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Changing Stress Mindsets With a Novel Imagery Intervention: A Randomized Controlled Trial

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Changing individuals' stress mindset has emerged as a technique that may be effective in aiding stress management, but there is limited data on the effects of this technique in managing stress in "real-world" contexts beyond a few days. This study aimed to (a) evaluate the efficacy of a novel imagery-based intervention in changing stress mindset and (b) evaluate the effect of the intervention on stress-related outcomes, compared to a control, after 2 weeks. The study adopted a preregistered randomized controlled trial design. University students ($N = 150$) attended a research laboratory twice over 2 weeks, receiving the intervention or control condition stimuli in Session 1, and completing measures in both sessions. Academic performance data was collected from university records. Mixed model ANOVAs revealed a large-sized difference in stress mindset among intervention group participants immediately following the intervention and at the follow-up relative to controls. There were also robust effects of the intervention on perceived distress, positive and negative affect, proactive behavior, and academic performance at the follow-up in individuals with high baseline perceived distress, although not in the whole sample. Findings indicate that the intervention is a promising approach for changing individuals' stress mindset and that changing stress mindset can have beneficial effects on coping with ecological stressors. Future research should use intensive longitudinal designs to examine momentary activation of stress mindset and responses to ecological stress.

Keywords: stress, implicit theories, coping, mental imagery, experiment

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Stress is defined as the feeling of tension that is experienced when an external event or stressor is perceived as outweighing one's capacity to cope afforded by personal resources (Lazarus & Launier, 1978; Lovallo, 2015). In developed nations such as the United States and Australia, high levels of stress are commonly reported among university students (American College Health Association, 2017; Casey, 2014). Due to the impact of stress on both physical and psychological health (Cohen, Murphy, & Prather, 2019), and considering that just 13% of Australians report seeking professional assistance in dealing with stress (Casey, 2014), exploring targets for nonclinical interventions to aid stress management is a research priority. One potential area for nonclinical intervention is changing individuals' stress mindsets.

Mindsets, otherwise known as "implicit" theories, refer to individuals' beliefs about the malleability of personal qualities, serving as a mental lens through which people judge the meaning of life events (Dweck, Chiu, & Hong, 1995; Yeager & Dweck, 2012). Crum, Salovey, and Achor (2013) applied the mindset concept to stress research, finding that stress mindset is related to important stress-related outcomes and distinct from other variables in the stress process, such as amount of stress and stressor appraisal. Stress mindset refers to a set of beliefs held by individuals about the consequences of experiencing stress (Crum et al., 2013; Keech & Hamilton, 2019). This includes holding the belief that stress can have enhancing consequences for learning and growth, performance and productivity, and health and vitality, which has been associated with more adaptive outcomes under stress (Crum et al., 2013). This contrasts with holding

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the belief that stress has debilitating consequences, which is associated with poorer outcomes.

Experimental and correlational studies have observed effects of stress mindset on physical and psychological well-being, coping behaviors, and affective outcomes in response to laboratory stressor tasks and ecological stress over short periods of time. For example, in an experimental study examining the influence of stress mindset on a range of outcomes in response to a laboratory stressor, Crum, Akinola, Martin, and Fath (2017) found that those who were primed with information about the positive consequences of stress exhibited greater positive but not negative affect in anticipation of and following the stressor. Other studies examining the association between stress mindset and health and performance outcomes have shown that those who endorsed a stress-is-enhancing mindset had improved coping behaviors, greater perceived physical health and well-being, and better academic performance when experiencing ecological stressors (Casper, Sonnentag, & Tremmel, 2017; Keech, Hagger, O'Callaghan, & Hamilton, 2018).

While these studies indicate that stress mindset influences positive outcomes when elicited prior to laboratory-induced stressors and is associated with ecological stressors over a short period of time, it is unclear whether these effects on stress mindset endure beyond these short follow-up periods and whether effects on stress-related outcomes are meaningful in the context of ecological stress over longer periods of time. To advance understanding of how stress mindsets can be leveraged to promote more adaptive responses to stress, it is important to investigate intervention effects in response to ecological stressors over a longer period of time and to use stronger intervention approaches aimed at strengthening these effects.

Interventions to Change Stress Mindsets

To date, stress mindset interventions have predominately used informational videos aiming to bias attention toward either the enhancing or debilitating properties of stress in separate experimental conditions. For example, Crum et al. (2013, 2017) used informational videos that presented stress in either strictly stress-is-enhancing or strictly stress-is-debilitating conditions. These polarized fixed presentations of stress contrast with the nuanced view of stress that was theorized by Crum et al. (2013) as being of value and also with mindset theory more broadly, which posits the distinction in mindsets about fundamental attributes to be based on beliefs about the malleability of the attribute (Job, Dweck, & Walton, 2010; Yeager & Dweck, 2012). More recent research has also found that presenting the balanced consequences of stress using informational videos resulted in significantly decreased heart rates and diastolic blood pressure after a lab-induced stressor compared to videos outlining only positive or negative consequences of stress (Liu, Vickers, Reed, & Hadad, 2017). We therefore contend that interventions aimed at encouraging more adaptive stress mindsets should present that stress "can be" rather than "is" enhancing.

Adopting this view, Keech et al. (2018) tested a stress beliefs model that identified mechanisms through which stress mindset influences outcomes (such as proactive coping behaviors under stress) and suggested that it may be beneficial to intervene upon both stress mindset and proactive coping behavior to strengthen intervention effects. Mental imagery interventions facilitate the process of representing and rehearsing future actions and consequences (Conroy & Hagger, 2018; Kavanagh, Andrade, & May, 2005; Pham & Taylor, 1999), and Conroy and Hagger (2018) provide meta-analytic evidence supporting effects of these interventions on belief-informed constructs and behaviors and that they are effective even in interventions with relatively low intensity.

Mental imagery is also an effective means of rehearsing and instilling psychological states, which in turn influence behavior, with interventions of this nature being successfully applied to increasing self-efficacy (Weibull, Cumming, Cooley, Williams, & Burns, 2015), increasing motivation (Vasquez & Buehler, 2007), reducing fear of reinjury in injury rehabilitation (Multhaupt & Beuth, 2018), and improving affective responses to exercise (Stanley & Cumming, 2010). Similar to observational learning, mental rehearsal may also stimulate neural networks related to what is being imagined, making them salient and accessible for when the individual finds themselves in a similar situation and having a resultant nonconscious influence on behavior in that later situation (Conroy & Hagger, 2018; Kosslyn & Moulton, 2009). This is particularly relevant to interventions aiming to aid individuals in stress management, because dual-process theories of cognition and behavior (Evans, 2008; Evans & Stanovich, 2013; Strack & Deutsch, 2004) suggest that implicit nonconscious processes are likely to regulate behavior when working memory is limited (Evans & Stanovich, 2013), such as when under stress (Banks & Boals, 2017). Mental imagery may therefore be particularly suited to intervening upon stress mindset and proactive coping behavior simultaneously. The mental imagery technique differs from other visualization-based strategies such as mental contrasting and implementation intentions (Gollwitzer, 1999) in that the former instructs explicitly comparing current and future (fantasized) states (Oettingen et al., 2009) and the latter instructs the development of concrete "if–then" plans to be evoked in particular situations, while the mental imagery intervention process usually comprises self-directed imagining of specific events or actions with the purpose of increasing motivation toward the target action (Conroy & Hagger, 2018).

The Current Study

The aim of the current preregistered study was (a) to evaluate the effect of a novel mental imagery-based intervention in changing university students' stress mindsets and (b) to evaluate the effect of the intervention on stress-related outcomes, immediately postintervention and after 2 weeks, compared to a control condition. University students from a large Australian university were selected as the target sample for this study because high levels of distress have been observed in large studies of students in Australia (Larcombe et al., 2016) and the prevalence of psychological distress in students in Australia is greater than their nonstudent peers (Stallman, 2010). Further, in our previous study, which sampled students from the same university (Keech et al., 2018), mean perceived distress scores were considerably higher than norms for the perceived stress scale in young adults (Cohen & Williamson, 1988). We therefore considered this to be a vulnerable population and expected that all individuals would experience at least some benefit from the intervention. In contrast with using a laboratory stressor, the 2-week period between intervention and follow-up occurred during a university term, and participants navigated their own ecological stressors in this time. The 2-week follow-up period was determined based on three key factors. First, there is meta-analytic evidence of a dose effect of mental imagery interventions and specifically that effects can decline over time and that boosters may be required over longer periods (Conroy & Hagger, 2018). Second, the longest follow-up period for a stress mindset manipulation in the published literature is 3 days (Crum et al., 2013). We aimed to extend the follow-up period in a modest way to develop an understanding of whether stress mindset can be influenced over a longer period of time. Finally, effects of stress mindset manipulations have been observed on affective, psychological, some behavioral outcomes, and health symptoms over short periods of time (e.g., Crum et al., 2013, 2017). Again, we sought to extend the follow-up period in a modest way in examining the impact of the intervention on these outcomes.

Preregistered Hypotheses

Nine preregistered hypotheses were tested in the current study. First, it was hypothesized that participants in the intervention condition would experience significantly higher stress mindset scores relative to participants in the control condition (a) immediately postintervention and (b) at the follow-up 2 weeks later (H_1). Turning to the secondary outcomes, it was hypothesized that participants in the intervention condition would experience significantly lower perceived distress (H_2), higher psychological well-being (H_3), higher positive affect (H_{4a}), lower negative affect (H_{4b}), higher perceived physical health (H_5), higher proactive behavior (H_6), lower perceived somatic symptoms (H_7), higher academic performance (H_8), and higher academic engagement (H_9), relative to participants in the control condition from baseline to the 2-week follow-up.

Theory-Guided Hypotheses

After conducting the preregistered analyses and observing nonsignificant effects of the intervention on the secondary outcomes for the overall sample, we consulted theory to guide further analyses. Specifically, the wise interventions framework provides a theoretical framework for testing interventions that target psychological processes (Walton, 2014; Walton & Wilson, 2018). Consistent with Park et al. (2018), who found that stress mindset moderated the effect of stressful life events on perceived distress, a key vulnerability mechanism targeted by the current intervention was the influence of stressors on distress. However, in the situation that an individual is coping well and not experiencing a considerable level of distress in the presence of a stressor, they may experience little benefit from a wise intervention targeting this stressor to distress process. A similar issue was encountered by Yeager, Lee, and Jamieson (2016), where the wise intervention being tested was hypothesized to moderate the relationship between daily social-evaluative stressors and neuroendocrine indicators of the stress response, but on some days of the intervention period a relationship between the stressors and the neuroendocrine indicators was not observed. The effect of their intervention was therefore tested for the days where this relationship was observed, and a strong effect of the intervention was found by Yeager et al. (2016).

Guided by the theory and empirical studies outlined above, we developed further hypotheses to examine whether those with high baseline perceived distress experienced greater benefits from the intervention than those with low baseline perceived distress. Specifically, it was hypothesized that changes in stress mindset across time would be greater in those with high baseline perceived distress. Turning to the secondary outcomes, we also hypothesized that those with high baseline perceived distress would experience greater reductions in perceived distress, increases in psychological well-being and positive affect, decreases in negative affect, increases in perceived physical health and proactive behavior, decreases in perceived somatic symptoms, and increases in academic performance and academic engagement over time when exposed to the intervention than those with low baseline perceived distress.

Method

The study has been reported in accordance with the CONSORT 2010 checklist for reporting randomized trials (Schulz, Altman, Moher, & the CONSORT Group, 2010).

Participants

Participants were young undergraduate university students (N = 150, 64% female) ranging in age from 17 to 25 years (M = 19.11, SD = 1.94) recruited from a major university in South East Queensland, Australia (see Section A in the online supplementary material for sample demographic characteristics). Participants were recruited through online advertisement, including a university participant pool. Eligibility criteria included age (17–25 years) and current registration as an undergraduate university student. Students received course credit or coffee and department store vouchers as a token of appreciation for their participation.

An a priori power analysis was conducted using G*Power v3.1 for a mixed model ANOVA estimating fixed effects, main effects, and interactions. The effect size was set to detect a medium effect (f = .25), with power set to .95 and α = .01 (adjusted to protect from inflation of Type I error rate due to multiple tests). The total minimum sample size required was n = 90 (45 participants in each condition). To allow for 40% attrition, the target sample size was 150 participants at the baseline. A stopping rule was used to govern when to cease recruitment.[1]

Design and Procedure

The study was preregistered prior to data collection on the Open Science Framework: https://osf.io/en7q8/. The Griffith University Human Research Ethics Committee approved the study (Reference: 2018/019). Data were collected between July and October 2018. Participants visited a university laboratory for two sessions, 2 weeks apart. In Session 1, participants received study information and provided informed consent, and then completed baseline measures of study variables followed by the intervention or control condition material. Stress mindset was also measured immediately

[1] Online participant sign-up slots were posted as far in advance as possible for the duration of the study term. Once 100 participants had completed the follow-up survey (to allow for some exclusions due to careless responding), sign-up slots were closed so that no participant could be further booked in to attend and face-to-face and online recruitment ceased. Data collection continued until all participants already signed-up had participated in the study.

postintervention. In Session 2, participants completed follow-up measures. See Figure 1 for full details of the study structure and Section B (online supplementary material) for the flow of participants through the study. The study adopted a parallel two-group mixed (within-between) randomized controlled design. The study was double-blinded such that both the participant and the experimenter were blinded to the condition to which participants were assigned. The experimenter followed a standardized script and procedure in administering the study to minimize bias. The study was advertised as a study on "understanding beliefs about stress and mental imagery," given that both groups complete a mental imagery task and answer questions about their beliefs about stress. No unintended consequences, harms, or adverse events were reported in the course of the study and there were no deviations from the preregistered protocol. For further details of the study design and procedure, see the study preregistration (https://osf.io/en7q8/).

Intervention development and optimization. The intervention materials were developed based on examples and mechanisms identified in our prior research (Keech et al., 2018); the three domains of stress mindset (performance and productivity, health and vitality, and learning and growth; Crum et al., 2013); and best-practice techniques for mental imagery interventions (Conroy & Hagger, 2018; Hamilton, Keech, Peden, & Hagger, 2019). Prior to recording, the imagery scripts were reviewed by a panel of experts, and by two members of the target population. Based on initial expert and member feedback, refinements to script wording were made. The scripts were then audio-recorded using a voiceover actor and developed into multimedia videos. The videos then underwent further expert review and a rigorous pilot test with members of the target population based on the procedures outlined by Hamilton et al. (2019). The pilot involved participants ($n = 8$) completing the baseline survey, the intervention, the postintervention survey, and then a semistructured interview where they were asked broadly to share their thoughts and feedback regarding the imagery exercise. The pilot participants were also asked for specific information regarding clarity and timing of the imagery exercises and information presented in the videos. Based on qualitative feedback provided by pilot participants, data-driven refinements to the presentation and timing allocated to the exercises were made. Intervention and control condition videos, scripts, and materials can be accessed on the Open Science Framework: https://osf.io/3rz7n/.

Intervention condition. Participants in the intervention condition watched a series of videos and then completed a writing exercise as outlined in Figure 1. Part 1 was a brief introduction to the activity. Part 2 provided balanced (negative and positive) information about stress and the consequences of stress. Part 3 was a practice imagery exercise entitled the "tangy lemon" mental imagery task (Holmes & Mathews, 2005). The purpose of this task was to introduce participants to imagery and allow them to practice prior to the following exercise. Part 4 began with some examples of the positive consequences of stress with regard to six types of stressors identified by students in our prior study (Keech et al., 2018). Part 4 then instructed a process mental imagery exercise, where participants were instructed to think about the potential positive consequences of the stress in their life, and the things they can do to experience these positive consequences. Following this exercise, participants were asked to write down the things that they imagined in the space provided.

Control condition. Participants in the no instruction control condition completed the "tangy lemon" mental imagery task. This was the same as the practice mental imagery task completed by the intervention group.

Randomization. Simple randomization was used with each participant being randomized into to one of two groups. The randomization was conducted by the Qualtrics randomization feature following completion of the preintervention survey. The Qualtrics randomization feature uses a Mersenne Twister pseudorandom number generator, which is seeded using a Unix timestamp (in milliseconds).

Measures

Stress mindset was measured at baseline, immediately postintervention, and at the 2-week follow-up. All other variables were measured at baseline and at the follow-up. See Section C (in the online supplementary material) for details of all measures used in the study.

Stress mindset. Stress mindset was measured using the 15-item Stress Control Mindset Measure (SCMM; Keech et al., 2018).

Perceived distress. Perceived distress was measured using the 10-item Perceived Stress Scale (PSS-10; Cohen & Williamson, 1988), which measures the extent to which current life situations were perceived as stressful over the preceding 2 weeks.

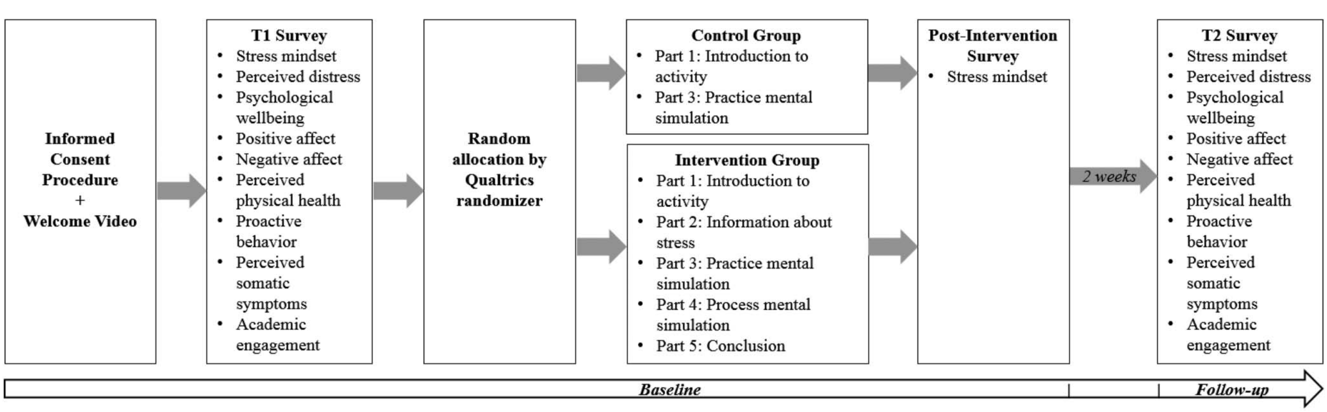

Figure 1. Randomized controlled trial design.

Psychological well-being. Psychological well-being was measured using the 14-item Warwick-Edinburgh Mental Well-Being Scale (WEMWBS-14; Tennant et al., 2007), which measured the extent to which people generally experienced well-being states over the past 2 weeks.

Affect. Positive and negative affect was measured using the 20-item Positive and Negative Affect Schedule-Short Form (PANAS-SF; Watson, Clark, & Tellegen, 1988), modified to reference the past 2 weeks.

Perceived physical health. Perceived physical health was measured using a single item, which was the first question from the CDC Health-Related Quality of Life (HRQOL-14; Centers for Disease Control & Prevention, 2000) Healthy Days measure, modified to reference the past 2 weeks.

Proactive behavior. Proactive behavior was measured using the six-item Proactive Under Stress Scale (Keech et al., 2018), modified to reference the past 2 weeks.

Perceived somatic symptoms. Perceived somatic symptoms was measured using the State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree, French, MacLeod, & Locke, 2008) somatic subscale (11 items) as a proxy measure for elevation in sympathetic nervous system activation (consistent with Keech et al., 2018). However, rather than in general, the questions were modified to reference the past 2 weeks for this study.

Academic performance. Academic performance was measured using participants' term grade point average (GPA) for the term prior to participating in the intervention (considered preintervention academic performance), and at the end of the term in which participation occurred (considered postintervention academic performance). Academic terms were 12 weeks in length and, therefore, for practical reasons academic performance was measured on a different scale of time to the other outcome measures. GPA was retrieved from the university system to objectively measure academic performance.

Academic engagement. Academic engagement was measured using the 17-item Utrecht Work Engagement Scale-Student (UWES-S; Schaufeli, Salanova, González-Romá, & Bakker, 2002), modified to reference the past 2 weeks.

Baseline participant characteristics. A range of participant characteristics were measured at the baseline to examine variability between the groups: gender, age, marital status, children, study load, employment status, work hours, personal income, English as a second language (ESL), domestic/international student status, and imagery ability.

Data quality questions. Four questions were used to detect careless responding (Maniaci & Rogge, 2014; Schroder, Dawood, Yalch, Donnellan, & Moser, 2016), with two used in the questionnaire in each session (e.g., "Please select option two to ensure you are paying attention"). The eight participants who did not answer all four of the questions correctly were excluded prior to data analysis. Visual inspection of the data supported the decision to exclude, with evidence of inattentive responding.

Preregistered Data Analysis Plan

The effect of the intervention on stress mindset was evaluated using a 2 × 3 mixed model ANOVA in SPSS v.25. Condition/group was the between-subjects independent variable; time (preintervention, immediately postintervention, 2-week follow-up) was the within-subjects variable; and stress mindset was the dependent variable. The effect of the intervention on the stress-related outcomes was evaluated using a series of 2 × 2 mixed model ANOVAs.[2] Condition/group was the between-participants independent variable; time (preintervention, immediately postintervention, 2-week follow-up) was the within-participants variable; and the stress-related outcomes (psychological well-being, perceived distress, positive and negative affect, perceived physical health, proactive behavior, perceived somatic symptoms, academic performance, and academic engagement) were separate dependent variables. Alpha level for inference was adjusted to $\alpha = .01$ to protect from inflation of Type I error rate due to multiple tests. Where an ANOVA indicated a Significant Time × Group interaction for any of the outcome variables, simple effects analyses using estimated marginal means were examined for that outcome. Specifically, within-group differences in the outcome between time points, and between-group differences in the outcome at each time point were compared. Outliers were retained due to no scores falling outside the possible range.

Theory-Guided Data Analysis Procedure

To understand individual differences in response to the intervention, and in order to aid in hypothesis generation for future research, a series of analyses guided by the wise interventions framework (Walton, 2014; Walton & Wilson, 2018) were conducted. It was expected that participants not experiencing a considerable amount of perceived distress may already be experiencing positive well-being states and, therefore, would be less likely to need to reconsider their beliefs about stress and in turn less likely to experience the same degree of change in stress-related outcomes as those experiencing higher stress. The overall sample was divided into two subgroups using the median of participants' baseline perceived distress scores. Those with a score less than 20 formed the "low perceived distress" subgroup and those with perceived distress scores greater than or equal to 20 formed the "high perceived distress" subgroup. A series of 2 × 2 × 2 mixed model ANOVAs were run to test all theory-guided hypotheses, with a 2 × 2 × 3 configuration used when stress mindset was the dependent variable. Interaction effects were followed-up with simple effects analyses using estimated marginal means, and $\alpha = .05$ was used as the threshold for statistical significance.

Results

Preregistered Analyses

Aside from the three participants who were lost to follow-up, there were no missing data on any of the study variables except for academic performance. The extent of missing data for academic performance was 19% (27 cases) at the baseline and 4% (six cases)

[2] A 2 × 3 mixed model ANOVA was used to evaluate the effect of the intervention on stress mindset because stress mindset was able to be measured at three time points. Measures of all other outcomes were referenced to the past 2 weeks and could not be measured both preintervention and immediately postintervention, as this would occur in a single session. Therefore, the effect of the intervention on these outcomes was evaluated using 2 × 2 mixed model ANOVAs.

at the follow-up. Little's test indicated that the academic performance data was not missing completely at random and therefore E-M imputation was not implemented and listwise deletion was used for analyses using academic performance (see Footnote 5 for ancillary regression analyses using the full-information maximum likelihood [FIML] procedure). All preregistered hypotheses were tested using $\alpha = .01$ adjusted to protect against error inflation due to multiple tests. Estimated marginal means, standard errors, and 99% confidence intervals of study variables by time and group are reported in Table 1. Estimated marginal means are graphically presented in Figure 2 for stress mindset and Section D (online supplementary materials) for secondary outcomes. Data and output files for all analyses can be accessed on the Open Science Framework (https://osf.io/3rz7n/).

Stress mindset. A mixed model ANOVA revealed a statistically significant Time × Group interaction effect on stress mindset with a large effect size, $F(1.59, 217.64) = 51.44$, $p < .001$, $\eta_p^2 = .27$.[3] This indicates that changes in stress mindset across time points were not equivalent between groups and provides support for Hypothesis 1. To probe the interaction effect, simple effects were examined. There was no significant difference between the intervention and control groups at the baseline ($p = .583$, $\eta_p^2 = .00$) and the control group did not change over time. However, stress mindset was significantly higher for the intervention group compared to the control group immediately postintervention ($p < .001$, $\eta_p^2 = .26$) and at the 2-week follow-up ($p < .001$, $\eta_p^2 = .18$). Stress mindset scores increased significantly for the intervention group from preintervention to immediately postintervention ($p < .001$, $\eta_p^2 = .18$). Stress mindset decreased significantly between the measure immediately postintervention and the follow-up; however, the effect size remained large and at a level still significantly greater than preintervention.

Secondary outcomes. Turning to the secondary outcomes,[4] mixed model ANOVAs revealed no statistically significant Time × Group interaction effects on perceived distress, $F(1, 137) = 9.75$, $p = .472$, $\eta_p^2 = .00$ psychological well-being, $F(1, 137) = .00$, $p = .993$, $\eta_p^2 = .00$; positive affect, $F(1, 137) = 1.16$, $p = .284$, $\eta_p^2 = .01$; negative affect, $F(1, 137) = 1.46$, $p = .229$, $\eta_p^2 = .01$; perceived physical health, $F(1, 137) = .58$, $p = .446$, $\eta_p^2 = .00$; proactive behavior, $F(1, 137) = 2.30$, $p = .132$, $\eta_p^2 = .02$; somatic symptoms, $F(1, 137) = 2.69$, $p = .622$, $\eta_p^2 = .00$; academic performance, $F(1, 107) = 1.31$, $p = .255$, $\eta_p^2 = .01$; or academic engagement, $F(1, 137) = 1.20$, $p = .275$, $\eta_p^2 = .01$. Effect sizes were also consistently small. Therefore, Hypotheses 2 to 9 were rejected.[5]

Theory-Guided Analyses

Following the preregistered analyses with the whole sample, a series of theory-guided analyses were conducted, which divided the sample into two subgroups: a high baseline perceived distress subgroup and a low baseline perceived distress subgroup. The analysis procedure is described in the Method section. Effects of the intervention described below were observed only in individuals in the high perceived distress subgroup. Estimated marginal means, standard errors, and 95% confidence intervals of study variables by time and subgroup are reported in Table 2, and estimated marginal means are graphically presented in Figures 2, 3, and 4.

Stress mindset. A three-way mixed model ANOVA revealed a significant Time × Group × Baseline Perceived Distress interaction effect on stress mindset, $F(6, 270) = 17.73$, $p < .001$, $\eta_p^2 = .28$. This indicates that changes in stress mindset across time points between the intervention and control group were different for those with high and low levels of baseline perceived distress. To probe the interaction effect, simple effects were examined. Estimated marginal means indicated that there were no significant baseline differences in stress mindset between the control and intervention groups for those with low baseline perceived distress ($p = .128$, $\eta_p^2 = .02$), or high baseline perceived distress ($p = .055$, $\eta_p^2 = .03$). However, there was a significant difference between the control and intervention groups for those with low perceived distress ($p = .001$, $\eta_p^2 = .07$) and high perceived distress ($p < .001$, $\eta_p^2 = .25$) immediately postintervention, and at the 2-week follow-up such that the intervention had a stronger effect on those in the high perceived distress group ($p < .001$, $\eta_p^2 = .17$) than those in the low perceived distress group ($p = .018$, $\eta_p^2 = .04$).

Secondary outcomes. Three-way mixed model ANOVAs revealed statistically significant Time × Group × Baseline Perceived Distress Effects on Perceived Distress, $F(3, 135) = 9.69$, $p < .001$, $\eta_p^2 = .18$; psychological well-being, $F(3, 135) = 3.31$, $p = .022$, $\eta_p^2 = .07$; positive affect, $F(3, 135) = 3.17$, $p = .027$, $\eta_p^2 = .07$; proactive behavior, $F(3, 135) = 4.37$, $p = .006$, $\eta_p^2 = .09$; and academic performance, $F(3, 105) = 2.97$, $p = .035$, $\eta_p^2 = .08$.[6] The Time × Group × Baseline Perceived Distress interaction effect on negative affect fell just short of the conventionally accepted level for statistical significance; however, a medium-sized effect was observed, $F(3, 135) = 2.66$, $p = .051$, $\eta_p^2 = .06$. This indicates that changes in perceived distress, psychological well-being, positive affect, proactive behavior, academic perfor-

[3] The Greenhouse-Geiser correction was applied due to Mauchly's test indicating sphericity cannot be assumed.

[4] There were no significant differences between the intervention and control groups at the baseline for any of the secondary outcomes, including perceived distress ($p = .189$, $\eta_p^2 = .01$), psychological well-being ($p = .128$, $\eta_p^2 = .02$), positive affect ($p = .403$, $\eta_p^2 = .01$), negative affect ($p = .470$, $\eta_p^2 = .00$), physical health ($p = .390$, $\eta_p^2 = .01$), proactive behavior ($p = .098$, $\eta_p^2 = .02$), perceived somatic symptoms ($p = .656$, $\eta_p^2 = .00$), academic performance ($p = .065$, $\eta_p^2 = .02$), and academic engagement ($p = .666$, $\eta_p^2 = .00$).

[5] Baseline levels of psychological well-being, proactive behavior, and academic performance approached conventional levels indicating statistically significant differences, which may compromise internal validity. There was also missing academic performance data. For completeness, ancillary analyses were conducted in R (R Core Team, 2019) using the *lavaan* (Rosseel, 2012) package to control for baseline differences in the preregistered analyses and to estimate values for the missing academic performance data. The ancillary analyses were regression analyses for each of the follow-up dependent variables, controlling for baseline levels of psychological well-being, proactive behavior, academic performance, and the dependent variable in each analysis. Missing data was estimated using the full-information maximum likelihood (FIML) procedure. There were no differences in the pattern of effects for any of the dependent variables, with the exception that in the analysis predicting proactive behavior, the effect of group was approaching our specified cutoff for statistical significance ($p = .027$). Readers are directed to the online supplemental material for details of these analyses.

[6] For completeness, the effect of the intervention on each subgroup was examined using a multigroup regression analysis in R (R Core Team, 2019) using the *lavaan* (Rosseel, 2012) package to estimate missing data with the FIML procedure.

Table 1
Estimated Marginal Means, Standard Errors, and Confidence Intervals of Study Variables by Time and Group (n = 139)

	Baseline						Follow-up					
	Control			Intervention			Control			Intervention		
	M	*SE*	99% CI	*M*	*SE*	99% CI	*M*	*SE*	99% CI	*M*	*SE*	99% CI
Stress mindset	3.27	.10	[3.01, 3.53]	3.35	.10	[3.09, 3.61]	3.22	.10	[2.95, 3.49]	4.02	.10	[3.75, 4.29]
Perceived distress	20.71	.94	[18.26, 23.17]	18.96	.95	[16.49, 21.43]	20.03	.87	[17.76, 22.30]	17.52	.88	[15.24, 19.81]
Psychological well-being	43.39	1.22	[40.19, 46.58]	46.04	1.23	[42.83, 49.26]	44.33	1.22	[41.15, 47.51]	47.00	1.23	[43.80, 50.20]
Positive affect	30.61	.93	[28.18, 33.05]	31.73	.94	[29.27, 34.18]	29.76	.89	[27.43, 32.08]	32.07	.90	[29.73, 34.42]
Negative affect	25.23	1.00	[22.63, 27.83]	24.20	1.00	[21.58, 26.83]	23.24	.94	[20.78, 25.71]	20.81	.95	[18.33, 23.30]
Physical health	3.17	.12	[2.86, 3.49]	3.31	.12	[3.00, 3.64]	3.16	.13	[2.83, 3.48]	3.42	.13	[3.09, 3.75]
Proactive behavior	2.88	.08	[2.68, 3.09]	3.07	.08	[2.80, 3.20]	3.00	.08	[2.80, 3.20]	3.32	.08	[3.12, 3.52]
Somatic symptoms	21.13	.78	[19.10, 23.15]	20.64	.78	[18.60, 22.68]	19.96	.77	[17.96, 21.96]	19.07	.77	[17.06, 21.09]
Academic performance	4.93	.13	[4.60, 5.26]	5.26	.13	[4.93, 5.59]	4.93	.16	[4.50, 5.35]	5.41	.16	[4.99, 5.59]
Academic engagement	4.25	.11	[3.96, 4.54]	4.32	.11	[4.02, 4.61]	4.27	.11	[3.98, 4.56]	4.44	.11	[4.15, 4.74]

Note. Follow-up = 2-week follow-up postintervention. Stress mindset was also measured immediately postintervention (Control: $M = 3.28$, $SE = .10$, 99% CI [3.02, 3.55]; Intervention: $M = 4.27$, $SE = .10$, 99% CI [4.01, 4.54]). Participants lost to attrition ($n = 3$) and participants excluded due to failing attention check questions ($n = 8$) are not included in estimates. Control group $n = 70$; intervention group $n = 69$. Due to missing data $n = 109$ ($n = 54$ control; $n = 55$ intervention) participants were used for academic performance analyses.

mance, and potentially negative affect across time points between the intervention and control group were different for those with high and low levels of baseline perceived distress. Estimated marginal means indicated that there were no significant differences in perceived distress, psychological well-being, positive affect, proactive behavior, academic performance, and negative affect between the control and intervention groups for those with low perceived distress or high perceived distress at the baseline.[7]

Probing the interaction effects revealed that there were no significant differences in perceived distress ($p = .868$, $\eta_p^2 = .00$), psychological well-being ($p = .915$, $\eta_p^2 = .00$), positive affect ($p = .898$, $\eta_p^2 = .00$), proactive behavior ($p = .546$, $\eta_p^2 = .00$), academic performance ($p = .653$, $\eta_p^2 = .00$), and negative affect ($p = .876$, $\eta_p^2 = .00$) between the control and intervention groups at the follow-up in those with low baseline perceived distress. For those with high perceived distress at the baseline, the intervention group had significantly lower perceived distress ($p = .014$, $\eta_p^2 = .04$), higher positive affect ($p = .037$, $\eta_p^2 = .03$), higher proactive behavior ($p = .001$, $\eta_p^2 = .08$), higher academic performance ($p = .021$, $\eta_p^2 = .05$), and lower negative affect ($p = .035$, $\eta_p^2 = .03$) than the control group at the follow-up. Further, for those with high perceived distress at the baseline, the intervention group exhibited higher psychological well-being than the control group at the follow-up, however, the difference was not significant ($p = .138$, $\eta_p^2 = .02$).

Three-way mixed model ANOVAs revealed no Time × Group × Baseline Perceived Distress interaction effects on perceived physical health, $F(3, 135) = 1.34$, $p = .266$, $\eta_p^2 = .03$; perceived somatic symptoms, $F(3, 135) = .39$, $p = .763$, $\eta_p^2 = .01$; and academic engagement, $F(3, 135) = 1.17$, $p = .325$, $\eta_p^2 = .03$. This indicates that changes in negative affect, perceived physical health, perceived somatic symptoms, and academic engagement across time points between the intervention and control group were not different for those with high and low levels of baseline perceived distress. Estimated marginal means indicated that there were no significant differences in negative affect, perceived physical health, perceived somatic symptoms, and academic engagement between the control and intervention groups for those with low perceived distress or high perceived distress at the baseline.[8]

Further Analyses

Following the mental imagery exercise, intervention group participants were asked to note down a few sentences summarizing what they visualized. We examined this data to develop an understanding of: (a) whether participants in the intervention group were able to imagine a stressor and the things they can do to experience the potential positive consequences of the stressor; and (b) whether participants in the intervention group made specific mention of the potential positive consequences of their stressor during the imagery exercise, which may provide insight into the potential for demand characteristics to influence stress mindset scores. With regard to the first question, all participants in the intervention group reported visualizing a stressor during the mental imagery exercise. This suggests that while not all participants were experiencing significant distress, they were all experiencing stressors that they were able to consider in completing the imagery exercise. With regard to the second question, 76% of participants in the intervention group made specific mention of the positive consequences of stress, while the remaining 24% simply described the things they thought about doing. We speculate that instruction regarding the positive consequences of stress was more salient for

[7] Low perceived distress group: perceived distress ($p = .396$, $\eta_p^2 = .01$), psychological well-being ($p = .892$, $\eta_p^2 = .00$), positive affect ($p = .717$, $\eta_p^2 = .00$), proactive behavior ($p = .524$, $\eta_p^2 = .00$), academic performance ($p = .174$, $\eta_p^2 = .02$), and negative affect ($p = .880$, $\eta_p^2 = .00$). High perceived distress group: perceived distress ($p = .124$, $\eta_p^2 = .02$), psychological well-being ($p = .141$, $\eta_p^2 = .02$), positive affect ($p = .420$, $\eta_p^2 = .01$), proactive behavior ($p = .281$, $\eta_p^2 = .01$), academic performance ($p = .300$, $\eta_p^2 = .01$), and negative affect ($p = .975$, $\eta_p^2 = .00$).

[8] Low perceived distress group: perceived physical health ($p = .456$, $\eta_p^2 = .00$), perceived somatic symptoms ($p = .850$, $\eta_p^2 = .00$), and academic engagement ($p = .663$, $\eta_p^2 = .00$). High perceived distress group: perceived physical health ($p = .284$, $\eta_p^2 = .01$), perceived somatic symptoms ($p = .836$, $\eta_p^2 = .00$), and academic engagement ($p = .532$, $\eta_p^2 = .00$).

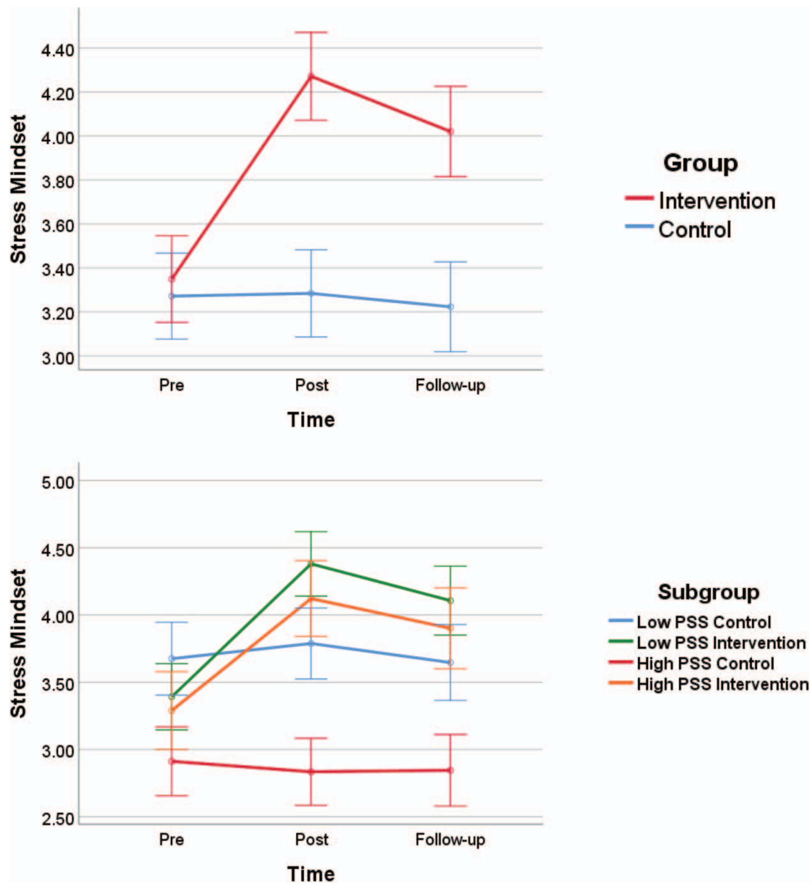

Figure 2. Stress mindset over time across intervention and control groups (top), and by subgroup (bottom). Intervention or control stimuli delivered between pre and post measures. Follow-up measure taken after 2 weeks. Error bars depict 95% confidence intervals. PSS = Perceived Stress Scale. See the online article for the color version of this figure.

those that made specific mention of positive consequences in their descriptions. Therefore, it could be expected that if demand characteristics were having a meaningful impact on postintervention stress mindset scores, the individuals for whom this was more salient would exhibit a greater change in stress mindset scores. However, an independent samples t test revealed no significant difference in average change in stress mindset scores (from pre- to immediately postintervention) between those who mentioned positive consequences of stress in their imagery descriptions (M = .95, SD = .73) and those who did not (M = 1.02, SD = 1.06), $t(69) = -.32$, $p = .749$. This lack of influence of demand characteristics is further supported by the distribution of stress mindset scores on individual items immediately postintervention. For all items, a small proportion of participants in the intervention group (between 2.80 and 16.70%) selected the highest scale point (M = 7.67%, SD = 4.48).

Discussion

The purpose of the current study was to develop and test the efficacy of a novel mental imagery-based intervention in changing stress mindset immediately postintervention, and at a 2-week follow-up using a preregistered randomized controlled design. The study also aimed to evaluate the effect of the intervention on a range of health- and performance-related outcomes. As predicted, the intervention yielded a large effect on stress mindset immediately postintervention, which was maintained at the 2-week follow-up. Contrary to expectations, no effect of the intervention from baseline to the 2-week follow-up was observed for any of the secondary health- and performance-related outcomes for the preregistered analyses of the whole sample. While estimated marginal means of the outcomes were more favorable in the expected directions for those in the intervention group at follow-up, effect sizes were small and did not reach conventional levels of statistical significance. Subsequent theory-guided analyses based on subgroups indicated that the intervention demonstrated robust effects on perceived distress, positive and negative affect, proactive behavior, and academic performance at the follow-up in individuals with high baseline perceived distress. These effects on secondary outcomes were not observed in those with low perceived distress or in the overall sample. Effects of the intervention on stress mindset were also stronger in individuals with high baseline perceived distress.

Current findings have several important theoretical and practical implications, with implications for future research. This study is the first to establish the efficacy of a mental imagery-based inter-

Table 2
Estimated Marginal Means, Standard Errors, and Confidence Intervals for Subgroups

	Baseline			Follow-up		
	M	*SE*	95% CI	*M*	*SE*	95% CI
Stress mindset						
Low PSS control	3.68	.14	[3.40, 3.95]	3.65	.14	[3.37, 3.93]
Low PSS intervention	3.39	.12	[3.15, 3.64]	4.11	.13	[3.85, 4.36]
High PSS control	2.91	.13	[2.66, 3.17]	2.85	.14	[2.58, 3.11]
High PSS intervention	3.29	.15	[3.00, 3.58]	3.90	.15	[3.60, 4.20]
Perceived stress						
Low PSS control	13.06	.73	[11.62, 14.50]	14.67	1.04	[12.62, 16.72]
Low PSS intervention	13.90	.66	[12.59, 15.21]	14.90	.94	[13.04, 16.76]
High PSS control	27.54	.69	[26.18, 28.90]	24.81	.98	[22.87, 26.75]
High PSS intervention	25.93	.78	[22.87, 26.75]	21.14	1.11	[18.95, 23.33]
Psychological well-being						
Low PSS control	51.15	1.37	[48.45, 53.85]	49.67	1.61	[46.47, 52.86]
Low PSS intervention	50.90	1.24	[48.45, 53.36]	49.90	1.47	[47.00, 52.80]
High PSS control	39.57	1.29	[33.91, 39.01]	39.57	1.53	[36.55, 42.59]
High PSS intervention	39.35	1.46	[36.46, 42.23]	43.00	1.72	[39.59, 46.41]
Positive affect						
Low PSS control	34.85	1.22	[32.44, 37.26]	32.76	1.25	[30.28, 35.23]
Low PSS intervention	34.25	1.11	[32.06, 36.44]	32.98	1.14	[30.73, 35.22]
High PSS control	26.84	1.15	[24.56, 29.11]	27.08	1.18	[24.75, 29.42]
High PSS intervention	28.24	1.30	[26.67, 30.81]	30.83	1.33	[28.19, 33.47]
Negative affect						
Low PSS control	19.67	1.15	[17.40, 21.93]	18.00	1.18	[15.67, 20.34]
Low PSS intervention	19.90	1.04	[17.84, 21.96]	18.25	1.07	[16.13, 20.37]
High PSS control	30.19	1.08	[28.05, 32.33]	27.92	1.12	[25.71, 30.12]
High PSS intervention	30.14	1.22	[27.72, 32.55]	24.35	1.26	[21.85, 26.84]
Physical health						
Low PSS control	3.85	.15	[3.56, 4.14]	3.70	.17	[3.37, 4.03]
Low PSS intervention	3.70	.13	[3.44, 3.96]	3.68	.15	[3.37, 3.98]
High PSS control	2.57	.14	[2.29, 2.84]	2.68	.16	[2.36, 2.99]
High PSS intervention	2.79	.16	[2.48, 3.10]	3.07	.18	[2.72, 3.42]
Proactive behavior						
Low PSS control	3.21	1.02	[3.01, 3.41]	3.29	.11	[3.08, 3.50]
Low PSS intervention	3.30	.09	[3.12, 3.48]	3.38	.10	[3.19, 3.57]
High PSS control	2.59	.10	[2.40, 2.78]	2.73	.10	[2.54, 2.93]
High PSS intervention	2.75	.11	[2.53, 2.96]	3.25	.11	[3.02, 3.47]
Somatic symptoms						
Low PSS control	17.46	.96	[15.56, 19.35]	16.73	.98	[14.78, 18.67]
Low PSS intervention	17.70	.87	[15.98, 19.42]	16.43	.89	[14.66, 18.19]
High PSS control	24.41	.91	[22.62, 26.20]	22.84	.93	[21.00, 24.68]
High PSS intervention	24.69	1.02	[22.67, 26.71]	22.72	1.05	[20.65, 24.80]
Academic performance						
Low PSS control	5.11	.18	[4.74, 5.47]	5.34	.24	[4.88, 5.81]
Low PSS intervention	5.45	.17	[5.12, 5.78]	5.48	.21	[5.06, 5.91]
High PSS control	4.78	.17	[4.44, 5.11]	4.57	.22	[4.14, 5.00]
High PSS intervention	5.04	.18	[4.67, 5.40]	5.32	.24	[4.86, 5.79]
Academic engagement						
Low PSS control	4.56	.16	[4.24, 4.87]	4.53	.16	[4.21, 4.85]
Low PSS intervention	4.46	.14	[4.18, 4.75]	4.51	.15	[4.23, 4.80]
High PSS control	3.97	.15	[3.68, 4.27]	4.04	.15	[3.74, 4.34]
High PSS intervention	4.11	.17	[3.78, 4.45]	4.35	.17	[4.01, 4.69]

Note. PSS = Perceived Stress Scale. Stress mindset was also measured immediately postintervention (Low PSS control: $M = 3.79$, $SE = .13$, 95% CI [3.52, 4.05]; Low PSS intervention: $M = 4.38$, $SE = .12$, 95% CI [4.14, 4.62]; High PSS control: $M = 2.83$, $SE = .13$, 95% CI [2.59, 3.08]; High PSS intervention: $M = 4.12$, $SE = .14$, 95% CI [3.84, 4.40]).

vention to effect a change in stress mindset that was retained at a 2-week follow-up. This builds on existing stress mindset manipulations that have focused on eliciting an attentional bias toward the positive consequences of stress and have been followed up a few days postintervention (e.g., Crum et al., 2017, 2013). Results indicate that mindset change beyond a brief attentional bias is possible in the context of stress mindset. It should be noted, however, that at the 2-week follow-up the effect size of the intervention on stress mindset was smaller, suggesting that the strength of the effect declined over time. This may be due to beliefs not being reinforced over the 2-week period; or, consistent with prior research, an attentional bias toward positive stress-related information being induced immediately following the intervention that dissipates over time (e.g., Crum et al., 2017, 2013).

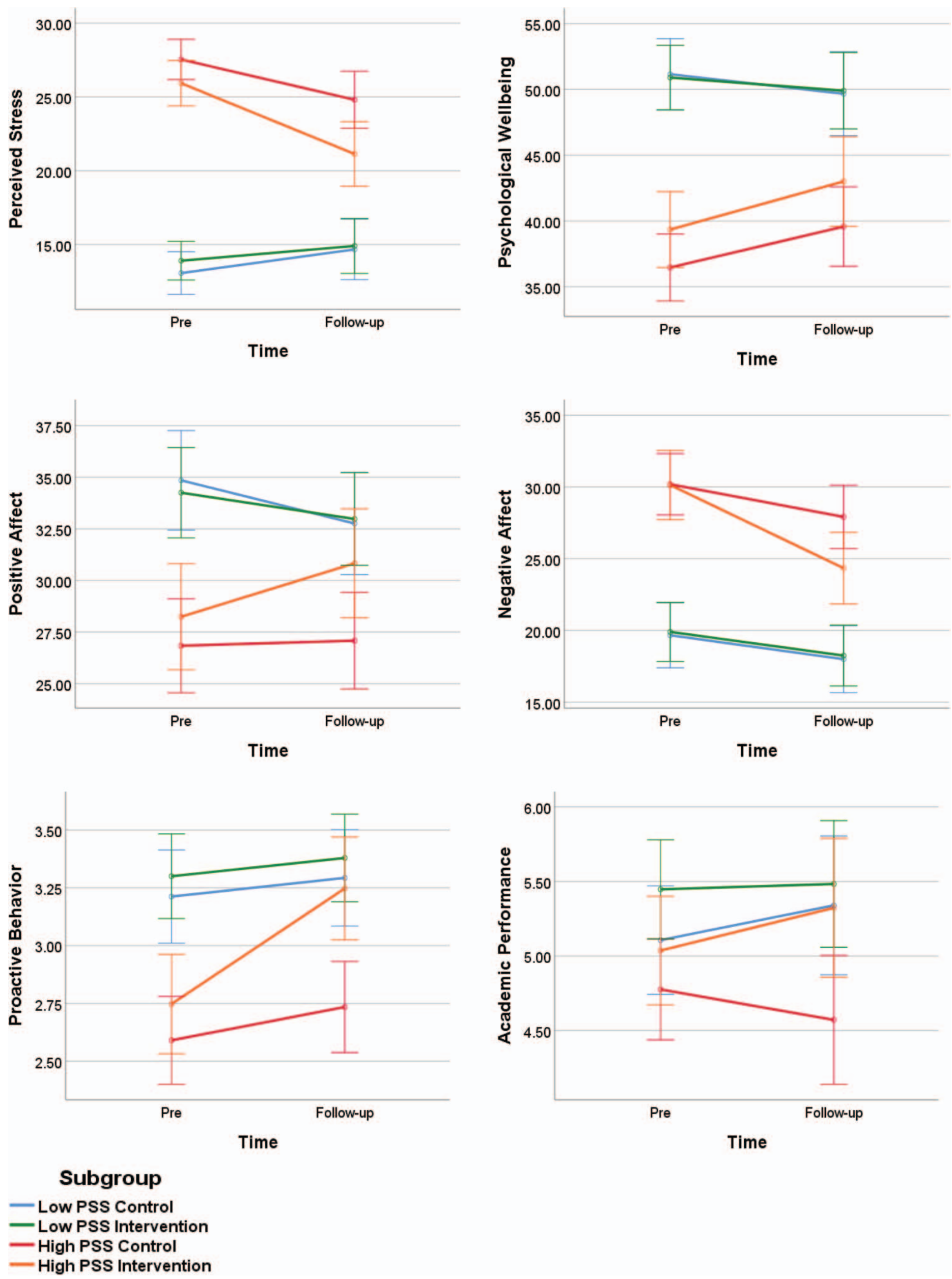

Figure 3. Secondary outcomes over time for intervention and control groups divided by baseline perceived distress where effects were observed for high baseline distress subgroup. Intervention or control condition stimuli delivered after pre measures. Follow-up measures taken 2 weeks later. Error bars depict 95% confidence intervals. PSS = Perceived Stress Scale. See the online article for the color version of this figure.

To better understand these processes, future research should examine the trajectory of stress mindsets over a longer period of time following the intervention and consider increasing the dose through the use of additional imagery sessions across the study period. Research should also seek to test the potential mechanisms that determine the induction of a stress mindset, and its subsequent decay over time, by including measures of attentional bias toward positive interpretation of stress-related information and conducting mediation analyses.

In contrast to our preregistered hypotheses, no effect of the intervention on the secondary outcomes at the 2-week follow-up was detected for the preregistered analyses of the whole sample. A possible explanation for this is that despite all participants reporting exposure to stressors, there was considerable heterogeneity in baseline levels of distress among the overall sample. Subsequent analyses guided by the wise interventions framework (Walton, 2014; Walton & Wilson, 2018) and prior research revealed robust effects of the intervention on perceived distress, positive and

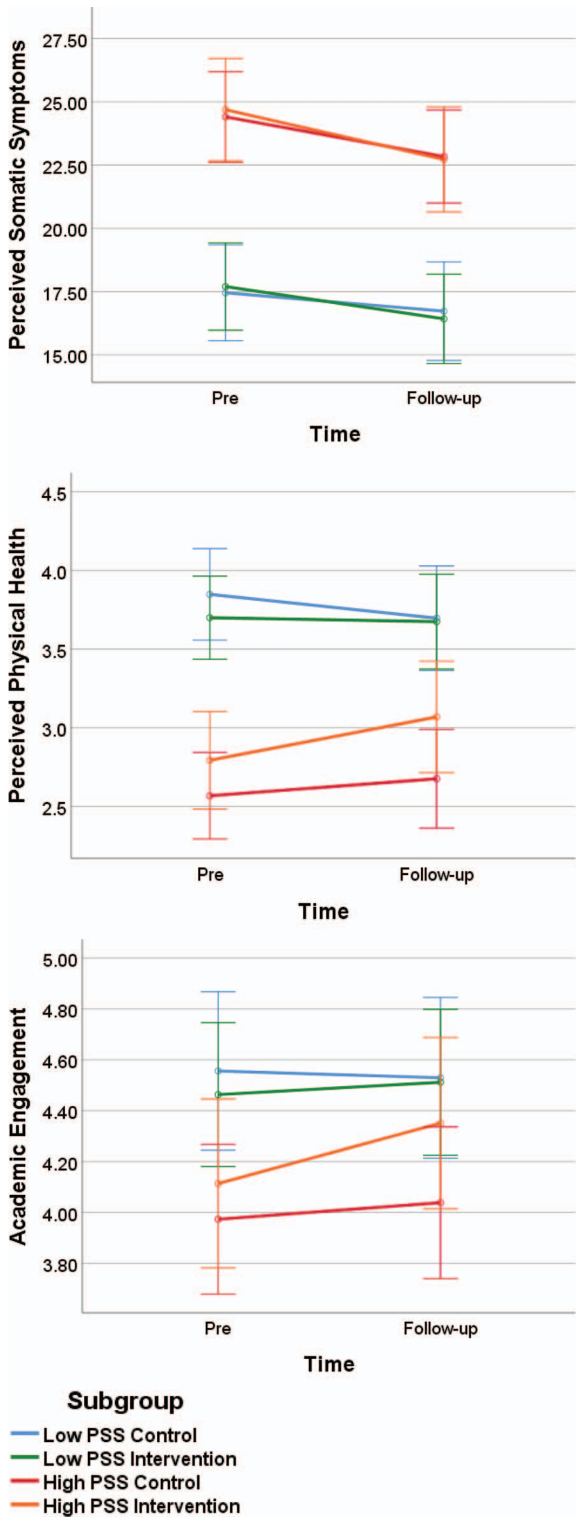

Figure 4. Secondary outcomes over time for intervention and control groups divided by baseline perceived distress where no significant effects were observed in either subgroup. Intervention or control condition stimuli delivered after pre measures. Follow-up measures taken 2 weeks later. PSS = Perceived Stress Scale. See the online article for the color version of this figure.

negative affect, proactive behavior, and academic performance at the follow-up in individuals with high baseline perceived distress. It is likely that individuals with low baseline perceived distress were already coping well and had little need to apply what they had learned in the intervention. Park and colleagues' (2018) findings indicate that stress mindset moderates the effect of stressful life events on perceived distress and, therefore, where individuals' exposure to stressors is not currently leading to distress there is no psychological mechanism of vulnerability on which the wise intervention can yield an effect. Yeager et al. (2016) also observed no effect of an incremental theories of personality intervention on neuroendocrine outcomes on days when stressor exposure was not influencing these outcomes. This is not to suggest that those not experiencing distress would never benefit from the intervention tested in the current study; however, examining potential stress inoculation benefits in these individuals would require longitudinal research over an extended period of time and would be best examined independently of studying distressed individuals.

While trends in the predicted directions were observed, no statistically significant effect of the intervention was observed on psychological well-being, perceived physical health and somatic symptoms, and academic engagement in high baseline perceived distress individuals, which contrasted with our theory-guided hypotheses. There are several possible explanations for this lack of observed effect. The study used retrospective recall of well-being, affective states, and behavior over a two-week period, which may not adequately capture momentary responses to stressors. Momentary responses to ecological stressors may in fact be similar to the momentary responses to laboratory stressors observed in prior research (e.g., Crum et al., 2017, 2013), and they may not necessarily be captured through retrospective recall at the end of a 2-week period. Beyond potential issues with retrospective recall, a longer period of time may be required for changes in momentary responses to ecological stress to translate into overall improvements in these outcomes. For example, impacts of distress on physical health tend to occur with chronic stress over longer periods of time (Cohen, Gianaros, & Manuck, 2016). Prior research has observed effects of a stress mindset manipulation on health symptoms (Crum et al., 2017, 2013), which may be more proximal to when an individual experiences stress. Further, behaviors such as academic engagement may involve complex self-regulatory processes—for example, habits around procrastination—and these may require more time and simultaneous intervention upon other mechanisms to change (Schnauber-Stockmann, Meier, & Reinecke, 2018).

Together, these findings provide further insight into when stress mindset interventions may be beneficial for improving stress-related outcomes. Specifically, the findings indicate that there may be a requisite baseline level of perceived distress for the induction of a stress mindset to make observable differences in adaptive outcomes such as well-being, affect, behavior, and performance. This extends upon current knowledge from studies that have observed beneficial effects of stress mindset interventions in response to laboratory-induced stressors that are designed to be as uniform as possible (e.g., Crum et al., 2017, 2013). The current study is the first to examine the effect of a stress mindset intervention on stress-related outcomes in response to an ecologically valid setting beyond a few days and, therefore, these findings should be replicated and extended upon in future preregistered studies of individuals with high perceived stress. To address the questions outlined above, future research should also seek to use methods such as ecological momentary assessment (Bolger & Laurenceau, 2013) to measure stress mindsets, well-being, affective responses, and behavior to examine within-subjects trajectories of these constructs when ecological stress is experienced prior to and following the intervention. It would also be valuable in future research to test mediation models to examine whether changes in the stress-related outcomes in those who receive the intervention occur via changes in stress mindset, or whether there are other processes that may explain these effects.

Study Strengths and Limitations

The current study has several strengths that enhance understanding of the effects of stress mindset on health and performance outcomes. First, the study tested a novel imagery-based intervention that was rigorously pilot tested and informed by prior research into stress mindset (Keech et al., 2018), and best practice guidelines for imagery interventions (Conroy & Hagger, 2018; Hamilton et al., 2019). Second, the study sought to minimize bias using a preregistered double-blinded randomized controlled trial design. Third, the study used student grade point average (GPA) scores from university student records to provide an objective measure of academic performance.

Current findings should also be considered in light of some limitations. First, with the exception of academic performance, measures of the secondary outcomes relied on retrospective recall of behavioral and affective states. While the self-report measures used have adequate validity and reliability, they do not allow for a fine-grained examination of how stress mindset may affect stress responses in a given moment. Future research using ecological momentary assessment methods (Bolger & Laurenceau, 2013) may help to overcome this limitation by frequently measuring exposure to stressors and momentary responses prior to and following a stress mindset intervention.

For the preregistered hypotheses, all effects were considerably smaller than anticipated, and power and sample size were not calculated for the scenario of conducting subgroup analyses that divide the size of the sample. It is possible, therefore, that the study was not sufficiently powered to detect potentially smaller effects of the intervention on psychological well-being, perceived physical health, perceived somatic symptoms, and academic performance. An important direction for future research is to replicate these findings in another preregistered study sampling individuals' experiencing high levels of distress (i.e., through screening potential participants) to ensure a sufficiently powered sample is recruited to examine the effects of the intervention on those who are likely to benefit most.

In an effort to minimize demand characteristics, the current study was designed to blind participants regarding the aims and the fact that the study was an intervention. As opposed to providing firm instruction to persuade participants that stress is positive, the intervention exercises were designed to encourage participants to consider that stress can have positive consequences and to consider potential positive consequences of the stress they are experiencing. We therefore expected that considering this would lead to a change in stress mindset for individuals who were able to visualize positive consequences of their stress and that changes in mindset scores would be unlikely to be due to demand characteristics. Examination of item distributions on the measure of stress mindset and analysis of qualitative data from intervention group participants provide some evidence to support this assertion. Further, a large-sized change in stress mindset was maintained at the 2-week follow-up, where we expect that the aims of the experiment, if guessed by participants, would have been less salient and therefore less likely to influence responses to the measure of stress mindset. While this information provides some evidence that changes in stress mindset scores were not due to demand characteristics, they cannot be entirely ruled out.

A further limitation of the design of the current study is that we did not control for differences in expectancy effects between conditions due to factors such as credibility of the stimuli as an intervention, expectancy of outcomes, and time and effort. Given that expected success in emotion regulation is a well-established determinant of actual emotion regulation (Bigman, Mauss, Gross, & Tamir, 2016; Tamir & Bigman, 2018; Tamir, Bigman, Rhodes, Salerno, & Schreier, 2015), it is important that possible expectancy effects are accounted for in future tests of this intervention. This could be implemented by designing a placebo control condition that is matched with the intervention condition on credibility of the stimuli as an intervention, on the expected benefits of having been exposed to the stimuli, and on the time and effort required for exposure to the stimuli.

Conclusion

The current study provided the first test of a mental imagery-based stress mindset intervention. The intervention had a large effect on stress mindset scores immediately postintervention and although stress mindset had started to decline, a large effect was retained after 2 weeks. While changes in the secondary outcomes were in the expected directions for the preregistered analyses, they were not statistically significant for the overall sample and this is likely due to not all individuals experiencing the stress response in the intervention period. Further theory-guided analyses indicated that there were robust effects of the intervention on perceived distress, positive and negative affect, proactive behavior, and academic performance at the follow-up in individuals with high baseline perceived distress. Together, these findings show that the intervention is a promising approach to changing individuals' stress mindset and that changing stress mindset can have beneficial effects on coping with ecological stressors. Further research is needed to replicate and extend these findings in a sample of individuals experiencing high levels of distress and to eliminate the potential role of expectancy effects in influencing the outcomes under investigation. To better understand the role of stress mindset in managing ecological stressors, future research should employ ecological momentary assessment to measure exposure to stressors and momentary responses prior to and following a stress mindset intervention. This method can also aid in understanding trajectories of stress mindset following an intervention, including whether booster doses are required to create longer-term mindset change, and whether the mindsets are activated and salient in stressful situations.

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