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The influence of university students' stress mindsets on health and performance outcomes

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Abstract

Background: Emerging evidence indicates that holding particular stress mindsets have favorable implications for peoples' health and performance under stress. **Purpose:** The aim of the current study was to examine the processes by which implicit and explicit stress mindsets relate to health- and performance-related outcomes. Specifically, we propose a stress beliefs model in which somatic responses to stress and coping behaviors mediate the effect of stress mindsets on outcomes. **Methods:** Undergraduate university students (N = 218, n = 144 female) aged 17 to 25 years completed measures of stress mindset, physical and psychological wellbeing, perceived stress, somatic responses to stress, proactive behaviors under stress, and an implicit association test assessing an implicit stress mindset. At the end of the semester, students' academic performance was collected from university records. **Results:** Path analysis indicated significant indirect effects of stress mindset on psychological wellbeing and perceived stress through proactive coping behaviors and somatic symptoms. Stress mindset directly predicted perceived stress and physical wellbeing, and physical wellbeing and academic performance were predicted by stress mindset through perceived somatic symptoms. Implicit stress mindset did not predict proactive behavior as anticipated. **Conclusions:** Current findings indicate that behaviors with the goal of proactively meeting demands under stress and perceived somatic symptoms are important mediators of the effect of stress mindset on health- and performance-related outcomes. The findings from this study provide formative data which can inform the development of future interventions aiming to encourage more adaptive responses to stress.

Keywords: Stress, mindsets, coping, implicit beliefs, perceived control

Stress is defined as the tension that occurs when one perceives an external event as outweighing the capacity to cope afforded by one's personal resources (1, 2). In developed countries such as the U.S. and Australia, young university students report experiencing high levels of stress (3, 4). Given the potential impact of stress on physical and mental health and that just 13% of Australians report seeking professional support for dealing with stress (4), potential targets for non-clinical interventions are a timely area to explore. Research has shown that beliefs about the consequences of stress itself, stress mindsets, may be influential in determining the impact of the stress response on health and performance (5-7). Recently, Crum, Salovey and Achor (5) found that holding a stress-is-enhancing mindset—the belief that stress has positive implications for health and performance—is associated with favorable self-reported outcomes such as lower perceived stress and health symptoms, increased work performance, and more adaptive cortisol reactivity profiles under acute stress. This contrasts with holding a stress-is-debilitating mindset—the belief that stress has negative implications for health and performance—which is associated with poorer outcomes under stress. However, there is a paucity of data on the process by which these beliefs relate to these outcomes. The current study tested a novel stress beliefs model proposing that stress mindsets may influence health and performance outcomes through two mechanisms: differences in coping behaviors under stress and differences in enduring physiological responses. Specifically, we propose that a mediation process in which coping behaviors under stress and enduring physiological responses mediate the effect of stress mindset on health and performance outcomes. We will test these mechanisms simultaneously in a nomological network (8-11).

Theoretical Basis of a Stress Beliefs Model

Mindsets, otherwise known as implicit theories, refer to beliefs regarding the malleability of personal qualities which people use to make predictions about and judge the

meaning of life events (12, 13). While the term “implicit” is ascribed to these beliefs as they tend not to be explicitly articulated (13, 14), it is not clear whether these mindsets are truly implicit, operating outside conscious awareness consistent with dual process theories of cognition and behavior. These theories formally specify a distinction between implicit and explicit cognitions that determine action through two pathways: a rapid, nonconscious pathway not reliant on information stored in working memory or deliberative processing; and a reasoned, deliberative pathway that involves drawing from stored information in working memory and processing information regarding behavioral alternatives (15). As working memory is impaired by stress (16), stress mindsets are likely to lead to a greater likelihood for individuals’ cognition and behavior to be determined by nonconscious factors. Thus, measuring stress mindsets both implicitly and explicitly may be an important step in understanding their influence on health and performance outcomes.

Crum and colleagues (5) outline evidence suggesting that stress can have both debilitating and enhancing consequences, a feature of stress that is often neglected. They proposed that there is value in a more "nuanced view of stress that recognizes that while experiencing stress can debilitate health and performance, stress can also fundamentally enhance health and performance" (p. 717). Mindsets referring to the malleable nature of a construct is consistent with research on mindsets for intelligence and willpower (13, 17). For example, a growth mindset regarding intelligence refers to the belief that intelligence can be further developed. Similarly, in some circumstances, stress can be enhancing (5). Crum and colleagues (5) used an experimental design where videos were used to elicit a stress-is-enhancing mindset or a stress-is-debilitating mindset. In the stress-is-enhancing mindset condition, stress was presented as strictly enhancing and that people could learn to enjoy and utilize stress, while in the stress-is-debilitating condition, stress was presented as strictly debilitating. The Stress Mindset Measure (5) also measures stress mindsets as fixed-

enhancing and fixed-debilitating. These polarized fixed presentations of stress in the intervention material and in the Stress Mindset Measure contrast with the nuanced view of stress that was theorized by Crum and colleagues (5) as being of value. Mean stress mindset scores across their studies (5) indicated that people tend to see stress as debilitating by default, so highlighting the enhancing consequences of stress may in fact contextualize stress alongside current beliefs to create a more nuanced view. The nuanced view of stress may render the experimental manipulation effective in part due to eliciting perceptions of control (i.e., the stress response is malleable and can be used to be enhancing) as perceived control in stressful situations and daily hassles has been found to lead to better physical outcomes (18, 19). Rather than contextualizing stress in this more nuanced way, presenting stress as strictly enhancing may also be ineffective for some people because it requires a complete paradigm shift in their conceptualization of stress. Rather than building upon their existing conceptualization to engender a more balanced view of stress, it may result in the video content being rejected altogether. More recent research (20) has found that presenting videos outlining the balanced consequences of stress results in significantly decreased heart rates and diastolic blood pressure following a lab-induced stressor compared to videos outlining strictly positive or negative consequences of stress. We contend that measurement of stress mindsets should be framed to explicitly measure nuanced beliefs about the malleability of the consequences of stress such that stress "can be" enhancing, on the basis of three arguments: (a) the potential benefits of holding a nuanced or balanced view of stress (20), (b) the importance, within mindset theory, of seeing particular traits as malleable (12, 13), and (c) the current conceptualization of stress mindsets indicating that stress can be both enhancing and debilitating (5).

Two mechanisms by which stress mindset may operate have been promulgated. First, stress triggers activation of the sympathetic nervous system (SNS) resulting in the production

of catecholamines such as adrenaline and noradrenaline. These hormones produce changes in heart rate, sweat secretion, blood pressure, and pupil dilation; and is characteristic of a "fight-or-flight" response (21). Further, stress triggers increased hypothalamic-pituitary-adrenocortical (HPA) axis activation (22, 23). Crum, Salovey and Achor (5) found that a stress-is-enhancing mindset was associated with more adaptive cortisol reactivity profiles under acute stress. Specifically, endorsing a stress-is-enhancing mindset lowered cortisol responses in those with high cortisol reactivity to stress, and those with low cortisol reactivity to stress experienced increased cortisol responses. As prolonged or frequent SNS or HPA activations are associated with negative health outcomes (24-26), it is expected that beliefs that lead to more adaptive physiological activations under stress will in turn lead to better health outcomes. The physiological stress response is therefore expected to be a key mechanism by which stress mindsets relate to health and performance outcomes, and investigation of enduring physiological responses is important to understand this mechanism.

Given the symptoms associated with the stress response (headaches, fatigue, muscle tension, sleep disturbance, and nausea; 27), it is unsurprising that the goal of coping behaviors is often to manage the felt discomfort and attenuate the heightened arousal. These behavioral coping strategies include emotion-focused strategies aimed at reducing the feeling of tension (e.g., avoidance, denial) and problem-focused strategies which are directed at the stressor itself and are aimed at reducing its magnitude (28). Examples of emotion-focused coping are self-soothing through relaxation, avoidance or denial, and expression of negative emotion (28). In contrast, problem-focused coping may involve behaviors such as planning, making a start on a task, or proactively acquiring resources (28). To date, desire for feedback under stress is the only behavior that has been examined as being influenced by stress mindsets (5). While seeking feedback is a form of proactive coping, it may not represent the tendency to use proactive behaviors under stress more broadly and cannot necessarily be generalized to

other active approaches to managing stress. Feedback is also not available in all stressful situations and cannot be relied on as the only problem-focused strategy for coping with stress. While Crum and colleagues' findings indicate that behavioral responses under stress may play a role in the process through which stress mindsets influence outcomes, it is important to explore how a range of proactive behaviors under stress (e.g., planning, coping proactively, avoiding procrastination) may mediate this relationship, as similar approach-oriented styles of coping have previously been associated with favorable physical health outcomes in students (29). A recent meta-analysis (30) has also indicated that coping strategies, including more proactive problem-focused strategies, account for a range of illness-related physical and psychological outcomes including reduced disease progression, improved wellbeing and reduced distress.

Aims and Hypotheses

The aim of the current study was to test a stress beliefs model (see Table 1 and Figure 1) to understand the behavioral and physiological mechanisms by which beliefs about the consequences of stress (i.e., an explicit stress-is-enhancing mindset and implicit beliefs) influence health and performance outcomes, and perceived stress. Given the importance of simultaneously testing the structural relations between theoretical constructs, the predicted paths within the stress beliefs model that follow were evaluated simultaneously as a nomological network (8-11). First, it is predicted that stress mindset will predict engagement in a higher level of proactive behaviors (planning to meet demands, proactivity toward meeting demands, avoiding procrastination) when under stress (P_1). Extending Crum and colleagues' (5) finding that stress mindsets predict cortisol reactivity under acute stress, it is expected that stress mindset will predict more enduring self-reported general somatic activation symptoms (P_2). There is currently limited knowledge regarding whether mindsets operate as more deliberative or automatic processes in the self-regulation of coping behaviors.

Given that implicit processes are likely to regulate behavior when working memory is limited (15), such as when individuals experience stress (16), it is expected that implicit stress mindset will predict greater engagement in proactive behaviors when under stress (P_3). That is, those with stronger automatic associations between the construct "stress" and the construct "enhancing" will tend to engage in more proactive coping behaviors when under stress. As problem-focused strategies address the stressor directly, and are related to psychological and physical health outcomes (29, 30), it is expected that proactive behavior will predict higher psychological wellbeing (P_4), lower perceived stress (P_5), higher physical wellbeing (P_6), and higher academic performance (P_7). Given the subjective experience of physiological stress symptoms (27) it is predicted that self-reported general somatic symptoms will predict lower psychological wellbeing (P_8), higher perceived stress (P_9), lower physical wellbeing (P_{10}), and lower academic performance (P_{11}).

As Crum et al. (5) found that stress mindset directly predicts health and work performance, it is anticipated that stress mindset will directly predict higher psychological wellbeing (P_{12}), lower perceived stress (P_{13}), higher physical wellbeing (P_{14}), and higher academic performance (P_{15}). Given that a combination of behavioral and physiological mechanisms is anticipated to account for these effects, several indirect effects are also proposed. It is anticipated that mediated by proactive behavior, stress mindset will indirectly predict higher psychological wellbeing (P_{16}), lower perceived stress (P_{17}), higher physical wellbeing (P_{18}), and higher academic performance (P_{19}). In addition, it is expected that stress mindset will predict higher psychological wellbeing (P_{20}), lower perceived stress (P_{21}), higher physical wellbeing (P_{22}), and higher academic performance (P_{23}) indirectly through perceived general somatic symptoms.

Method

Participants

Participants were young undergraduate university students (N = 218, 66% female) ranging in age from 17 to 25 years (M = 19.26, SD = 2.19) recruited from a university in South East Queensland, Australia. Participants were recruited via three methods: face-to-face at the university, online through email and social media (i.e., Facebook), and posters advertising the study displayed in common areas at the university. Undergraduate students aged 25 years and younger were eligible to participate. Potential participants were advised of the eligibility criteria prior to indicating their interest in participating. Two participants were deemed ineligible to participate due to age after indicating their interest in participating. The majority (79%) of participants were born in Australia and 75% of participants indicated that their ethnic identity is Australian. Almost all participants were enrolled in their program of study full-time (96%) and 8% of participants were international students. As an incentive to participate, individuals received course credit if they were a first-year psychology student or a voucher for one free coffee and entry into a prize draw for the chance to win a department store gift card valued at approximately USD35.

Design and Procedure

The University Human Research Ethics Committee (reference: 2015/723) approved the study. Prior to participating, students were provided with details of study requirements and signed consent forms. The current study adopted a correlational design, with participants completing study measures in a research laboratory between March and October 2016. Participants completed a survey containing self-report measures of psychological and behavioral constructs and questions capturing demographic characteristics using an online survey tool (Qualtrics©). They then completed a Single-Category Implicit Association Task (SC-IAT) using Millisecond Inquisit 4 Web© online research software measuring their

implicit beliefs about the nature of stress as enhancing or debilitating. To minimize bias, the experimenter followed a standardized script and procedure in administering the study. Minimum sample size was calculated based on Kline's (31) recommendation that the number of parameters multiplied by 10 is adequate for maximum-likelihood model estimation. As there are 20 parameters, 200 was the target sample size.

Measures

Proactive behavior. Proactive behavior was measured using six questions scored on a five-point Likert scale (1 = *never* to 5 = *very often*). Participants were asked to indicate the extent to which they have engaged in planning, were proactive, and avoided procrastination, while under stress; and, in order to cope with stress in the last month (e.g., "In the last month, how often did you engage in planning your time to cope with stress?"). The proactive behavior scale was evaluated using exploratory and confirmatory factor analysis, suggesting a single-factor structure. Items of the measure of proactive behavior and results of factor analyses are available on the project website (https://osf.io/xdvqt). Internal consistency was also adequate (Cronbach's $\alpha = .77$). After recoding negatively-worded items, a composite score was formed by computing the mean of item scores.

Psychological wellbeing. Psychological wellbeing was measured using the Warwick-Edinburgh Mental Well-being Scale (WEMWBS; 32). The WEMWBS is a 14-item scale that has been validated in student populations (33, 34). Participants are asked to indicate the extent to which they generally experience wellbeing states (e.g., "I've been feeling good about myself") on a five-point Likert scales (1 = *none of the time* to 5 = *all of the time*). Internal consistency was excellent in the current study (Cronbach's $\alpha = .92$). The WEMWBS was scored by computing the sum of item scores.

Physical wellbeing. Physical wellbeing was measured using the United States Centers for Disease Control and Prevention (CDC) Health-Related Quality of Life Healthy Days

(HRQOL-14) measure (35). The Healthy Days measure was developed by the CDC as a shorter alternative to existing health measures such as Medical Outcomes Survey Short Form 36 (SF-36), measuring the same underlying constructs. The validity of the Healthy Days measure has been established in several studies (36), and has demonstrated acceptable criterion validity with the SF-36 (37). The Healthy Days measure has been used widely, including in US national surveys such as the National Health and Nutrition Examination Survey (NHANES; 36), and in prior research investigating stress mindsets (5). Contrasting with other self-report measures of health, the Healthy Days measure does not have specified summary scores or psychometrically derived subscales but was designed to comprise a series of individual indicators (36). These indicators are combined in different ways to fit different uses. In the current study, we used the two indicators of physical health that are scaled according to days, whereby participants indicated the number of days their physical health was not good or that pain interfered with their daily activities in the past month on two items (e.g., "Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?"). The scores were averaged and subtracted from 30, to give the number of "healthy days" experienced in the past month (36). Internal consistency between the two items was acceptable (Cronbach's $\alpha = .70$).

Perceived stress. Perceived stress was measured using the 10-item Perceived Stress Scale (PSS-10), which measures the extent to which current life situations are perceived as stressful (38). The measure has been associated with higher cortisol levels, increased biological markers of aging, and suppressed immune function (39). Participants responded to items (e.g., "In the last month, how often have you felt you were on top of things?") on five-point Likert scales (0 = *never* to 4 = *very often*) and the scale exhibited good internal consistency (Cronbach's $\alpha = .88$). The PSS-10 was scored by recoding negatively-worded

items and computing the sum of item scores.

Academic performance. Participants' semester grade point average (GPA) was provided by the university to objectively measure academic performance. The GPA score is measured on a 1-7 scale, with scores from 1-3 indicating an average grade of less than 50%, 4 indicating an average grade between 50%-64%, 5 indicating an average grade between 65%-74%, 6 indicating an average grade between 75%-84%, and 7 indicating an average grade of 85% or greater.

Perceived general somatic symptoms. The State-Trait Inventory for Cognitive and Somatic Anxiety – *Trait Version* (STICSA-T) somatic subscale (11 items) was used as a self-report (40, 41) proxy measure for chronic elevation in SNS activation. Participants indicated the extent to which they generally experience a range of somatic symptoms (e.g., my breathing is fast and shallow). Experimental research has found that participants reported significantly increased STICSA-S perceived somatic symptoms and cortisol when exposed to a Trier Social Stress Task (42). The STICSA-T and -S (*State Version*) differ only based on the preamble to the measure. The T version asks respondents to answer in reference to symptoms in general while the S is in reference to symptoms in the moment of answering the questionnaire. The STICSA-T was used in the current study as more enduring physiological responses to stress are a proposed mechanism through which stress affects health (24-26). The STICSA-T is measured on a 4-point Likert scale (1 = *almost never* to 4 = *almost always*) and exhibited good internal consistency in the current study (Cronbach's $\alpha = .85$). The STICSA-T somatic subscale was scored by computing the sum of item scores.

Stress mindset. The Stress Control Mindset Measure (SCMM) was developed to assess stress mindset in the current study. We sought to overcome divergence that exists between stress mindset theory and measurement by developing a measure of stress mindset more closely aligned to how stress mindset is theorized, and more closely aligned to mindset

theory more broadly. Specifically, the SCMM is designed to measure stress mindset in a manner that aligns to a nuanced view of stress such that stress "can be" enhancing. Thus, the SCMM includes the domains of the stress-is-enhancing mindset contained within the Stress Mindset Measure (5)—performance and productivity, learning and growth, health and vitality, and a general domain—but also encompasses malleability of the consequences of the stress response (e.g., "Stress can be used to enhance my performance and productivity"). Participants are asked to indicate on six-point Likert scales (1 = *strongly disagree* to 6 = *strongly agree*) their agreement with the presented statements about the consequences of stress. As a part of a larger project aimed at validating the SCMM in a series of samples, the structure of the SCMM was evaluated using exploratory and confirmatory factor analysis, and validity regarding conceptually related constructs was examined. For further information on these analyses, please see Electronic Supplementary Material 1. Internal consistency of the SCMM was excellent, Cronbach's $\alpha = .93$. After recoding negatively-worded items, a composite score for the SCMM was formed by computing the mean of item scores.

Implicit stress mindset. A single category implicit association test (SC-IAT) based on Karpinski and Steinman's (43) original measure was developed to measure implicit beliefs of stress as enhancing or debilitating. An initial pool of stimulus words for the SC-IAT attribute ("enhancing" and "debilitating") and target ("stress") categories were rated for their appropriateness by a small subset of participants from the target population. Twenty-one stimulus words each for the enhancing (e.g., vitalizing, enriching) and debilitating (e.g., limiting, depleting) attribute categories and seven stimuli words for the target category (e.g., stressor, stressful) were identified based on participants' top-ranked stimulus words from the pilot study. The list of stimulus words is presented in Electronic Supplementary Material 2. The four-step SC-IAT procedure comprised two practice rounds (one and three) of 24 trials each, and two test rounds (two and four) of 72 trials each. Rounds one and two were

"compatible" rounds, in which "stress" and "enhancing" categories were presented together on one side of the screen with the "debilitating" category on the other. Rounds three and four were "incompatible" rounds in which "stress" and "debilitating" categories were presented together on one side of the screen with the "enhancing" category on the other. During each of the rounds, stimulus words from the three categories were presented in the center of the screen in random order. Participants were instructed to use the "E" key on the computer keyboard to match the presented word to categories presented on the left side of the screen or the "I" key to match stimuli to categories presented on the right. The composition of the SC-IAT used in the current study is presented in Table 2. Participants' *D* scores were calculated using the improved scoring algorithm (44) to provide a measure of implicit stress mindset, with higher positive scores indicating stronger endorsement of an implicit stress-is-enhancing mindset. Those with higher *D* scores are on average able to more quickly associate words related to "stress" and "enhancing" together than words related to "stress" and "debilitating", which in theory reflects a stronger automatic association between the two constructs for that individual (44). Internal consistency was calculated by correlating the mean latency scores for the two test rounds (44). Reliability of the stress mindset SC-IAT (r = .68) was comparable to values found for SC-IATs in other domains (43).

Covariates. *Amount of stress* was measured on a single item ("Overall, how much stress do you have in your life right now?") which used a 7-point Likert scale (1 = *no stress* to 7 = *an extreme amount of stress*). This measure was used by Crum and colleagues (5) to examine convergent and discriminant validity of the Stress Mindset Measures and exhibited the same strength of relationship with the stress mindset measure as the social readjustment rating scale (45). *Stressor severity appraisal* was measured by asking participants to identify the primary source of stress in their life right now, and then asking how stressful they perceive that stressor to be on a 7-point Likert scale (1 = *not at all stressful* to 7 = *extremely*

stressful). This measure was also used by Crum and colleagues (5) to examine convergent and discriminant validity of the Stress Mindset Measure. Because Crum and colleagues (5) found amount of stress and stressor severity appraisals to be significantly correlated with stress mindsets; these variables were included as covariates in the analysis, allowing us to examine the unique variance in health and performance accounted for by the proposed stress beliefs model.

Data Analysis

Path analysis using M*plus* version 7.4 (46) was employed to test the hypothesized stress beliefs model with maximum-likelihood estimation method (i.e. ML in M*plus*). Indirect effects were estimated with bias-corrected bootstrapped (replications N = 10,000) 95% confidence intervals. Seven univariate outliers were detected in initial data screening ($z > \pm 3.29$). As it is possible that the outliers are true scores, and removal of the outliers did not affect the significance of any estimated paths; all cases were included in the analysis. Multivariate skewness (ratio of skew to *SE* > 3.29), univariate kurtosis (ratio of Kurtosis to *SE* > 3.29), and heteroscedasticity with academic performance as the outcome was present. Therefore, significance of effects was evaluated based on the bias-corrected bootstrapped 95% confidence intervals for all paths to guard against non-normality. Three participants' academic performance data were missing due to their withdrawal from university prior to collection of data on academic performance. There were no other missing data. The three missing data points were imputed using a full-information, maximum-likelihood regression procedure. Due to statistically significant correlations between some of the variables in the model, the following error terms were allowed to covary: proactive behavior with perceived somatic symptoms, perceived stress with psychological wellbeing and physical wellbeing, and psychological wellbeing with physical wellbeing. The proposed set of predictions were tested simultaneously as a single nomological network (8-11), with fit of the proposed model with

the data evaluated using goodness-of-fit criteria for structural equation models including non-significant chi-square test of model fit, RMSEA < .06, SRMR < .05, CFI > .95, TLI > .95 (47). Pending confirmation of good fit, we evaluated individual effects within the network. We adopted an alpha level of 0.05 and corresponding 95% confidence intervals were used in evaluating the paths in the model.

Results

Preliminary Analyses

Means, standard deviations, ranges and intercorrelations among study variables are presented in Table 3. Stress mindset was significantly correlated with all variables except implicit stress mindset (measured using the SC-IAT) and academic performance. Proactive behavior was significantly correlated with all variables except implicit stress mindset and stressor severity appraisal, and perceived general somatic symptoms was correlated with all variables except implicit stress mindset. Implicit stress mindset exhibited no correlation with any of the study variables. Stress mindset composite scores ranged from 1.13 to 5.07 (M = 3.28, SD = .81), with scores above 3.50 indicative of a level of agreement that stress is enhancing. Implicit stress mindset SC-IAT D scores ranged from -1.01 to .61 (M = -.30, SD = .33), with positive scores indicating a stronger implicit stress-is-enhancing mindset.

Model Effects

The final model exhibited a good fit to the data ($\chi^2(6) = 4.20$ [p = .65], RMSEA = .00, SRMR = .02, CFI = 1.00, TLI = 1.02. Standardized parameter estimates for the structural relations among the variables in the proposed model are presented in Figure 2 and a summary of standardized path coefficients and 95% bias-corrected bootstrapped confidence intervals is presented in Table 4. Stress mindset had a statistically significant positive direct effect on proactive behavior (P_1) and a statistically significant negative direct effect on perceived general somatic symptoms (P_2), as predicted. There were no statistically significant direct

effects of implicit stress mindset on proactive behavior, thus P_3 was not supported. Proactive behavior had a statistically significant positive direct effect on psychological wellbeing (P_4) and a statistically significant negative direct effect on perceived stress (P_5), as predicted. There were no statistically significant direct effects of proactive behavior on physical wellbeing (P_6) or academic performance (P_7), thus these predictions were not supported. Perceived somatic symptoms had a statistically significant negative direct effect on psychological wellbeing (P_8) and a statistically significant positive direct effect on perceived stress (P_9), as predicted. Perceived somatic symptoms had a statistically significant negative direct effect on physical wellbeing (P_{10}) and a statistically significant negative direct effect on academic performance (P_{11}), as predicted. In contrast to predictions, there were no statistically significant direct effects of stress mindset on psychological wellbeing (P_{12}) or academic performance (P_{14}). However, a significant positive direct effect of stress mindset on perceived stress (P_{13}), and physical wellbeing was found (P_{15}).

Turning to the predicted indirect effects, there was a significant positive indirect effect of stress mindset on psychological wellbeing through proactive behavior (P_{16}), as predicted. There was a significant negative indirect effect of stress mindset on perceived stress through proactive behavior (P_{17}), as predicted. There was, however, no significant indirect effect of stress mindset on physical wellbeing (P_{18}) or academic performance (P_{19}) through proactive behavior, indicating a lack of support for these predicted effects. There was a significant positive indirect effect of stress mindset on psychological wellbeing (P_{20}) and a significant negative indirect effect on perceived stress (P_{21}) through perceived somatic symptoms, as predicted. As predicted, there was a significant indirect effect of stress mindset on physical wellbeing (P_{22}) and academic performance (P_{23}) through perceived somatic symptoms.

Discussion

The purpose of the current study was to test a stress beliefs model proposing the

mechanisms by which beliefs about the consequences of stress influence physical and psychological wellbeing, perceived stress, and academic performance. The role of implicit beliefs, and explicit beliefs about the consequences of stress in this process were evaluated in young undergraduate university students. The model identified the key behavioral and physiological mechanisms by which these beliefs influence health and performance outcomes. Specifically, proactive behavior had a positive direct effect on psychological wellbeing and a negative direct effect on perceived stress but no direct effects on physical wellbeing or academic performance. Perceived general somatic symptoms had a negative direct effect on psychological and physical wellbeing and academic performance, and a positive direct effect on perceived stress. Moreover, stress mindset directly influenced perceived stress and physical wellbeing, and indirectly influenced psychological wellbeing and perceived stress via proactive behavior under stress and perceived general somatic symptoms. Further, general somatic symptoms mediated the effect of stress mindset on physical wellbeing and academic performance. Implicit stress mindset had no effect on proactive behavior, and no direct or indirect effects on outcomes.

An important contribution of the current research is the identification of key indirect pathways by which stress mindsets influence health and performance outcomes. Indirect effects of proactive behaviors and somatic symptoms mediated the effect of stress mindset on psychological wellbeing and perceived stress, suggesting that stress mindset leads to uptake of more proactive and problem-focused behaviors under stress; which, in turn, results in increased psychological wellbeing and reduced levels of perceived stress. Conversely, stress mindset leads to reports of lower perceived general somatic symptoms; which, in turn, results in higher psychological wellbeing, lower perceived stress and higher physical health. These mediation pathways provide preliminary support for the mechanisms outlined in the stress beliefs model whereby beliefs about the malleability of the stress response influence

wellbeing by exerting changes in behavioral and physiological responses to stress.

In contrast to expectations, indirect effects of stress mindset on physical wellbeing through proactive behavior was not found. Given the correlational nature of the study, it is possible that behaviors used in coping with stress had not yet resulted in an observable effect on health. Future research should therefore consider longitudinal comparisons of the effect of stress mindsets on a range of specific coping behaviors known to directly influence health to further explore the mechanism through which stress mindsets may determine physical health outcomes. Measures of health in which respondents are required to indicate their physical health over a longer period of time may be better placed to detect health effects that take some time to manifest, and future research may consider extending the follow-up period of health measures to determine long term effects of stress mindset on health outcomes.

Consistent with expectations, stress mindset was indirectly related to academic performance through perceived general somatic symptoms. This suggests that the lower subjective tension afforded by stress mindsets when under stress may be an important mechanism for the effect of mindset on academic performance. In contrast and contrary to expectations, stress mindset did not predict academic performance directly or indirectly through proactive behavior. This raises the possibility that performance outcomes in academic contexts may not be as strongly influenced by stress mindset as health outcomes. An alternative explanation is that stress mindset may represent an individual difference that affects individuals' behavior beyond their awareness, but our implicit measure was insufficiently sensitive to capture any shared variance between stress mindset and academic performance attributable to this "impulsive" pathway. Evidence that this effect may reflect an impulsive process arises from the mediation of the effect of stress mindset on academic performance by somatic symptoms, an emotional response consistent with more impulsive, non-conscious behavior.

It was expected that implicit stress mindset would have a significant direct effect on proactive behavior under stress. This prediction was based on dual-process theories of cognition (15) which postulate that observed behaviors are regulated by Type 1 (intuitive) and Type 2 (reflective) processes, with the Type 1 processes not requiring working memory and thus regulating behavior when working memory is limited such as while stressed (16). While this theoretical proposition is well suited to predicting behavior in stressful situations, our implicit stress mindset measure did not predict proactive behaviors in the current study. To speculate, we propose two explanations for the lack of effect. First, our implicit measure of stress mindset tested the speed with which participants associated *stress*-related stimuli with either *debilitating* or *enhancing* attributes. Similar to Henderson, Orbell and Hagger (48), who identified that successful past coping strategies were encoded in schematic representations of illness, behaviors previously effective in promptly reducing stress (i.e. emotion-focused strategies) may also be encoded in schematic representations of stress. Given that stress is generally labelled as a potential health threat that must be reduced or removed (5), these schematic representations, may be for the most part, incongruous to the stress mindset being measured and, thus, potentially unlikely to predict proactive coping behaviors.

Second, the implicit mindset SC-IAT used in the current study may not have been suitable. The standard SC-IAT (43) used 21 stimulus words to represent each of the two attribute categories (e.g., depleting, enriching). In the current study, the attribute categories were represented with two stimulus words: enhancing and debilitating. These stimuli may not have been sufficiently familiar compared to stimuli that represent positive/approach (e.g., good, happy) and negative/avoidance (e.g., bad, sad) attributes to adequately capture the implicit beliefs. Future research aiming to measure stress mindset implicitly should seek to use more common attribute categories and stimuli words such as in the standard test (43). Alternatively, dual-category implicit association tests (44) use a smaller range of words for

each attribute category which may help to reduce the potential for lack of familiarity with the stimuli. Further refining the measurement of these implicit beliefs will help to answer the question of whether stress mindsets do to some degree influence health and performance outcomes outside of conscious awareness, or solely through the tendency to consciously utilize a technique for interpreting the stressful response in a given moment. For example, recent research has found that techniques for reappraising the physiological arousal associated with stress and anxiety in a given moment (49-54) lead to lower perceived stress and better performance in stressful situations.

Recommendations for Future Research and Practice

The current study makes several important theoretical contributions and identifies areas for future investigation. First, stress mindset has been found to influence proactive behaviors under stress and perceived general somatic symptoms. This supports two key predictions of the stress beliefs model, and suggests that beliefs about the consequences of stress are important determinants of the choice of coping behaviors utilized when under stress, and the experience of chronic physiological stress symptoms. Second, proactive behaviors under stress and perceived general somatic symptoms emerged as mediators of the relationship between stress-is mindset and some stress-related outcomes. This is an important theoretical implication in that some of the mechanisms driving the effect of beliefs about the consequences of stress on health and performance outcomes have been identified. In addition, the effects were observed even when controlling for amount of stress and stressor severity appraisal. This suggests that the stress mindsets are an important determinant of these outcomes, regardless of how much stress a person experiences and their appraisals of the stressor, which aligns with prior research (5).

The current research also has practical ramifications for stress management. For example, future interventions aiming to manipulate stress mindsets can include information

about the malleable nature of the stress response alongside information about the enhancing properties of stress, and can also provide skills training in proactive and problem-focused coping strategies. This is important in that it has the capacity to enhance the effects of short and easily accessible non-clinical stress mindset interventions. Based on the findings of the current study, there are some specific strategies to consider when changing peoples' mindsets toward stress. First, rather than simply drawing an individual's attention toward the enhancing properties of stress, attention should be drawn to the malleable and controllable nature of the stress response in order to elicit the belief that one is in control of their personal response to stressors. Supporting this assertion, recent research has found that showing a video presenting a balanced conceptualization of stress results in more adaptive physiological outcomes under acute stress in contrast with presentation of an unbalanced-positive or unbalanced-negative conceptualization of stress (20). Second, a recent meta-analysis (55) reviewed 24 university student stress-reduction interventions; all of which required engagement in a cognitive (including mindfulness) or behavioral strategy to deal with the stress. The study found that that these interventions were effective; however, all rely on an individual consciously engaging in the strategy. Hence, a key practical implication of the current study is beliefs which underpin actual engagement in coping behaviors have been identified, which could be used to enhance the effects of coping strategies taught to individuals in future research. Finally, while a focus on imparting proactive coping strategies paired with changing beliefs about the consequences of stress is important, there is a potential gap between coping goals and coping behaviors, and a volitional component may also be useful in maximizing the influence of these beliefs on actual health and performance outcomes.

Strengths and Limitations

The current study has several strengths that enhance our understanding of how beliefs about the consequences of stress influence health and performance outcomes. First, the study

tested a novel and comprehensive stress beliefs model and revealed potential targets for future interventions aimed at reducing the effect of stress on health and performance in non-clinical populations. This is important, as many people do not seek professional support in coping with stress (4). Second, as GPA was requested directly from the university system, an objective measure of academic performance was used, which contrasts from previous studies that have tended to rely on self-report performance measures (e.g., 5). Finally, the current study evaluated the role of stress mindset in predicting health and performance outcomes in undergraduate students, a population that may be susceptible to stress (4). However, future research should also seek to test the model in other contexts and population groups as it cannot be assumed that current results will translate to individuals in stressful occupations (e.g., police, emergency workers, army personnel) or environments (e.g., floods, earthquakes, war zones).

The results of the current study must also be considered in light of some limitations. First, while the correlational design is appropriate due to the study being the first test of the stress beliefs model, the results of correlational research do not provide strong evidence of causal links between variables. Future research should seek to experimentally manipulate stress mindsets framed consistent with the SCMM that stress “can be” enhancing in order to establish causal links between these beliefs and health and performance outcomes. Second, self-reported general somatic symptoms to indicate students’ general level of physiological activation were reported. While the STICSA-T is a well validated scale that has been found to be related to cortisol in prior research (42), direct analysis of hair cortisol or other biomarkers of chronic stress would be beneficial. The current study evaluated the role of proactive behavior under stress in mediating the effect of stress mindset on health and performance outcomes but did not evaluate the role of other emotion-focused behaviors that may be used to cope when under stress in this process. Future research should further explore the causal

links between stress mindset and specific behaviors aimed at reducing tension or proactively meeting demands under stress. This would help to inform future interventions using proactive coping skills training in combination with eliciting a mindset that stress can be enhancing. While we did include amount of stress and stressor severity appraisal as covariates in the model, it may be fruitful to measure and include depression and trait anxiety as covariates in future research in order to understand whether they exert an influence on the nomological network. Finally, stress mindset is currently conceptualized as beliefs about the consequences of stress. We anticipate, however, that an understanding of how stress mindsets influence the experience of feeling of stress during stressful moments would provide further insight into how they operate and is therefore an important avenue for future research.

Conclusion

The current study tested a novel stress beliefs model which proposed that the effect of stress mindset on health and performance outcomes is mediated by proactive behavior under stress, and perceived general somatic symptoms. It was also proposed that implicit beliefs influence behaviors seeking to proactively meet demands. The study fills a significant gap in knowledge in that it begins the process of understanding the mechanisms through which beliefs about the consequences of stress, stress mindsets, affect physical and psychological wellbeing, perceived stress, and academic performance. Understanding these processes is important for maximizing the effectiveness of stress mindset interventions, which are promising due to their accessibility for non-clinical populations. While the study used a correlational design, the findings have important implications for future experimental research including interventions aimed at activating a mindset that stress can be enhancing and developing self-regulatory skills to engage in proactive coping behaviors under stress.

Availability of Data and Analysis Output

The data file and output files from all analyses can be accessed on the project website at: https://osf.io/xdvqt

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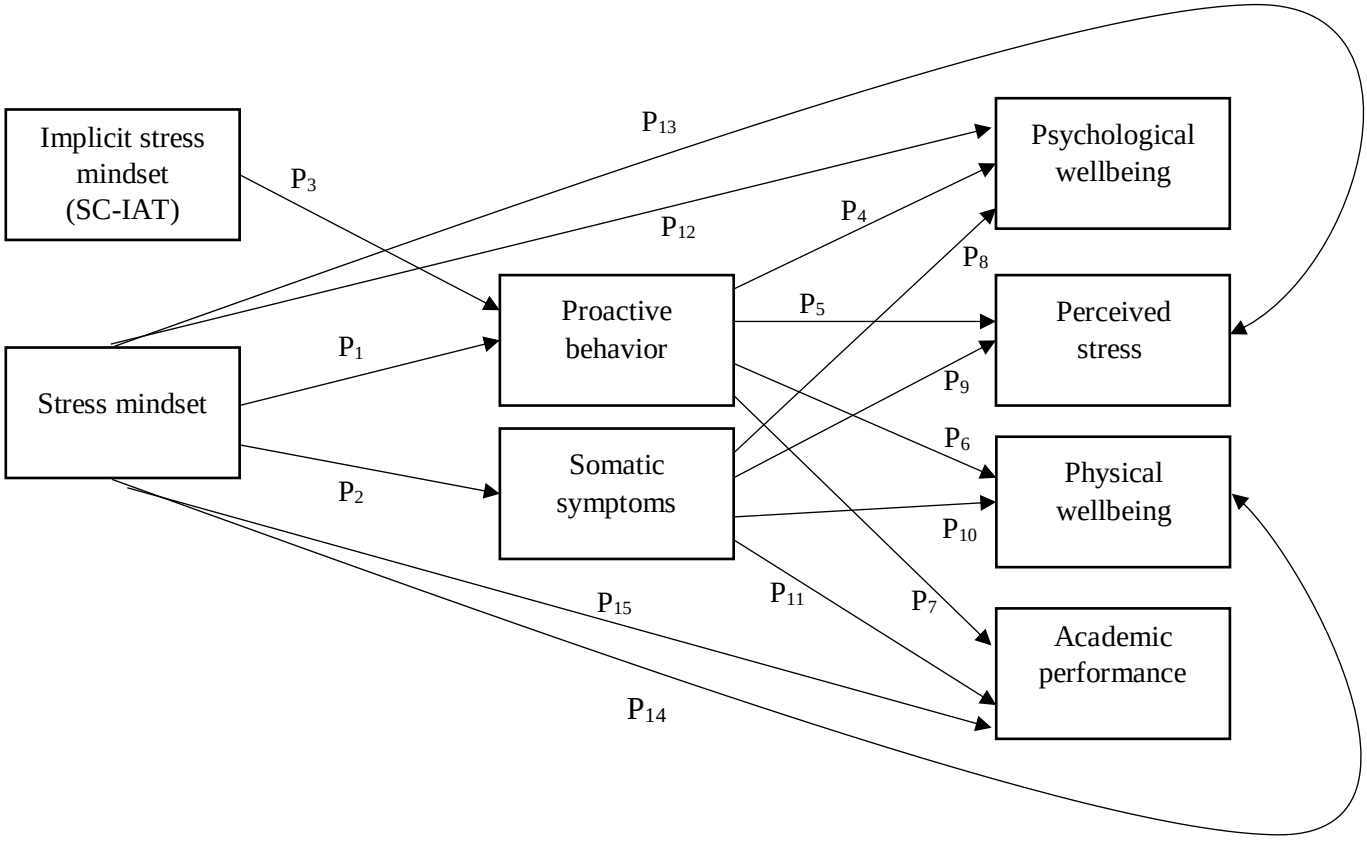


Figure 1. The hypothesized stress beliefs model.

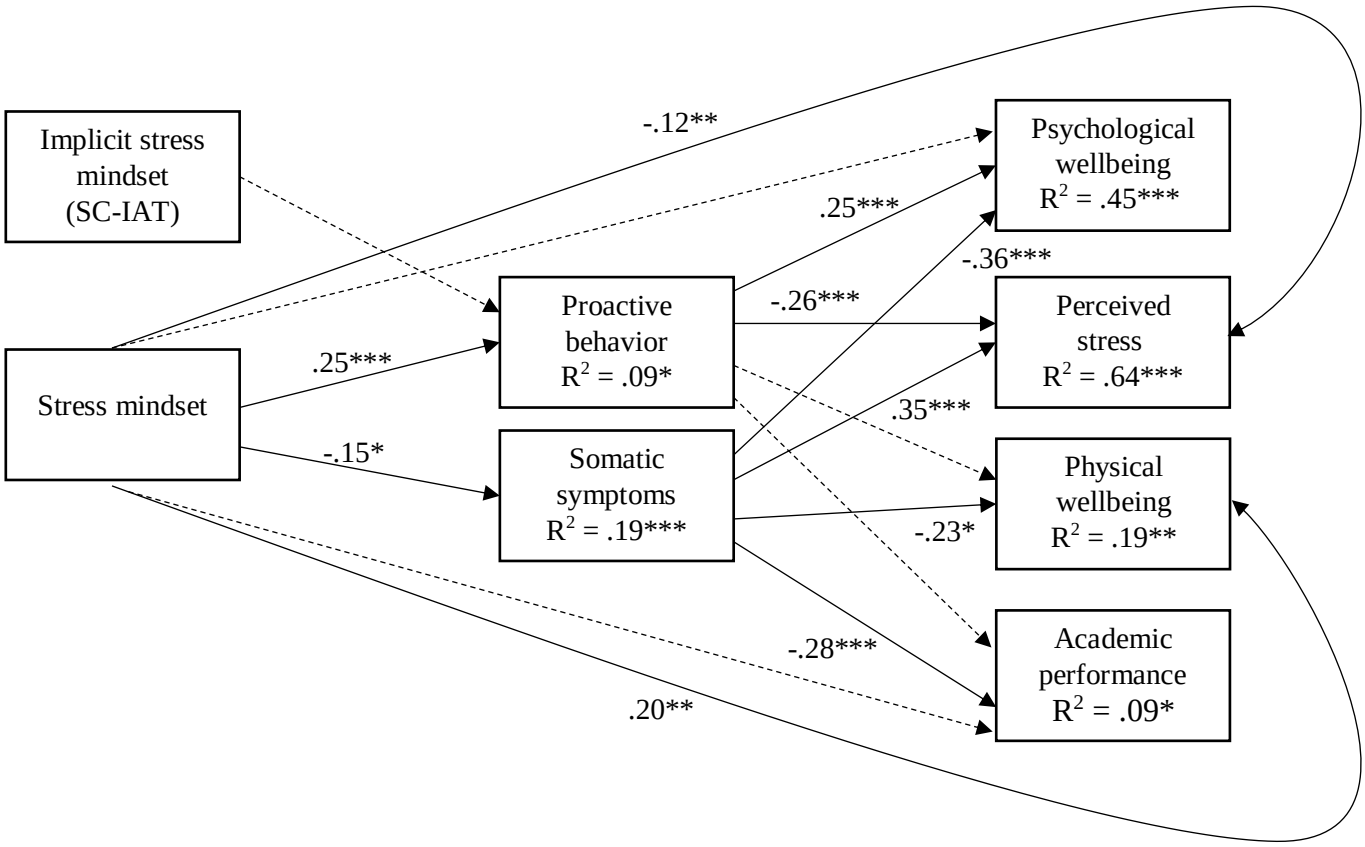


Figure 2. Standardized path coefficients for path model of hypothesized relations between stress mindset and four stress-related outcomes, mediated by proactive behavior under stress and perceived general somatic symptoms.

Note. Broken lines between constructs indicate effects proposed in the model but not found to be statistically significant. Effects of variables controlled for in the model are not included in the diagram for clarity: amount of stress → stress-is-controllable mindset, β = -.09, *p* =.30; stressor severity appraisal → stress-is-controllable mindset, β = -.18, *p* = .03; amount of stress → proactive behavior, β = -.11, *p* =.17; stressor severity appraisal → proactive behavior, β = .01, *p* = .83; amount of stress → perceived general somatic symptoms, β = .26, *p* = .001; stressor severity appraisal → perceived general somatic symptoms, β = .16, *p* = .02; amount of stress → psychological wellbeing, β = -.18, *p* = .01; stressor severity appraisal → psychological wellbeing, β = -.17, *p* = .01; amount of stress → perceived stress, β = .26, *p* = .000; stressor severity appraisal→ perceived stress, β = .22, *p* = .000; amount of stress → physical wellbeing, β = -.23, *p* = .001; stressor severity appraisal → physical wellbeing, β = .05, *p* = .47; amount of stress → academic performance, β = .14, *p* = .05; stressor severity appraisal → academic performance, β = .05, *p* = .45. *$p < .05$, **$p < .01$, ***$p < .001$

Table 1
Summary of Predicted Direct and Indirect Effects in the Proposed Stress Beliefs Model

Prediction	Independent variable	Dependent variable	Mediator(s)	Prediction[a]
Direct Effects				
P_1	Stress-is-controllable mindset	Proactive behavior	–	Effect (+)
P_2	Stress-is-controllable mindset	Perceived somatic symptoms	–	Effect (-)
P_3	Implicit stress mindset	Proactive behavior	–	Effect (+)
P_4	Proactive behavior	Psychological wellbeing	–	Effect (+)
P_5	Proactive behavior	Perceived stress	–	Effect (-)
P_6	Proactive behavior	Physical wellbeing	–	Effect (+)
P_7	Proactive behavior	Academic performance	–	Effect (+)
P_8	Perceived somatic symptoms	Psychological wellbeing	–	Effect (-)
P_9	Perceived somatic symptoms	Perceived stress	–	Effect (+)
P_{10}	Perceived somatic symptoms	Physical wellbeing	–	Effect (-)
P_{11}	Perceived somatic symptoms	Academic performance	–	Effect (-)
P_{12}	Stress-is-controllable mindset	Psychological wellbeing	–	Effect (+)
P_{13}	Stress-is-controllable mindset	Perceived stress	–	Effect (-)
P_{14}	Stress-is-controllable mindset	Physical wellbeing	–	Effect (+)
P_{15}	Stress-is-controllable mindset	Academic performance	–	Effect (+)
Indirect effects				
P_{16}	Stress-is-controllable mindset	Psychological wellbeing	Proactive behavior	Effect (+)
P_{17}	Stress-is-controllable mindset	Perceived stress	Proactive behavior	Effect (-)
P_{18}	Stress-is-controllable mindset	Physical wellbeing	Proactive behavior	Effect (+)
P_{19}	Stress-is-controllable mindset	Academic performance	Proactive behavior	Effect (+)
P_{20}	Stress-is-controllable mindset	Psychological wellbeing	Perceived somatic symptoms	Effect (+)
P_{21}	Stress-is-controllable mindset	Perceived stress	Perceived somatic symptoms	Effect (-)
P_{22}	Stress-is-controllable mindset	Physical wellbeing	Perceived somatic symptoms	Effect (+)
P_{23}	Stress-is-controllable mindset	Academic performance	Perceived somatic symptoms	Effect (+)

Note. [a]Denotes whether the hypothesis specifies a positive (+) effect, a negative (–) effect, or no effect.

Table 2
Composition of the Stress Mindset Single Category Implicit Association Test (SC-IAT)

Block	Trials	Function	Left-key response	Right key response
1	24	Practice	Enhancing words + stress words	Debilitating words
2	72	Test	Enhancing words + stress words	Debilitating words
3	24	Practice	Enhancing words	Debilitating words + stress words
4	72	Test	Enhancing words	Debilitating words + stress words

Table 3

Observed Pearson Correlations and Descriptive Statistics for Study Variables and Covariates in the Stress Beliefs Model

Variable		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	Psychological wellbeing	-									
2.	Perceived stress	-.77***	-								
3.	Physical wellbeing	.31***	-.28***	-							
4.	Academic performance	.11	-.16*	.02	-						
5.	Proactive behavior	.38***	-.42***	.03	.12	-					
6.	Perceived general somatic symptoms	-.54***	.60***	-.33***	-.24***	-.19**	-				
7.	Stress-is-controllable mindset	.27***	-.38***	.26***	.12	.27***	-.24***	-			
8.	Implicit stress mindset	-.07	.01	-.01	-.02	.06	.01	-.00	-		
9.	Amount of stress	-.46***	.58***	-.31***	.03	-.16*	.38***	-.20**	-.09	-	
10.	Stressor severity appraisal	-.43***	.55***	-.21**	.01	-.11	.35***	-.24***	.01	.59***	-
	M	44.45	20.04	25.28	4.98	2.93	19.63	3.28	-.30	4.52	5.45
	SD	9.44	6.31	5.49	1.05	.66	6.09	.81	.33	1.15	1.23
	Minimum	19	6	0	1.50	1	11	1.13	-1.01	1	1
	Maximum	67	34	30	7	4.33	41	5.07	.61	7	7
	Skew	-1.67	-.62	-13.61	-2.05	-2.61	4.89	-1.33	1.04	-2.27	-4.89
	Kurtosis	-1.03	-2.28	18.75	1.26	.07	.58	-1.17	-.23	.81	3.02

Note: *$p < .05$. **$p < .01$. ***$p < .001$. Skew = ratio of skewness to skewness standard error. Kurtosis = ratio of kurtosis to kurtosis standard error. Scale ranges: 1. [1] *none of the time* to [5] *all of the time* (responses summed; possible range 14 to 70); 2. [0] *never* to [4] *very often* (responses summed; possible range 0 to 40); 3. [0] to [30] healthy days; 4. [1] to [7] grade point average; 5. [1] *never* to [5] *very often*; 6. [1] *almost never* to [4] *almost always* (responses summed; possible range 0 to 44); 7. [1] *strongly disagree* to [6] *strongly agree*; 8. [-2] *debilitating orientation* to [2] *enhancing orientation*; 9. [1] *no stress* to [7] *an extreme amount of stress*; 10. [1] *not at all stressful* to [7] *extremely stressful*

Table 4
Summary of Standardized Path Coefficients and 95% Bias-Corrected Bootstrapped Confidence Intervals

Prediction	Paths	β	*p*	95% CI
Direct				
P_1	Stress-is-controllable mindset → Proactive behaviour*	.25	.000	[.10, .38]
P_2	Stress-is-controllable mindset → Perceived somatic symptoms*	-.15	.03	[-.28, -.02]
P_3	Implicit stress mindset → Proactive behavior	.06	.34	[-.06, .18]
P_4	Proactive behavior → Psychological wellbeing*	.25	.000	[.14, .36]
P_5	Proactive behavior → Perceived stress*	-.26	.000	[-.34, -.18]
P_6	Proactive behavior → Physical wellbeing	-.09	.14	[-.22, .03]
P_7	Proactive behavior → Academic performance	.08	.28	[-.06, .22]
P_8	Perceived somatic symptoms → Psychological wellbeing*	-.38	.000	[-.48, -.22]
P_9	Perceived somatic symptoms → Perceived stress*	.35	.000	[.26, .44]
P_{10}	Perceived somatic symptoms → Physical wellbeing*	-.23	.01	[-.41, -.05]
P_{11}	Perceived somatic symptoms → Academic performance*	-.28	.000	[-.40, -.13]
P_{12}	Stress-is-controllable mindset → Psychological wellbeing	.04	.50	[-.07, .15]
P_{13}	Stress-is-controllable mindset → Perceived stress*	-.12	.01	[-.21, -.03]
P_{14}	Stress-is-controllable mindset → Physical wellbeing*	.20	.01	[.06, .33]
P_{15}	Stress-is-controllable mindset → Academic performance	.07	.29	[-.06, .21]
Indirect via Proactive Behaviour				
P_{16}	Stress-is-controllable mindset → Psychological wellbeing*	.06	.01	[.02, .12]
P_{17}	Stress-is-controllable mindset → Perceived stress*	-.07	.004	[-.12, -.03]
P_{18}	Stress-is-controllable mindset → Physical wellbeing	-.02	.18	[-.07, .00]
P_{19}	Stress-is-controllable mindset → Academic performance	.02	.32	[-.01, .07]
Indirect via Perceived Somatic Symptoms				
P_{20}	Stress-is-controllable mindset → Psychological wellbeing*	.05	.04	[.01, .11]
P_{21}	Stress-is-controllable mindset → Perceived stress*	-.05	.04	[-.11, -.01]
P_{22}	Stress-is-controllable mindset → Physical wellbeing*	.04	.10	[.01, .09]
P_{23}	Stress-is-controllable mindset → Academic performance*	.04	.06	[.01, .10]

Electronic Supplementary Material 1

Stress Control Mindset Measure (SCMM) Validity Additional Information

An exploratory factor analysis was initially conducted to explore the factor structure of the SCMM. This indicated that there was a measurement artefact occurring due to the reverse worded items. A confirmatory factor analysis was then conducted to test the hypothesized 4-factor structure that the measure had been conceptualized around, controlling for the measurement artefact by creating a latent variable to account for the error variance attributed to the reverse coded items. The four factors were stress mindset in the context of performance and productivity, learning and growth, health and vitality, and the consequences of stress generally. In addition to the variables included in the nomological network, the Stress Mindset Measure (General and Specific versions) was also administered (5) for the purposes of determining validity of the SCMM. An additional confirmatory factor analysis was conducted to assess discriminant validity of the SCMM with conceptually-related constructs including stress mindset (Stress Mindset Measure General and Specific versions; 5), perceived stress (PSS-10; 38), and psychological well-being (WEMWBS; 32). Bagozzi and Kimmel (56) suggest that discriminant validity is supported if the factor correlation between two constructs is significantly different from unity. They suggest that a significant difference from unity and discriminant validity is supported if the factor correlation between two constructs is less than 1 minus 1.96 multiplied by the standard error of the correlation. We also employed an alternative approach by assessing whether the 95% CI about the latent correlation between two constructs includes unity. If the CIs do not encompass 1, there is evidence for discriminant validity (57, 58). Discriminant validity of the SCMM with measures of stress, well-being and stressor specific stress mindset (Stress Mindset Measure-Specific) was supported, with latent factor correlations ranging from $r = .12$, $p > .05$, 95% CI [-.26, .02] (amount of stress) to $r = .68$, $p < .001$, 95% CI [.57, .78] (stress mindset measure-specific). Preliminary support for discriminant validity between the SCMM and Stress Mindset Measure-General was indicated as the latent correlation between the two factors was significantly different from unity 95% CI [.87, .97], however, the high latent correlation indicates a large degree of crossover between the two constructs, $r = .92$, $p < .001$. Full results of factor analyses of the SCMM, items included in the SCMM, and goodness-of-fit and validity statistics (5) are available on the project website: https://osf.io/xdvqt

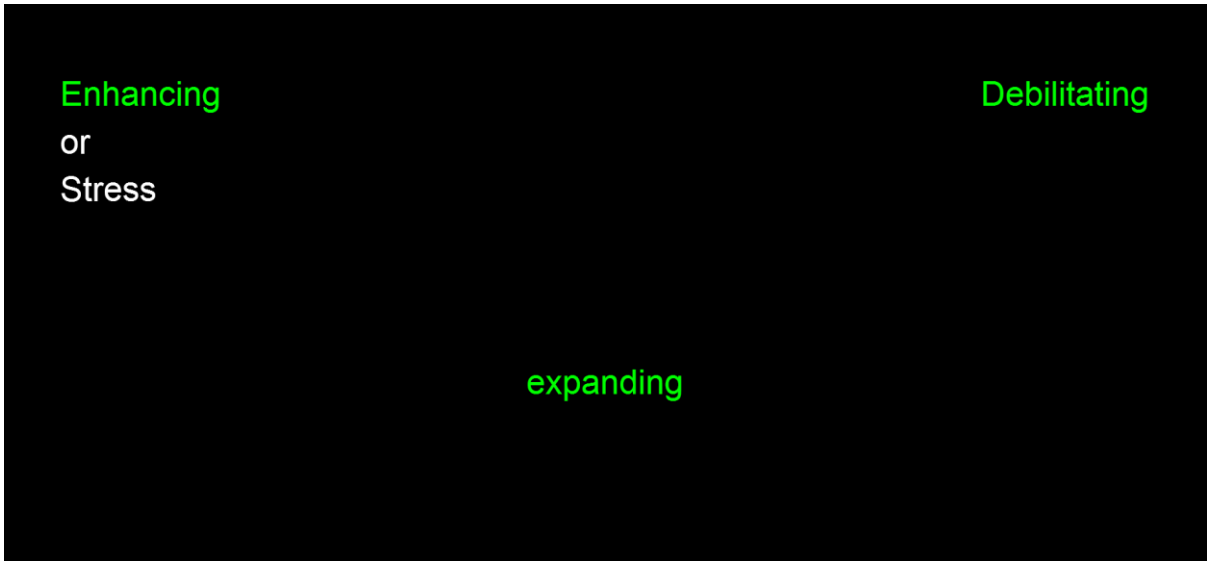
Electronic Supplementary Material 2

Stress Mindset SC-IAT (Single Category Implicit Association Test) Stimuli Words

Enhancing	**Debilitating**
Positive	Crippling
Strengthening	Incapacitating
Developing	Devastating
Enriching	Disabling
Expanding	Immobilising
Elevating	Depleting
Energising	Harmful
Boosting	Negative
Healthy	Useless
Improving	Failing
Growing	Exhausting
Inspiring	Inhibiting
Stimulating	Draining
Heightening	Unhealthy
Thriving	Fatiguing
Vitalising	Diminishing
Flourishing	Devitalising
Beneficial	Dysfunctional
Advancing	Limiting
Productive	Unhelpful
Helpful	Restricting

Stress
Stressful
Stressed
Stressor
Pressure
Burden
Tension
Tense

Round 1 and 2 (Compatible Trials) – Screenshot from SC-IAT



Round 3 and 4 (Incompatible Trials) – Screenshot from SC-IAT