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Mindfulness Training Fosters a Positive Outlook During Acute Stress: A Randomized Controlled Trial

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The tendency to maintain a positive outlook during adversity associates with better health. Interventions that help people cope with stress by maintaining a positive perspective have potential to improve health. Mindfulness interventions show promise for enhancing positive affect in daily life, and developing acceptance toward momentary experiences may help people notice more positive experiences under stress. In a sample of 153 healthy stressed adults (M_{age} = 32 years; 67% female; 53% White, 22% Black, 22% Asian, 4% other race; 5% Hispanic; collected in 2015–2016), we tested whether mindfulness training, and acceptance training in particular, boosts awareness of positive experiences during acute stress. Participants were randomly assigned to one of three matched 15-lesson remote interventions: (1) Monitor + Accept, standard mindfulness instruction in both monitoring and acceptance; (2) Monitor Only, dismantled mindfulness instruction in monitoring only; or (3) Coping control. After the intervention, positive (and negative) experiences during acute stress challenge (using a modified Trier Social Stress Test) were assessed using a new checklist measure. As predicted, Monitor + Accept participants reported noticing significantly more positive experiences during acute stress than Monitor Only (d = .61) and control (d = .58) participants, whereas the number of negative experiences noticed did not differ by condition. Across conditions, positive experiences during acute stress correlated with daily life positive emotions at postintervention (r = .21). Results suggest that mindfulness training, and acceptance training in particular, can broaden awareness to include more positive affective experiences. This work has important implications for understanding coping and affect dynamics following mindfulness interventions.

Keywords: mindfulness, positive affect, stress, acceptance, intervention

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Major life stress has long been associated with poor health outcomes (e.g., Cohen et al., 1993), yet the way people respond to stressful life events can moderate this relationship (Bonanno & Mancini, 2008). One resilience factor that may promote stress recovery and health is the tendency to maintain a positive outlook in the face of adversity (Fredrickson & Levenson, 1998; Ong et al., 2006; Tugade & Fredrickson, 2004). In response to daily life stressors, maintaining positive affect is associated with better sleep (Ong et al., 2013), fewer depressive symptoms (O'Neill et al., 2004), lower systemic inflammation (Sin et al., 2015), and decreased mortality risk (Mroczek et al., 2015; Ong & Steptoe, 2020). Similarly, maintaining positive affect in response to acute laboratory

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stress has been associated with more adaptive inflammatory and immune outcomes (Aschbacher et al., 2012; Robles et al., 2009) and lower risk of developing depressive symptoms (Aschbacher et al., 2012). Moreover, these effects are specific to positive affect and independent of negative affect, joining evidence that the experience of positive emotions may be more important for health than the absence of negative emotions (Cohen et al., 2006, 2009). Whereas larger deflections in positive affect in response to stress reflect greater reactivity (Mroczek et al., 2015), the tendency to maintain a positive outlook despite stress promotes resilience (Ong et al., 2006). Interventions that help people maintain a positive perspective even in the context of stress have the potential to improve mental and physical health over time.

Mindfulness interventions, which train people to *monitor* their present-moment experiences through a lens of equanimity or *acceptance*, show promise for enhancing positive affect in daily life (Davis & Zautra, 2013; Fredrickson et al., 2017; Garland, Geschwind, et al., 2015; Geschwind et al., 2011; Lindsay, Chin, et al., 2018). Initial evidence also suggests that mindfulness interventions may help people maintain a positive outlook in the context of stress; after an 8-week Mindfulness-Based Stress Reduction intervention, mindfulness-trained participants endorsed more positive self-statements during acute stress compared to active control participants (Hoge et al., 2013). The common tendency in the context of stress is to narrow one's attention toward negative cognitions and threat-related cues (e.g., Derryberry & Tucker, 1994; Easterbrook, 1959; Wells & Matthews, 2014) to the exclusion of neutral or positive cues. In contrast, mindfulness meditation is thought to broaden one's awareness to encompass pleasant, unpleasant, and neutral sensations and emotions alike (Farb et al., 2010; Garland, Farb, et al., 2015). This broadened scope of awareness may ultimately lessen the negative impact of stressful experiences. Thus, mindfulness interventions are a promising candidate for boosting one's outlook in the context of stress.

Developing an orientation of acceptance—a noninterference with the flow of sensory experience—may be a critical mechanism by which mindfulness interventions cultivate a more positive perspective in the context of stress (Lindsay & Creswell, 2017). We demonstrated in two mindfulness intervention dismantling trials that training in acceptance of momentary experiences is a key mechanism for boosting positive affect in daily life (Lindsay, Chin, et al., 2018). Briefly, compared to dismantled mindfulness training in monitoring present-moment experiences only ("Monitor Only"), full mindfulness training in monitoring momentary experiences through a lens of acceptance ("Monitor + Accept") increased daily life positive affect, with no group differences observed in reducing daily life negative affect. These results suggest that acceptance training allowed people greater access to positive affective experiences and had little effect on already low rates of negative affect. Fostering this orientation of open awareness may also help people access positive emotions, thoughts, and sensations in the context of stress. Practice in approaching one's momentary experiences with receptivity, openness, and acceptance may reduce negative attentional bias and broaden the scope of awareness, thus affording greater access to positive stimuli even while experiencing stress. Acceptance training may also reduce negative affective experiences during a potent stressor, or it may allow people to notice more positive experiences while simultaneously acknowledging and experiencing negative ones (Lindsay, Young, et al., 2018). In sum, acceptance may be a key ingredient that allows people to notice positive experiences while concurrently acknowledging situations and feelings of stress.

To test this idea, we developed a checklist assessment of positive and negative experiences tailored to the experience of acute social-evaluative stress in the laboratory (specifically, a modified version of the widely used Trier Social Stress Test [mTSST]; Kirschbaum et al., 1993). A variety of approaches have been used to assess acute stress-related processes, including measures of subjective stress (e.g., Hellhammer & Schubert, 2012), coping (e.g., Carver & Scheier, 1994), and self-esteem and cognitive reactions (e.g., Hofmann & Dibartolo, 2000). Given that mindfulness is an awareness practice, our new measure was modeled after a life events checklist approach (e.g., Holmes & Rahe, 1967) to assess awareness of a variety of valenced experiences, including positive and negative emotional, cognitive, and sensory reactions to the stress task. This measure—the Stress-Affect Experiences Checklist—enables a test of whether mindfulness practice alters the contents of one's awareness in the context of acute stress from a negative attentional bias to a broadened state of awareness.

Using data from a preregistered randomized controlled trial, this report tests the hypothesis that acceptance training is a necessary component of mindfulness interventions for boosting positive experiences during acute stress. Stressed community adults were randomly assigned to receive one of three structurally equivalent 15-lesson smartphone interventions: (1) Monitor + Accept (MA), standard mindfulness training with instruction in both monitoring and acceptance techniques; (2) Monitor Only (MO), dismantled mindfulness training with instruction in monitoring techniques only; or (3) Coping control, which provided guidance in free reflection, analytic thinking and reappraisal, and problem solving. After the intervention, positive (and negative) experiences were assessed in response to the mTSST using the Stress-Affect Experiences Checklist measure. MA training was predicted to increase awareness of positive experiences during acute stress compared to MO and control trainings without impacting negative experiences. Positive affect was also assessed in daily life for 3 days before and after the intervention period; exploratory correlational analyses evaluated whether postintervention daily life positive affect relates to positive experiences during acute laboratory stress.

Method

Participants

Enrolled participants were 153 stressed adults (M_{age} = 32 years, SD = 14; see Table 1 for baseline characteristics) recruited from the Pittsburgh community via participant registries, community advertisements, and mass emails to local organizations for a study testing smartphone training programs for managing stress. Study analyses are reported using all available data. Of 153 participants, 150 completed the intervention, 149 provided ecological momentary assessment (EMA) and 148 provided diary data at postintervention, 149 returned for the postintervention assessment, and 142 completed mTSST assessments (of primary interest). See Figure 1 for the Consolidated Standards of Reporting Trials flowchart.

The study design described here was preregistered with Clinical Trials identifier NCT02433431; hypotheses were guided by the Monitor and Acceptance Theory (Lindsay & Creswell, 2015, 2017). This report describes positive and negative affect outcome data

Table 1
Baseline Characteristics of Randomized Participants

Characteristic	Full sample (N = 153)	Monitor + Accept (N = 58)	Monitor Only (N = 58)	Control (N = 37)	Condition difference statistic
Age in years	32.42 (13.68)	32.76 (14.21)	32.64 (12.93)	31.54 (14.31)	$F(2, 150) = 0.10$
Sex					$\chi^2(2) = 0.75$
Female	103 (67.32%)	39 (67.24%)	41 (70.69%)	23 (62.16%)	
Male	50 (32.68%)	19 (32.76%)	17 (29.31%)	14 (37.84%)	
Race					$\chi^2(8) = 14.49$
American Indian/Alaska Native	1 (0.65%)	0 (0.00%)	0 (0.00%)	1 (2.70%)	
Asian	33 (21.57%)	15 (25.86%)	13 (22.41%)	5 (13.51%)	
Black/African American	33 (21.57%)	14 (24.14%)	16 (27.59%)	3 (8.11%)	
White/Caucasian	81 (52.94%)	28 (48.28%)	28 (48.28%)	25 (67.57%)	
Bi- or multiracial	5 (3.27%)	1 (1.72%)	1 (1.72%)	3 (8.11%)	
Ethnicity					$\chi^2(2) = 1.40$
Hispanic or Latino	7 (4.58%)	2 (3.45%)	2 (3.45%)	3 (8.11%)	
Not Hispanic or Latino	146 (95.42%)	56 (96.56%)	56 (96.56%)	34 (91.89%)	
Nativity					$\chi^2(2) = 2.53$
U.S. Native	121 (79.08%)	42 (72.41%)	48 (82.76%)	31 (83.78%)	
Not U.S. Native	32 (20.92%)	16 (27.59%)	10 (17.24%)	6 (22.22%)	
Education level					$\chi^2(14) = 14.26$
GED	3 (1.96%)	1 (1.72%)	1 (1.72%)	1 (1.72%)	
High school diploma	20 (13.07%)	9 (15.52%)	10 (17.24%)	1 (2.70%)	
Technical training	1 (0.65%)	1 (0.65%)	0 (0.00%)	0 (0.00%)	
Some college	41 (26.80%)	15 (25.86%)	12 (20.69%)	14 (37.84%)	
Associate degree	10 (6.54%)	4 (6.90%)	2 (3.45%)	4 (10.81%)	
Bachelor's degree	48 (31.37%)	15 (25.86%)	21 (36.21%)	12 (32.43%)	
Master's degree	26 (16.99%)	10 (17.24%)	11 (18.97%)	5 (13.51%)	
MD, PhD, JD, PharmD	4 (2.61%)	3 (5.17%)	1 (1.72%)	0 (0.00%)	

Note. Data are reported as means (and standard deviations) or numbers (%). GED = General Educational Development.

from the postintervention mTSST, EMA, and diary assessments. Lindsay, Young, et al. (2018) described full eligibility criteria. Briefly, participants were healthy English-speaking smartphone owners between the ages of 18–70 years who scored >5 on the four-item Perceived Stress Scale (reflecting higher-than-average perceived stress; Cohen et al., 1983; Warttig et al., 2013) and did not have a regular systematic mind–body practice (>2 times per week). Written informed consent was obtained from all participants, and all study procedures were approved by the Carnegie Mellon University institutional review board. Study data were collected between February 2015 and April 2016.

Sample size was determined for this clinical trial (Lindsay, Young, et al., 2018) by estimating a medium effect (d = 0.52) in G*Power (Faul et al., 2007). At 80% power, N = 147 participants were needed to detect omnibus differences between three study conditions (Group × Time interaction) using analyses of variance (ANOVA).

Procedure

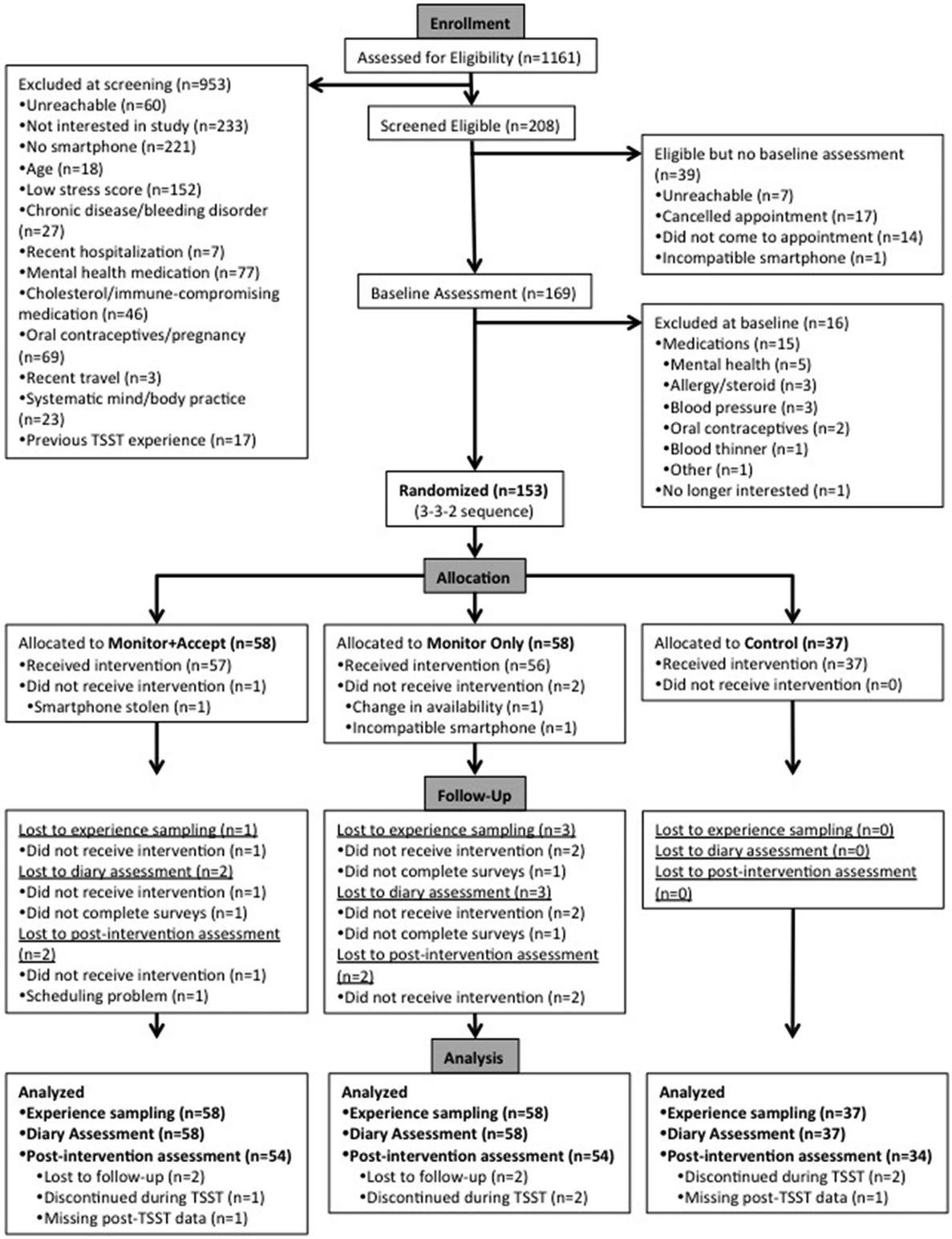
Interested participants were prescreened for eligibility by telephone and then further screened at an in-person baseline assessment. Subject IDs were assigned to a condition by using a 3:3:2 randomization sequence (MA:MO:control), a strategy chosen to maximize power to detect differences between MA and MO mindfulness interventions. At the baseline assessment, enrolled participants provided a dried blood spot sample, completed a questionnaire and task battery, and were oriented to the at-home study assessments and intervention. During 3 weeks of at-home study activities, participants completed three consecutive days of preintervention EMA and diary assessments (see Measures section), a 2-week intervention period (see Intervention Programs section), and three consecutive days of postintervention EMA and diary assessments immediately following the intervention period (outcomes reported in Lindsay, Chin, et al., 2018; Lindsay et al., 2019). Participants received standardized study reminder texts and phone calls throughout the at-home period and were able to call or text the study hotline to ask questions or resolve technical issues.

Participants returned for a postintervention assessment an average of 4.66 days (SD = 1.88 days) after the completion of training (immediately following postintervention EMA and diary assessments; Table 2). They provided a dried blood spot sample (reported in Villalba et al., 2019), completed questionnaires and tasks (including a measure of treatment expectancies; see Measures section), received a booster training lesson, underwent the mTSST (primary stress reactivity outcomes reported in Lindsay, Young, et al., 2018), and completed mTSST assessments, including the Stress-Affect Experiences Checklist measure (see Measures section). After all outcome measures were collected, participants were funnel-debriefed, informed of the primary aims of the study (to test the active ingredients of mindfulness training), given access to the training program of their choice, and compensated up to $190 for their time ($120 base compensation plus up to $70 in bonus compensation for high adherence).

Postintervention mTSST Assessment

The Stress-Affect Experiences Checklist was administered at postintervention following a mTSST (Kirschbaum et al., 1993),

Figure 1
Consolidated Standards of Reporting Trials Flowchart



Note. TSST = Trier Social Stress Test.

Table 2
Adherence, Treatment Expectancies, and Preintervention Outcomes of Randomized Participants

Characteristic	Full sample (N = 153)	Monitor + Accept (N = 58)	Monitor Only (N = 58)	Control (N = 37)	Condition difference statistic
Intervention dropouts	3 (1.96%)	1 (1.72%)	2 (3.45%)	0 (0.00%)	$\chi^2(2) = 1.42$
Intervention adherence (lessons)[a]	13.49 (1.19)	13.45 (1.51)	13.60 (0.91)	13.39 (1.04)	$F(2, 147) = 0.39$
Home practice (average sessions/day)[b]	1.88 (0.71)	1.83 (0.72)	1.91 (0.75)	1.96 (0.63)	$F(2, 141) = 0.41$
Treatment expectancies[c]	5.37 (1.90)	5.71 (1.77)	5.26 (2.02)	5.05 (1.86)	$F(2, 146) = 1.55$
Postintervention days elapsed[c]	4.66 (1.88)	4.61 (1.60)	4.46 (1.72)	5.03 (2.43)	$F(2, 146) = 1.03$

Note. Data are reported as means (and standard deviations) or numbers (%). Intervention dropouts are reported as number of dropouts at the completion of the intervention period. MA = Monitor + Accept; MO = Monitor Only.
[a] N = 150 (MA N = 57; MO N = 56; Control N = 37). [b] N = 144 (MA N = 57; MO N = 53; Control N = 34). [c] N = 149 (MA N = 56; MO N = 56; Control N = 37).

which induced social-evaluative stress in a controlled laboratory setting. Participants heard prerecorded instructions for the mTSST speech performance ("defend yourself against a false shoplifting charge") and were given 3 min to mentally prepare for the speech. Then, the lights were dimmed for a 20-min booster training based on condition assignment (see Intervention Programs section). Next, two evaluators (blind to study condition) dressed in white lab coats and carrying clipboards administered the mTSST. Participants were videotaped giving a 5-min speech and performing 5 min of mental arithmetic (counting backward from 2083 by 17 s). Evaluators maintained a cold and nonaccepting attitude, giving critical feedback during the speech task and pointing out errors during the math task. If a participant expressed any desire to quit during the mTSST, an evaluator confirmed by asking, "Would you like to discontinue the task?" and, if affirmed, the experimenter returned to the room for debriefing (N = 5 participants discontinued during the mTSST). Otherwise, participants remained seated for a 5-min recovery period, after which the experimenter returned and administered the Stress-Affect Experiences Checklist (see Measures section). Two additional participants did not complete this measure due to experimenter error (see Figure 1).

EMA and Diary Assessments

A two-pronged ambulatory assessment approach was used to sample both momentary affective states (EMA) and end-of-day positive affect (diary) in participants' natural environments (see Measures section). The assessment strategy is described in detail in Lindsay, Chin, et al. (2018). Briefly, assessments were administered on participants' smartphones at four quasirandom times throughout the day (EMA) and at the end of each day (diary) for 3 days at pre- and postintervention.

Materials

Intervention Programs

Participants were randomly assigned to receive one of three 15-lesson smartphone-based interventions (described below): MA, MO, or Coping control. To maximize experimental control in isolating the effects of monitoring and acceptance instruction, all three interventions were delivered by the same female instructor and were matched on attentional demand, length of each lesson, structure, and delivery tone of voice. To equalize expectancies at the baseline appointment, all participants viewed the same 5-min introductory video explaining how to prepare for and what to expect in the training program, and "mindfulness" was not mentioned until the completion of study activities. During the 2-week intervention period, participants were expected to complete one 20-min audio lesson (tied to their condition assignment) each day, plus a brief homework practice (3–10 min per day). Each lesson trained specific techniques through didactic explanation (what the technique was and how it would help), guided practice, and self-guided practice. A study manager contacted all participants by phone on Days 3 and 9 of the intervention program to discuss program content, answer questions, address difficulties, and encourage and address issues with program adherence (e.g., delays between audio guidance and survey responses).

During the postintervention assessment (before the mTSST), participants received a 20-min booster training lesson tied to their condition assignment (Lesson 15). Each booster lesson began by addressing the upcoming performance task, encouraging participants to apply the skills learned throughout the course during this challenge; the lesson then presented guided content from the training course that best represented the targeted skills.

The intervention programs were developed in collaboration with Shinzen Young and were based on his Unified Mindfulness system (Young, 2016). The two mindfulness meditation programs were designed to systematically parse mindfulness instruction in (1) attention monitoring and (2) acceptance; the MA program is representative of a standard mindfulness program, whereas MO is a dismantled program with no training in acceptance skills. The foundation of both programs involved the development of concentration, described as a state of stable attention on the intended target (in this intervention, the focus was physical and emotional body experiences). From there, MA participants learned how to (a) monitor and discriminate their present-moment body experience (in the lessons, this skill was referred to as "sensory clarity") while (b) welcoming and accepting each experience (in the lessons, this was referred to as "equanimity"). Specifically, monitoring ("sensory clarity") was explained in terms of two dimensions: resolution (*discriminating* types of experiences) and sensitivity (*detecting* subtle sensations). "Equanimity" was trained through three tangible strategies that embody the attitude of acceptance: participants were encouraged to (1) maintain a state of global *body relaxation*,

(2) *mentally welcome* all physical and emotional body experiences, and (3) use a gentle, matter-of-fact tone of voice (an "equanimity tone") while labeling these experiences. The MO program explicitly trained participants to (1) monitor and discriminate body experience ("sensory clarity"), with no instruction on acceptance. The Coping control training program (referred to in the lessons as "MyTime") was developed to parallel the structure of MA without encouraging focus on or acceptance of present experience; instead participants were instructed to freely reflect and let their minds drift, reframe past and anticipated events, and analyze and solve personal problems. The program was designed to be useful for managing stress by reinforcing common reappraisal and coping strategies without training mindfulness and was included to control for nonspecific effects of undergoing a training program (e.g., treatment expectancies, daily practice toward the goal of reducing stress, instructor effects). See Lindsay, Young, et al. (2018) for an outline of lesson content in each training condition.

Measures

Stress-Affect Experiences Checklist

Awareness of positive and negative experiences during acute stress was assessed at postintervention following the mTSST. Thus, this outcome reflects positively (and negatively) valenced experiences in relation to a controlled laboratory stress provocation. Immediately after the 5-min mTSST recovery period, participants viewed a series of 30 common experiences reported during the mTSST and were asked to indicate the number of times they noticed each experience (using a sliding scale from 0 to 20). If an experience was endorsed (M = 20 items; range: 8–29 items), an exploratory question probing self-judgment was presented; a greater number of experiences noticed correlated with greater self-judgment (r = .36, $p < .001$). Details and results on this measure are provided as Supplemental Materials.

Checklist items were developed and refined from data collected in two previous studies. First, 66 participants provided qualitative data about their thoughts, emotions, and body sensations during the TSST from open-ended written responses and interviews (Creswell et al., 2014). Common responses (primarily negative in valence) were categorized into themes and used to develop a 24-item survey of thoughts, feelings, and body sensations during the TSST. Second, this survey was administered to 147 participants, who estimated the number of times they noticed each experience during the TSST and were interviewed about their experiences during the TSST (Rahl et al., 2017). Open-ended responses were used to develop six additional positively valenced items, resulting in the 30-item scale administered in the present study. Common experiences spanned cognitive (e.g., "I noticed that I was focused on talking about the positive aspects of my character"), emotional (e.g., "I noticed that I felt calm"), and sensory (e.g., "I noticed that I was able to relax my body") domains and were intended to reflect either positive or negative experiences.

Exploratory factor analysis using oblimin oblique rotation with Kaiser normalization (which allows for correlated factors) revealed four factors with eigenvalues greater than 1 (9.58, 3.62, 1.34, and 1.14). All 30 items loaded most strongly onto the first two factors, these two factors clearly reflected positive and negative valence dimensions, and scree plot analysis showed a clear decline in eigenvalues after two factors. Thus, we retained a two-factor solution, with the two factors explaining 68% of the total variance. All but one item loaded more strongly onto their intended factor (see Table 3 for pattern matrix loadings); this item was dropped from analysis. Because the mTSST is designed to induce stress, participants were expected to have a greater variety of negative experiences, and as such, the experiences checklist included more negative than positive items. The nine positive experiences were summed to create a composite Positive Experiences scale (Cronbach's α = .85), and the 20 negative experiences were summed to create a composite Negative Experiences scale (Cronbach's α = .94). Table 3 lists the 30 original items and the category to which they were assigned.

Daily Life Positive Affect

Momentary and end-of-day positive (and negative) affect were assessed on participants' smartphones 5 times daily for 3 days pre- and postintervention. Detailed methods and results are reported in Lindsay, Chin, et al. (2018). Briefly, EMA was used to assess momentary positive (and negative) affect at four random times daily between 9 a.m. and 7 p.m., with 45 min given to complete each survey. End-of-day diaries assessed nine positive (and nine negative) emotions felt throughout the day, which were divided into three subscales each (happiness, calm, vigor; anxiety, depression, hostility) and one overall positive (or negative) affect scale (Cohen et al., 2003; Usala & Hertzog, 1989). Diaries were completed between 8:30 p.m. and 11:30 p.m. Average completion rates across EMA and diary surveys were 91% at preintervention and 86% at postintervention. In this report, correlations between daily life positive affect and positive experiences during acute stress were tested.

Treatment Expectancies

To evaluate whether the three training programs produced equivalent perceived treatment benefits, participants completed an adapted six-item Credibility/Expectancy Questionnaire (Devilly & Borkovec, 2000) to assess their beliefs about the efficacy of the training program at postintervention (but before beginning the mTSST procedures). Logical and emotional subscales were averaged to create an overall measure of positive treatment expectancies (Cronbach's α = .95).

Treatment Adherence

The smartphone training application automatically timestamped the initiation and completion of each lesson in the 14-day at-home training period. This timestamp was used to calculate the number of lessons completed. Participants reported on home practice frequency at the beginning of Lessons 2 through 14. Home practice assignments varied, but brief practice was recommended on average at least twice each day. The number of home practice sessions reported was summed and divided by 13 to calculate the average number of home practice sessions each day. Home practice data were missing from six participants (all of whom completed 14 at-home lessons).

Table 3
Stress-Affect Experiences Checklist Items and Factor Loadings to Positive Experiences and Negative Experiences Scales

Checklist item	Eigen value	Factor loading	
		Positive = 3.83	Negative = 9.37
1. I noticed that I was worried about performing poorly.			.79
2. I noticed that I was able to relax my body.		.58	
3. I noticed thinking that I was not very good at math.			.57
4. I noticed that I was talking very quickly or slowly.			.70
5. I noticed that I felt smart and capable.		.75	
6. I noticed that I was shaking.			.71
7. I noticed that I was able to remember the last number I recited, even when the evaluators interrupted with feedback.		.48	
8. I noticed thinking that I was not a very good public speaker.			.71
9. I noticed that I felt angry.			.62
10. I noticed that I was able to remember the speaking points that I had prepared.		.63	
11. I noticed that I was slouching in the chair.			.41
12. I noticed that my heart was racing.			.72
13. I noticed that I felt anxious.			.80
14. I noticed that I was focused on talking about the positive aspects of my character (e.g., trustworthy).		.49	
15. I noticed that I felt self-conscious.			.75
16. I noticed that I was thinking about things unrelated to the speech/math tasks.			.56
17. I noticed that I felt concentrated.		.50	
18. I noticed that I was wondering what the evaluators were thinking about me.			.69
19. I noticed that my body was tense.			.82
20. I noticed that I was trying to change my strategy.			.55
21. I noticed that my mouth was dry.			.51
22. I noticed that I zoned out.			.55
23. I noticed that I felt excited.		.35	
24. I noticed my desire for the task to be over.			.63
25. I noticed that I felt confused.			.72
26. I noticed that I felt frustrated.			.72
27. I noticed that I felt calm.		.75	
28. I noticed sounds coming from inside or outside the room.			
29. I noticed that I was sweating.			.46
30. I noticed that I felt in control.		.76	

Note. Item 28 loaded weakly onto both factors (<.30) and was dropped from the checklist.

Analyses

Preliminary analyses evaluated baseline differences in demographic variables using chi-square (for categorical variables) and ANOVA tests (for continuous variables). ANOVAs tested for condition differences on intervention adherence, dropout rate, and treatment expectancies to evaluate potential covariates.

Primary analyses tested for condition differences in the number of positive and negative experiences reported during stress using ANOVAs. Pearson's correlation coefficients tested for associations between positive experiences during acute stress and daily life positive affect (diary positive affect composites averaged across three postintervention assessments; average positive affect across 3 days of postintervention EMA). Cohen's *d* effect sizes were calculated by dividing the mean difference between conditions by the pooled standard deviation.

Transparency and Openness

We report how we determined our sample size, all data exclusions, and all manipulations. Measures collected in this randomized controlled trial are listed on ClinicalTrials.gov, identifier NCT02433431. We follow the Consolidated Standards of Reporting Trials guidelines for reporting parallel group randomized trials. Data, analysis code, and research materials used in this report are available at (https://osf.io/vbwpz; Lindsay, 2024). Data were analyzed using StataSE (StataCorp, College Station, Texas). This study's design, treatment conditions, and variables were preregistered on clinicaltrials.gov, but the analysis plan was not preregistered.

Results

Preliminary Results

There were no condition differences on age, sex, race, ethnicity, U.S. nativity, or education (see Table 1). There were also no condition differences in intervention adherence, intervention dropouts, or treatment expectancies at postintervention (Table 2). Participants across all conditions were highly adherent to the training programs (96% adherence) and home practice assignments, and study attrition was low (2% dropout rate; Table 2).

Across the full sample, positive items on the Stress-Affect Experiences Checklist were noticed an average of 3.64 times per item (totaling 33 positive experiences from a list of nine items), and negative items were reported an average of 3.90 times per item (totaling 78 negative experiences from a list of 20 items; Table 4).

Table 4
Stress-Affect Experiences Checklist Outcomes in Each Condition

Outcome	Full sample (N = 142)	Monitor + Accept (N = 54)	Monitor Only (N = 54)	Control (N = 34)	Condition difference
Positive experiences	32.77 (27.72)	42.74 (34.28)	26.31 (20.05)	27.18 (22.08)	$F(2, 141) = 6.05$, $p = .003$*
Negative experiences	77.82 (69.15)	84.69 (69.66)	77.37 (70.42)	67.62 (66.98)	$F(2, 141) = 0.63$, $p = .532$

Note. Data are reported as means (and standard deviations).
* $p < .05$.

Primary Results

Stress-Affect Experiences Checklist

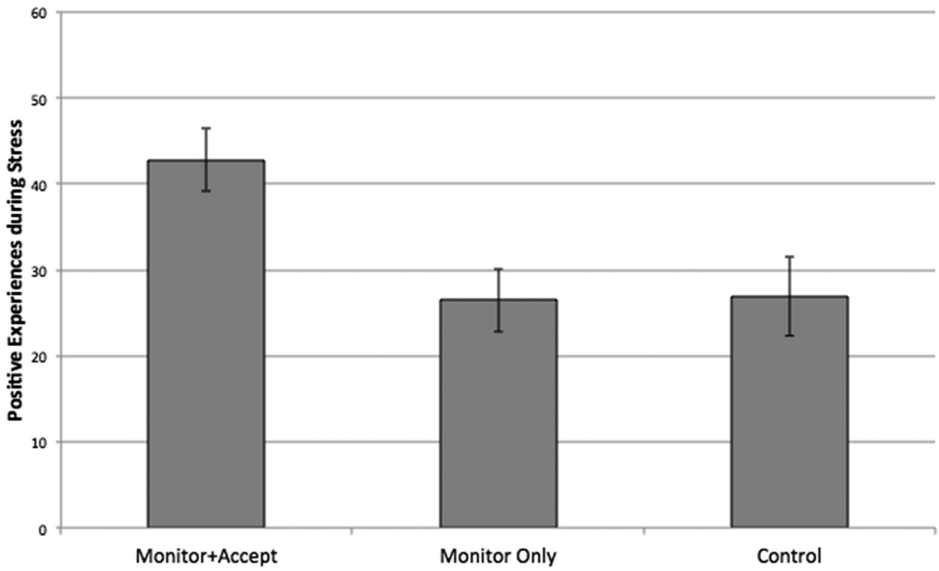
We hypothesized that MA-trained participants would notice more positive experiences during acute stress compared to MO- and control-trained participants. Indeed, there were significant condition differences in the number of positive experiences noticed during the mTSST, $F(2, 139) = 6.05$, $p = .003$; see Figure 2. As predicted, MA-trained participants reported noticing significantly more positive experiences during the mTSST than MO-trained ($M_{difference}$ = −16.42, 95% CI [−26.61, −6.23], $p = .002$, $d = .61$) and control-trained ($M_{difference} = -15.56$, 95% CI [−27.16, −3.97], $p = .009$, d = .58) participants, with no differences between MO and control groups ($M_{difference} = 0.86$, 95% CI [−10.72, 12.45], $p = .88$, $d = .03$; Table 4). Mirroring our previous work assessing daily life affect (Lindsay, Chin, et al., 2018), there were no condition differences in the number of negative experiences noticed during the mTSST, $F(2, 139) = 0.63$, p = .532; Table 4. Thus, MA training selectively increased awareness of positive experiences during acute stress without similarly increasing negative experiences.

The effects of the MA intervention on positive experiences were independent of negative experiences; a follow-up analysis of covariance revealed condition differences in positive experiences while controlling for negative experiences, $F(2, 138) = 5.60$, p = .005. Again, MA-trained participants reported more positive experiences during the mTSST than MO-trained ($M_{difference}$ = −15.74, 95% CI [−25.67, −5.81], $p = .002$, $d = .60$) and control-trained participants ($M_{difference} = -13.97$, 95% CI [−25.31, −2.63], $p = .016$, $d = .53$) after accounting for the number of negative experiences reported, with no differences between MO and control groups ($M_{difference} = 1.77$, 95% CI [−9.53, 13.08], $p = .76$, $d = .07$).

Do Affective Experiences During Laboratory Stress Relate to Daily Life Affect?

We tested whether this new measure related to positive affect reported in daily life. We previously reported increases in diary-assessed positive affect and EMA state positive affect following MA compared to MO and control trainings, with no condition differences

Figure 2
Mean (Standard Error) Number of Positive Experiences Noticed During Acute Laboratory Stress (mTSST) in Each of Three Study Conditions



Note. mTSST = modified version of the widely used Trier Social Stress Test.

in daily life negative affect (Lindsay, Chin, et al., 2018). Here, correlation analyses tested whether positive experiences during the mTSST were related to higher daily life positive affect at postintervention (but not preintervention). Daily life positive affect composites showed high reliability in each condition at pre- and postintervention (Cronbach's $\alpha = .81–.95$; see Supplemental Table 1).

Overall, mTSST positive experiences significantly correlated with diary-assessed positive affect at postintervention ($r = .21$, $p = .013$), including daily feelings of happiness ($r = .19$, $p = .025$), calm ($r = .19$, $p = .024$), and vigor ($r = .21$, $p = .011$). Likewise, there was a small but nonsignificant positive correlation between mTSST positive experiences and EMA state positive affect at postintervention ($r = .15$, $p = .069$). Correlations between mTSST positive experiences and daily life positive affect at postintervention were stronger for MA- and control-trained participants (diary positive affect: MA $r = .24$, MO $r = -.00$, control $r = .36$; diary happiness: MA $r = .23$, MO $r = -.04$, control $r = .32$; diary calm: MA $r = .20$, MO $r = -.05$, control $r = .40$; diary vigor: MA $r = .25$, MO $r = .08$, control $r = .29$; EMA state positive affect: MA $r = .18$, MO $r = -.07$, control $r = .28$). These associations were specific to daily life positive affect reported after the intervention; mTSST positive experiences did not correlate with preintervention diary-assessed positive affect ($r = .09$, $p = .297$), including feelings of happiness ($r = .03$, $p = .684$), calm ($r = .10$, $p = .256$), and vigor ($r = .11$, $p = .177$), or with preintervention EMA state positive affect ($r = .05$, $p = .530$). Correlations between preintervention positive affect in daily life and postintervention positive experiences during the mTSST were weaker among MA-trained participants (diary positive affect: MA $r = .01$, MO $r = .10$, control $r = .22$; diary happiness: MA $r = -.02$, MO $r = .05$, control $r = .13$; diary calm: MA $r = -.00$, MO $r = .12$, control $r = .33$; diary vigor: MA $r = .05$, MO $r = .12$, control $r = .15$; EMA state positive affect: MA $r = -.01$, MO $r = -.03$, control $r = .20$).

Discussion

Despite a large literature showing stress buffering effects of mindfulness interventions (Creswell & Lindsay, 2014), less is known about how mindfulness interventions shape affective awareness under stress. This work provides some of the first in situ findings on how mindfulness interventions change people's thoughts and emotional experiences under stress. In the midst of a potent laboratory stressor, a remote mindfulness intervention (the MA program) increased awareness of positive thoughts, feelings, and sensations compared to matched control interventions; mindfulness-trained participants noticed nearly twice as many positive experiences as control participants. Importantly, acceptance training is a key ingredient for these effects; practice in simply monitoring moment-by-moment experiences (MO intervention) was not enough to boost awareness of positive experiences during stress relative to an active control program. Learning to accept present-moment experience broadens awareness during acute stress to include both positive and negative experiences. Overall, this work demonstrates the potential of mindfulness interventions for boosting stress resilience and long-term health by helping people maintain a positive outlook while experiencing stress. Learning how to approach stressful experiences through a lens of acceptance can change one's perspective in ways that may be beneficial for coping and health.

Although mindfulness interventions have been shown to reduce negative affect (Schumer et al., 2018), this study showed no benefit of mindfulness training for reducing negatively valenced experiences during stress beyond an active coping control intervention. Instead, mindfulness training effects were specific to positive experiences; across conditions, participants noticed negative cognitions, emotions, and sensations that arose during a potent stressor, but mindfulness-trained participants also reported more awareness of concurrent positive experiences. These results are in line with previous reports that mindfulness training (and acceptance training in particular) selectively boosts positive affect in daily life but has no relative benefit for reducing daily life negative affect compared to placebo-matched control training (Lindsay, Chin, et al., 2018). Whereas in daily life, negative affect was low on average, we also found equivalent subjective stress reactivity across all three active interventions, possibly reflecting unique stress reduction mechanisms in each condition (e.g., acknowledgment and subsequent disengagement with negative experiences following mindfulness training vs. stress management expectancies following control training; Lindsay, Young, et al., 2018). Here we extend these findings to show in a potent acute stress context that mindfulness training does not minimize the momentary experience of negative affect, thoughts, and sensations but, instead, shifts the balance of subjective experience toward a more positive perspective.

There is some suggestion that the absence of positive emotions is more predictive of poor health outcomes than the presence of negative emotions (Cohen et al., 2006; Cohn et al., 2009). From an intervention perspective, rather than aiming to diminish negative experiences, broadening awareness to include positive cues during acute stress may be a more important target. The finding that mindfulness training selectively impacts positive experiences in the context of stress aligns with mindfulness theory and research. Whereas stress tends to narrow attentional focus to threat-relevant features (Chajut & Algom, 2003; Derryberry & Tucker, 1994), thus limiting the ability to notice positive cues, mindfulness training has been shown to reduce negative attentional bias (Kiken & Shook, 2011; Vago & Nakamura, 2011) and increase attention to neutral somatic sensations (Farb et al., 2010) and positive stimuli (e.g., positive film clips; Erisman & Roemer, 2010; Kiken & Shook, 2011). Together, this evidence suggests that mindfulness training, and acceptance skills in particular, may help to reduce fixation on stressful stimuli, broaden the scope of awareness, and allow greater access to positive experiences in the context of stress (Garland, Farb, et al., 2015).

Moreover, mindfulness is a practice of maintaining equanimity regardless of external circumstances (Young, 2016). Rather than relying on external conditions to provide a source of happiness (e.g., physical comfort, entertainment, food, money), mindfulness practice fosters an even-minded internal state that allows for awareness of positive experiences even in the midst of outwardly stressful circumstances. Thus, this study demonstrates that a brief mindfulness meditation intervention may begin to promote "happiness independent of conditions," providing experimental evidence that learning to accept present-moment experiences promotes an ability to hold positive and negative experiences at once.

These findings were demonstrated using a new checklist-based measure of cognitions, emotions, and sensations relevant to acute social stress, the Stress-Affect Experiences Checklist. Inspired by a

longstanding tradition in using checklist measures to assess objective chronic stressors (Turner & Wheaton, 1995), this measure explores valenced perceptions during acute stress. This new behavioral measure may prove useful in assessing the breadth of awareness during acute stress and whether awareness of positive experiences during acute stress relates to more adaptive coping and mental and physical health. One possibility is that this shift toward noticing positive aspects of stressors influences a shift toward challenge (vs. threat) appraisals in ways that buffer physiological stress responding (Blascovich, 2013; Daubenmier et al., 2019). However, since over twice as many negative as positive experiences are probed on this measure, the absolute proportion of positive versus negative experiences may be skewed. We caution against comparing proportions of experiences by valence and, instead, recommend evaluating frequency of positive experiences by treatment condition and associations between positive experiences and emotion or health outcomes.

The checklist approach may help to reduce recall bias in reporting on momentary experiences, but it would also be interesting to test for differences in the affective content of freely recalled experiences during the stress task. Mindfulness training may reduce ruminative processing in the aftermath of stress as participants continue to openly monitor experiences as they unfold. MA versus MO condition differences in awareness of positive experiences during stress indicate that the checklist measure captures the synergistic effects of monitoring and acceptance processes cultivated through mindfulness training, whereas our attempt to explore a more face-valid approach to measuring self-reported nonjudgment was not successful (see Supplemental Material). This underscores the difficulty in self-reporting on acceptance and suggests that task-based measures (Hadash & Bernstein, 2019) may hold more promise for capturing changes in acceptance through mindfulness training.

Positive experiences during acute stress were related to daily life positive affect at postintervention (but not preintervention), suggesting that mindfulness intervention-related effects on daily life positive affect extend to a more positive outlook during acute stress. Notably, although daily life positive affect and positive experiences during acute stress were correlated at both preintervention and postintervention in the control group, daily life and acute stress measures were only correlated at postintervention in the MA group. This pattern of findings possibly suggests that training-related changes in monitoring and acceptance skills drove associations between daily life and acute stress experiences among MA participants but that baseline differences in positive affect drove associations among control participants.

This study has several notable strengths and limitations. Strengths include its use of well-matched intervention programs to isolate the active training components of mindfulness training and its high rates of treatment adherence and retention. Thus, the study provides evidence that acceptance training plays a critical role for the effects of mindfulness training on boosting positive perceptions in the context of acute stress. The study also demonstrates the potential of brief remote mindfulness interventions for enhancing stress resilience and coping among people who may not have access to in-person mindfulness programs (also see Lindsay, Young, et al., 2018). However, the study did not include a long-term follow-up assessment. The stability of the changes in awareness cultivated through mindfulness training remains to be tested. And whether increased access to positive experiences during acute stress observed here translates to greater resilience in the face of life adversity, and ultimately improvements in health and well-being, is an important direction for future research.

Constraints on Generality

The sample enrolled in this study was recruited for a stress management study, and participants reported moderate-to-high levels of perceived stress. The majority of participants were recruited from a university hospital research registry, city bus advertisements, and advertisements posted around the Pittsburgh area. The sample's racial demographics generally reflect the Pittsburgh demographic, although more educated and female participants were overrepresented. We note that adherence to the intervention programs in this study is much higher than would be expected in real-world contexts. Results might differ in lower socioeconomic samples, among people less willing to participate in academic research studies, or among people unable or unwilling to commit to a 2-week mindfulness intervention.

Conclusions

Maintaining a positive outlook in the face of adversity has important implications for health. This study shows that mindfulness training, and acceptance training in particular, can broaden awareness during acute stress to encompass positive experiences alongside negative ones. This shift in perspective may help to explain the benefits of mindfulness interventions on mental and physical health.

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