for such differences. Specifically, we calculated the AUC of the total increase in cortisol and DHEAS over time 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. We then conducted 2 (Mindset: stress-is-enhancing vs. stress-is-debilitating) x 2 (Feedback condition: positive vs. negative) ANOVAs for cortisol and DHEAS separately.

Positive and Negative Affect

We examined changes in positive and negative affect separately using a mixed model ANOVA with mindset (stress-is-enhancing vs. stress-is-debilitating) and feedback (positive vs. negative) conditions as between-subjects factors, and time (baseline, pre-speech, and post-speech) as a within-subjects factor.[2] The mindset x feedback x time interaction was not significant for positive affect, however, we did observe a significant time x feedback effect $F(2,107)=27.88$, $p<.001$, $\eta 2=.207$ such that participants in the positive feedback condition experienced increases in positive affect over time, $F(2,53)=11.09$, $p<.001$, $\eta 2=.173$, relative to those in the negative condition, who experienced decreases in positive affect over time, $F(2,55)=8.08$, $p=.001$, $\eta 2=.129$ (Figure 2a). We also found a significant time x mindset effect $F(1,107)=7.838$, $p=.006$, $\eta 2=.068$. Simple-effects tests within each time period in the positive feedback condition showed that there were no differences between mindset conditions at baseline, $t(54)=.600$, $p>.250$, but positive affect was greater pre-speech $t(53)=2.091$, $p=.041$ and post-speech $t(54)=2.46$, $p=.017$ in the stress-is-enhancing condition than in the stress-is-debilitating condition. In the negative feedback condition, simple effects tests revealed there were no significant differences in positive emotions at baseline, pre-speech, or post-speech between participants with stress-is-enhancing mindsets relative to those with stress-is-debilitating mindsets, $t(55)=.067$, $p>.250$; $t(54) = .630$, $p>.250$, $t(55)=1.25$, $p=.218$ (Figure 2a). This result suggests that a stress-is-enhancing mindset only boosted positive affect when participants were in the positive feedback condition (challenge stress).

For negative affect, the mindset x feedback x time interaction was not significant, but again, we observed a significant time x feedback condition effect, $F(2,107)=21.241$, $p<.001$, $\eta 2=.166$ (Figure 2b). Simple-effects tests within each time period indicated that there were no differences in negative affect between positive and negative conditions at baseline or pre-speech $t(111)=-.625$, $p>.250$; $t(109) = -1.09$, $p>.250$, although both the positive and negative conditions did experience increases in negative affect between these two periods, $F(1,109)=68.091$, $p<001$, $\eta 2=.384$. Following the speech, differences in negative affect did emerge. Simple comparisons between feedback conditions post-speech revealed that negative affect remained elevated for participants in the negative feedback condition, $F(1,55)=.448$, $p>.250$, but declined for participants in the positive feedback condition, $F(1,54)=57.93$, $p<.001$ (Figure 2b).

Taken together, the positive and negative affect results offer evidence that the feedback manipulation produced strong mood effects and that a stress-is-enhancing mindset appears to exert greater influence on positive affect than a stress-is-debilitating mindset, particularly under challenge states.

Attentional Bias

We then examined the effect of stress mindset and feedback condition on participants' attentional bias to happy and angry faces by conducting a series of univariate ANOVAs. 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). We then calculated attentional bias scores 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 (c.f. Richeson & Trawalter, 2008). Greater bias scores indicate greater attention to the happy (or angry) faces and in

prior research has been associated with anxiety, depression and other emotional disorders (MacLeod, Mathews, & Tata, 1986).

Results for the 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, however results yielded a significant mindset x feedback condition effect $F(1,95)=4.422$, $p=.038$, $\eta 2=.046$[1]. Simple effects tests showed that, in the positive feedback 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, $F(1,46)=4.403$, $p=.042$, $\eta 2=.091$, again suggesting that a stress-is-enhancing mindset only boosted attentional bias towards happy faces when participants were in the positive feedback condition (challenge stress state). In contrast, in the negative feedback condition, there was no difference in bias toward happy faces between mindset conditions, $F(1,48)=.875$, $p>.250$, $\eta 2=.019$ (Figure 3a). With respect to attentional bias toward angry faces on the Dot Probe task, we observed a significant effect of feedback condition, $F(1,100)=3.984$, $p=.049$, $\eta 2=.039$, such that those in the positive condition showed greater attentional bias towards angry faces than those in the negative condition (Figure 3b).

Cognitive Flexibility

Next, we tested whether this pattern of differing mindset effects, particularly in the positive feedback condition relative to the negative feedback condition, held for our four cognitive flexibility metrics. We observed no effect of mindset, feedback condition, or their interaction on fluency, elaboration, or originality. However, for flexibility, while there was no effect of mindset, we observed a significant main effect of feedback condition $F(1,110)=4.509$, $p=.036$, $\eta 2=.040$, such that participants in the positive condition received higher cognitive flexibility scores than those in the negative condition. This main effect was qualified by a significant interaction, $F(1,110)=3.891$, $p=.050$, $\eta 2=.035$. Consistent with our attentional bias findings, participants who received positive feedback and held a stress-is-enhancing mindset received higher flexibility scores than those who held a stress-is-debilitating mindset, $F(1,53)=4.376$, $p=.041$, $\eta 2 = .078$ (Figure 3c). Aligned with the aforementioned effects, this suggests that a stress-is-enhancing mindset only generated creative flexibility when participants were in the positive feedback condition (challenge state). In contrast, in the negative feedback condition, there was no difference in flexibly between mindset conditions, $F(1,56)=.516$, $p>.250$, $\eta 2 = .009$. In other words, whereas stress-is-enhancing and stress-is-debilitating mindsets significantly differed from each other in cognitive flexibility in the positive condition, they did not differ in the negative 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 condition (challenge state).

Neuroendocrine Responses: Cortisol and DHEAS

Our final analyses examined the effect of the mindset and feedback manipulations on cortisol and DHEAS separately using AUC analysis. With respect to cortisol, there were no effects of mindset, feedback condition, or their interaction on cortisol increase, (all ps>.250) (Figure 4a). For DHEAS, similarly, there were also no main effects of mindset or feedback condition, however there was a significant mindset x feedback condition interaction, $F(1,107)=5.061$, $p=.027$, $\eta 2=.047$[3]. Simple effects tests revealed that counter to our affect and cognitive performance findings, there was no difference in DHEAS AUC between stress-is-enhancing and stress-is-debilitating mindsets for participants in the positive feedback condition, $F(1,52)=1.00$, $p>.250$, $\eta 2=.020$. However, in the negative feedback condition

the increase in DHEAS was greater for those with a stress-is-enhancing mindset relative to those with a stress-is-debilitating mindset, $F(1,54)=4.30$, $p=.043$, $\eta 2=.076$ (Figure 4b).

Discussion

The goal of the present research was to examine how stress mindset would differentially affect emotional, cognitive, and neuroendocrine responses to challenge and threat states, with the prediction that under threat states, having a stress-is-enhancing mindset would be associated with more adaptive responses than having a stress-is-debilitating mindset. Further, given that challenge states are already associated with more adaptive responses to stress relative to threat states, we did not expect to see mindset effects under challenge states. To this end, consistent with our primary prediction, we found that participants with a stress-is-enhancing mindset secreted more DHEAS in the negative feedback condition (in which a threat state was evoked) than those with a stress-is-debilitating mindset or in the positive feedback condition (in which a challenge state was evoked). However, counter to our prediction, it was *only with* DHEAS that we observed this adaptive pattern of responses for those with a stress-is-enhancing mindset under threat states and *not for* cortisol or any of our other affective and cognitive measures.

This finding regarding the DHEAS-amplifying effect of a stress–is-enhancing mindset in threatening contexts contributes to stress management theory and practice by showing that one can acknowledge a stressor as "threatening," yet still have adaptive outcomes. Specifically, 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, having a stress-is-enhancing mindset in the context of threat can potentially promote physiological thriving as evidenced by the heightened DHEAS we observed. The anabolic and antiglucocorticoid effects of DHEAS (Morgan et al., 2004), particularly when combined with its ability to promote psychological resilience (Charney, 2004) and positive mood (Frye & Lacey, 1999) may foster resilience under threat, facilitating one's ability to endure future stressors. Although the effects we found of mindset on DHEAS are provocative, it is important to point out that this effect was the only benefit associated with a stress-is-enhancing mindset under threat. Therefore, while adopting a stress-is-enhancing mindset may promote growth in the long-term, our results suggest that it is under challenge states that these effects are the most pronounced.

Interestingly, while we predicted no effect of stress-is-enhancing mindsets in challenge states, it was in this context that we *did* observe significant effects for our key measures of interest. Specifically, a stress-is-enhancing mindset was associated with greater positive affect, attentional bias towards happy faces, and more cognitive flexibility than a stress-is-debilitating mindset for participants receiving positive feedback. In other words, although mindset *did* moderate the effects of stress differentially depending on whether a challenge or threat state was evoked, the majority of the benefits of a stress-is-enhancing mindset occurred primarily under the challenge states, *counter* to our prediction that the benefits of a stress-is-enhancing mindset would occur under threat states. In contrast, those with a stress-is-debilitating mindset did not reap the benefits of the challenge state, experiencing worse cognitive and affective outcomes despite facing a seemingly manageable stressor (i.e., positive feedback). The finding that individuals in a stress-is-debilitating mindset under challenge states exhibited similar outcomes as those under threat may help explain why even small everyday stressors can have negative effects on mental and physical health (McIntyre, Korn, & Matsuo, 2008), sometimes evoking worse somatic outcomes than more threatening life events (Almeida, 2005; DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982). Moreover, the unexpected amplifying we observed of having a stress-is-enhancing mindset under challenge states is particularly interesting as this finding 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 et al., 2005; Fredrickson, 2001; Tugade & Fredrickson, 2004).

Additionally, of critical importance is our finding that although having a stress-is-enhancing mindset did indeed increase the positive aspects of stress (e.g., positive mood, attention to happy faces, cognitive flexibility, and DHEAS responses), it *did not buffer or reduce* the negative effects of stress (e.g., cortisol responses, negative emotion, and attentional bias toward angry faces) in either the positive or negative feedback conditions. These findings suggest that adopting a stress-is-enhancing mindset in the face of both challenging and threatening situations can be beneficial, not necessarily because of its ability to reduce the negative aspects of stress, but rather, having a stress-is-enhancing mindset aids in recruiting and magnifying the *positive* aspects of stress. Stress is most commonly considered pernicious, with the dominant message being that stress should be avoided and its effects should be reduced. This portrayal is not ill-founded as stress can have deleterious consequences for health, performance, and wellbeing (e.g., Herbert & Cohen, 1993; Sapolsky, 1996). Yet the negative effects are only half the story and the current research extends the stress literature by demonstrating that stress mindset can play a crucial role in helping individuals elicit the beneficial effects of stress. Additionally, our findings affirm that stress mindset is a pragmatically useful stress moderator as it is malleable, which we demonstrate through the use of a video intervention. While there is evidence that the effects of stress can be influenced by a variety of factors, including, but not limited to dispositional characteristics such as optimism (Chang, 1998) and self-esteem (Seery, Blascovich, Weisbuch & Brooke, 2004), these traits are difficult to shift in the short-term. In contrast, stress mindset is amenable to change and can be induced quickly—through a three-minute educational intervention.

Several limitations should be acknowledged and addressed. First, our stress task was highly constrained as we focused on the relative effects of mindset only under threat and challenge. It was important to create a stressful situation that was metabolically demanding to get a clear sense of the effects of stress mindset. However, without a control condition, it is unclear whether our findings generally reflect enhancements in neuroendocrine, cognitive, and emotional functioning relative to baseline or decrements. Future research should explore the effect of mindset in more ambiguous and naturally-occurring stressful situations to better tease apart the process through which stress mindsets exert psychological, physiological, and behavioral effects. Additionally, 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.

Stress is an undeniable part of everyday reality for most individuals. Our findings provide 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—not necessarily by reducing or avoiding stress, but rather, by changing their mindset.

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Footnotes

[1] Participants also performed BART and Stroop tasks. We do not report on these as they were not measured for this article's target research question.

[2] There was a significant effect of baseline SMM on happiness bias therefore baseline SMM was included as a covariate. Without baseline SMM the interaction is marginally significant, $F(1,100)=3.631$, $p=.10$, $\eta 2=.027$.

[3] There was a significant effect of gender on DHEAS therefore gender was included as a covariate. Without gender, the interaction is marginally significant, $F(1,107)=2.901$, $p=.092$, $\eta 2=.027$.

Author Contributions

A.J. Crum and M. Akinola developed the study concept. All authors developed the study design. Data collection and data entry were performed by A.J. Crum, A. Martin and S. Fath. A.J. Crum and M. Akinola drafted and revised the manuscript and A. Martin and S. Fath provided numerous critical revisions. All authors approved the final version of the manuscript for submission.

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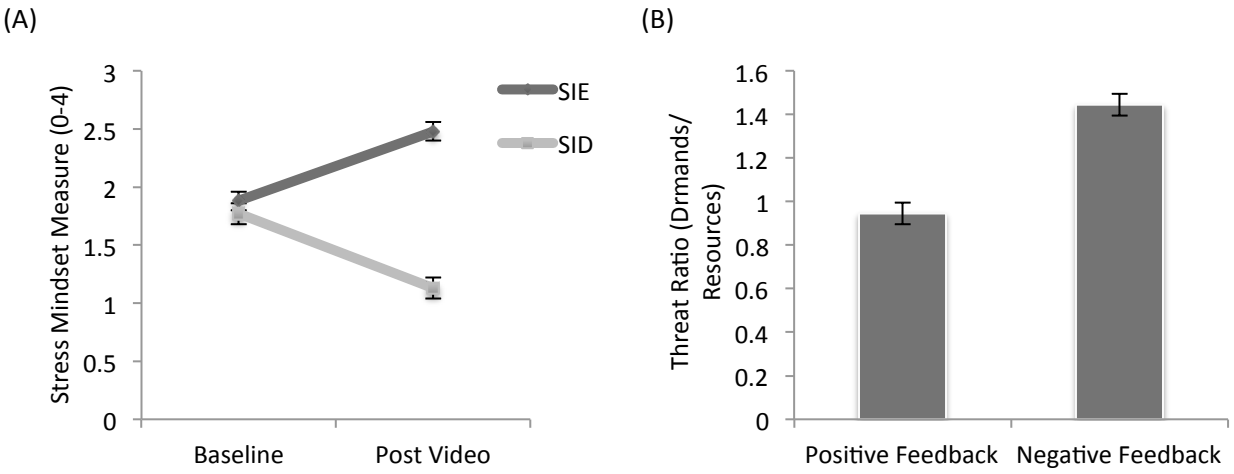
Table 1. Means and Standard Deviations (in Parentheses) for Key Outcome Variables as a function of mindset and feedback conditions

Variable	Positive Feedback (Challenge)		Negative Feedback (Threat)	
	Stress-is-Enhancing	Stress-is-Debilitating	Stress-is-Enhancing	Stress-is-Debilitating
Positive Affect (1-5)				
Baseline	2.99(.81)$_{a}$	2.91(.75)$_{a}$	3.10(.66)$_{a}$	3.04(.80)$_{a}$
Pre Speech	3.11(.66)$_{a}$	2.69(.83)$_{bc}$	2.96(.87)$_{c}$	2.80(.96)$_{bc}$
Post Speech	3.51(.81)$_{a}$	2.99(.86)$_{b}$	2.80(.77)$_{b}$	2.58(.91)$_{b}$
Negative Affect (1-5)				
Baseline	1.42(.37)$_{a}$	1.55(.57)$_{a}$	1.52(.47)$_{a}$	1.58(.56)$_{a}$
Pre Speech	1.86(.57)$_{a}$	1.97(.70)$_{a}$	2.02(.59)$_{a}$	2.10(.75)$_{a}$
Post Speech	1.35(.35)$_{a}$	1.48(.41)$_{a}$	2.06(.67)$_{b}$	2.14(.76)$_{b}$
Attentional Bias				
Happy Faces	19.08(33)$_{a}$	-0.84(45)$_{b}$	-1.81(45)$_{b}$	5.17(45)$_{b}$
Angry Faces	0.78(33)$_{a}$	3.09(50)$_{a\,b}$	-11.34(50)$_{b\,c}$	-21.16(37)$_{c}$
Cognitive Flexibility	6.34(2.03)$_{a}$	5.12(2.21)$_{b}$	4.63(2.19)$_{b}$	5.06(2.30)$_{b}$
Cortisol Increase (ng/ml)	39.22(13.5)$_{a}$	61.49(10.78)$_{a}$	41.24(10.55)$_{a}$	55.00(9.40)$_{a}$
DHEAS Increase (ng/ml)	588.26(420.3)$_{a}$	684.20(620.3)$_{a}$	890.62(789.2)$_{b}$	582.53(510.2)$_{a}$

Note: Within a row, means with different subscripts differ at $p < .05$.

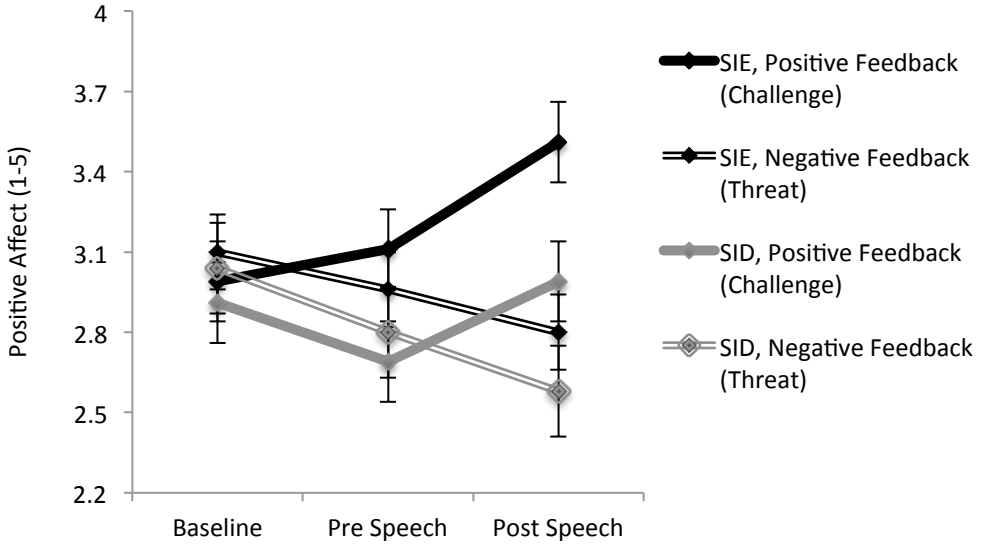
Figure 1. Means and standard errors for Stress Mindset Measure pre and post mindset video (A) and Threat ratio post speech (B)



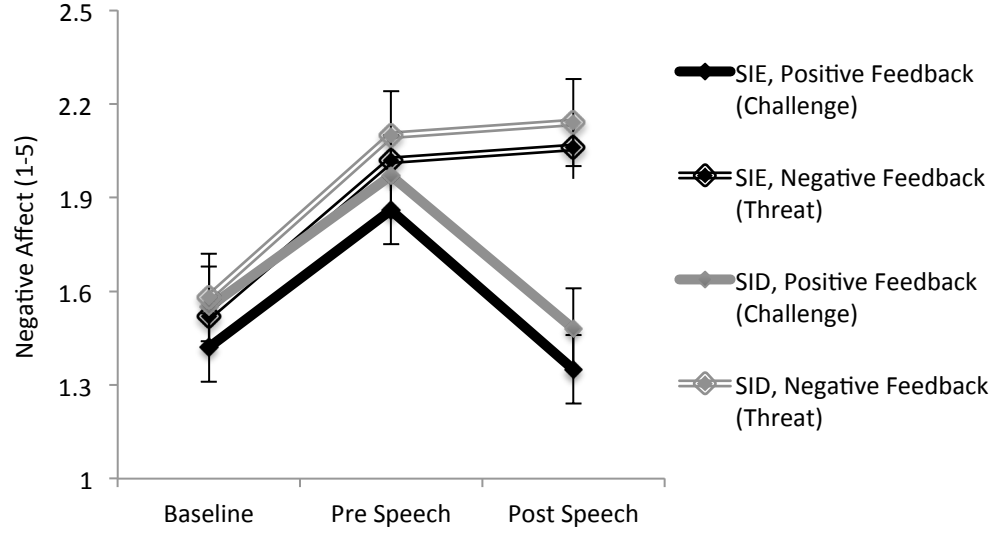
Note: SIE= Stress-is-Enhancing and SID= Stress-is-Debilitating

Figure 2. Mean Positive Affect (A) and Negative Affect (B) ratings as a function of mindset and feedback condition over three time periods.

(A)

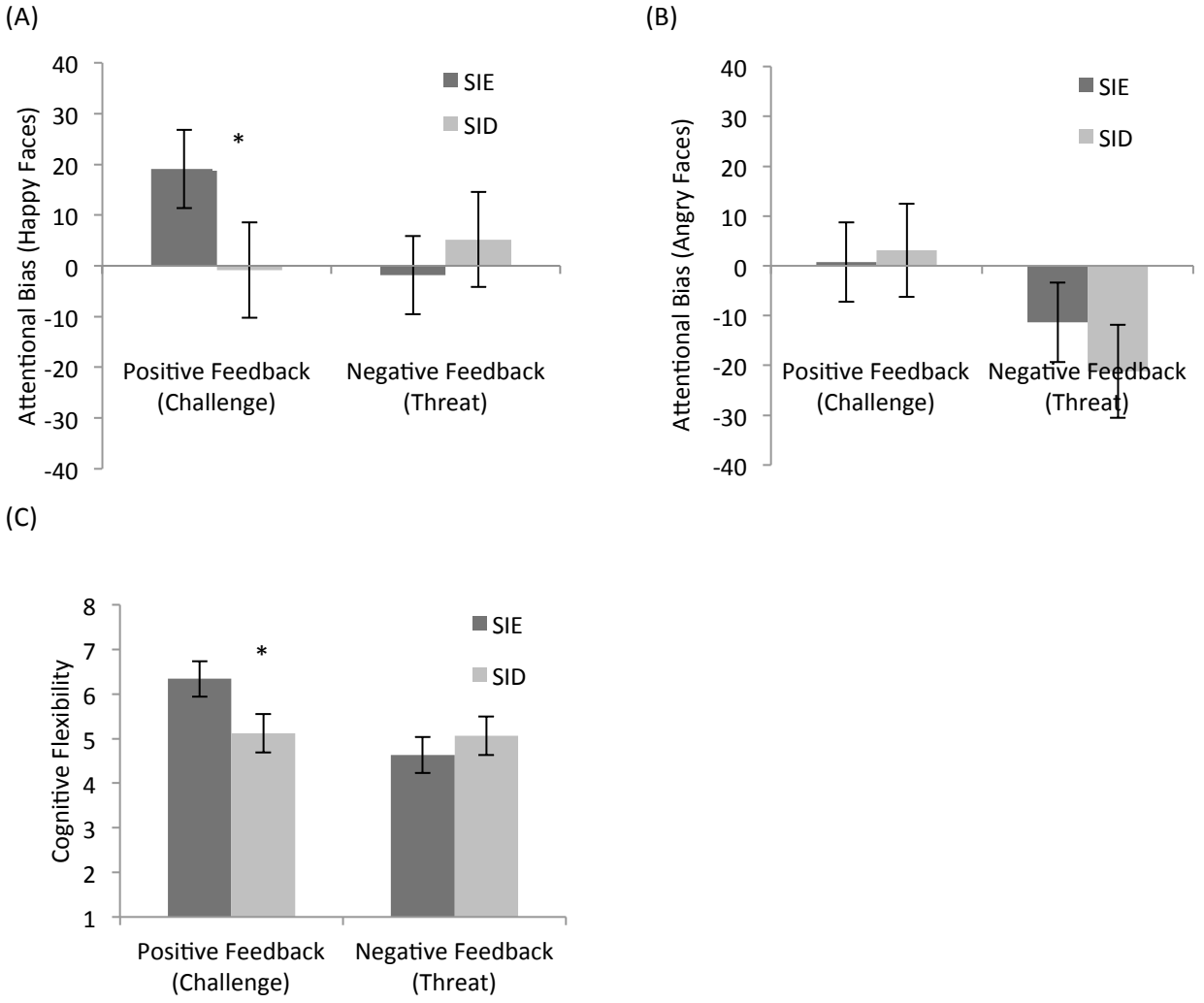


(B)



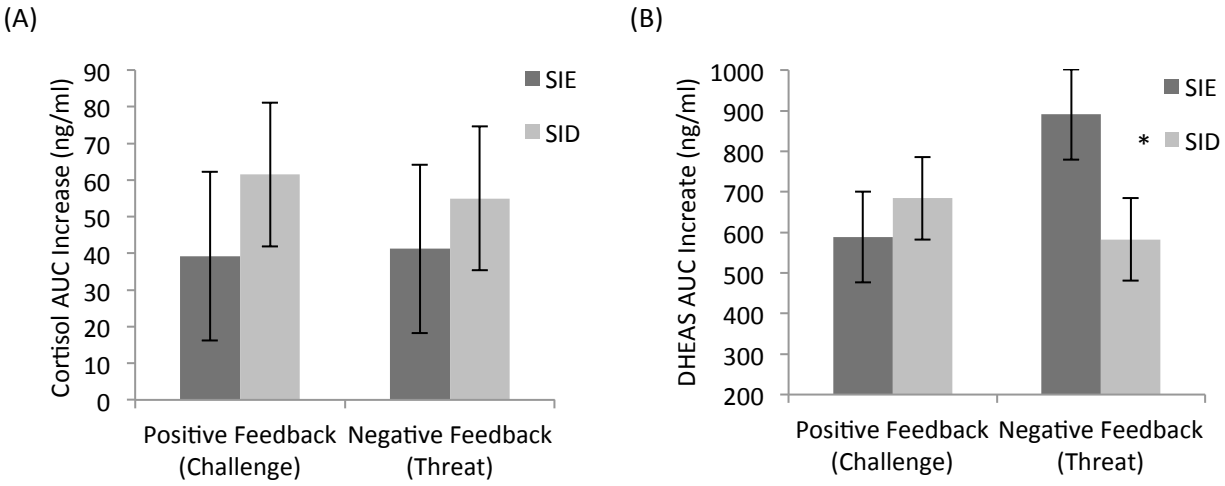
Note: SIE= Stress-is-Enhancing and SID= Stress-is-Debilitating; Error bars show standard errors.

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

Figure 4. Cortisol AUC increase (A) and DHEAS increase (B) 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