Contemplative/Emotion Training Reduces Negative Emotional Behavior and Promotes Prosocial Responses

Margaret E. Kemeny and Carol Foltz
University of California, San Francisco

James F. Cavanagh
Brown University

Margaret Cullen
University of California, San Francisco

Janine Giese-Davis
University of Calgary

Patricia Jennings
Pennsylvania State University

Erika L. Rosenberg
University of California, Davis

Omri Gillath
University of Kansas

Phillip R. Shaver
University of California, Davis

B. Alan Wallace
Santa Barbara Institute for Consciousness Studies,
Santa Barbara, California

Paul Ekman
University of California, San Francisco

Contemplative practices are believed to alleviate psychological problems, cultivate prosocial behavior and promote self-awareness. In addition, psychological science has developed tools and models for understanding the mind and promoting well-being. Additional effort is needed to combine frameworks and techniques from these traditions to improve emotional experience and socioemotional behavior. An 8-week intensive (42 hr) meditation/emotion regulation training intervention was designed by experts in contemplative traditions and emotion science to reduce "destructive enactment of emotions" and enhance prosocial responses. Participants were 82 healthy female schoolteachers who were randomly assigned to a training group or a wait-list control group, and assessed preassessment, postassessment, and 5 months after training completion. Assessments included self-reports and experimental tasks to capture changes in emotional behavior. The training group reported reduced trait negative affect, rumination, depression, and anxiety, and increased trait positive affect and mindfulness compared to the control group. On a series of behavioral tasks, the training increased recognition of emotions in others (Micro-Expression Training Tool), protected trainees from some of the psychophysiological effects of an experimental threat to self (Trier Social Stress Test; TSST), appeared to activate cognitive networks associated with compassion (lexical decision procedure), and affected hostile behavior in the Marital Interaction Task. Most effects at postassessment that were examined at follow-up were maintained (excluding positive affect, TSST

rumination, and respiratory sinus arrhythmia recovery). Findings suggest that increased awareness of mental processes can influence emotional behavior, and they support the benefit of integrating contemplative theories/practices with psychological models and methods of emotion regulation.

Contemplative practices are core features of many religious traditions, practiced by millions of individuals around the world (Wallace, 2005). Interest has been growing in the potential benefit of secular forms of contemplative practice for promoting mental capacities, treating mental disorders, and enhancing mental and physical health (Ekman, Davidson, Ricard, & Wallace, 2005; Ludwig & Kabat-Zinn, 2008).

One of the contemplative practices frequently used in secular contexts is mindfulness. While behavioral scientists have yet to reach consensus on the definition of mindfulness, most emphasize nonjudgmental awareness and acceptance of present-moment experience (Brown & Ryan, 2003; Wallace & Shapiro, 2006). Training in mindfulness meditation has been incorporated into stress-reduction programs and other psychological interventions, with demonstrated benefits, such as reductions in anxiety in patients with anxiety disorder and other psychiatric conditions (Hayes, 2004), a decreased prevalence of depression relapse in patients with recurrent major depression (Teasdale et al., 2002), reductions in suicidal behavior in patients with borderline personality (Linehan, Armstrong, Suarez, Allmon, & Heard, 1991), and decreases in other negative psychological and physical states (Baer, 2003; Ludwig & Kabat-Zinn, 2008).

While these studies have yielded critical and novel findings, limitations exist in this literature. For example, in a Cochrane review of meditation interventions in the treatment of anxiety, only two of 50 studies met the required methodological inclusion criteria (Krisanaprakornkit, Krisanaprakornkit, Piyavhatkul, & Laopaiboon, 2006). Many studies used small samples, did not randomize to active and control conditions, and/or focused on immediate benefits, failing to determine whether effects were maintained once the immediate "glow" of the experience had receded. In addition, many studies rely exclusively on self-report questionnaires as primary outcomes. Self-reports can confound measurement of "first order" moment-to-moment phenomenal *experience* of mental states, with individual differences in "second order" *awareness* of those mental states (Lambie & Marcel, 2002). This can be particularly problematic when investigating effects of awareness-focused practices. While self-reports are essential for gauging psychological benefit, task-based or behavioral approaches are important complements to these assessments.

While attentional, perceptual, and neurophysiological effects of meditation have been investigated, much less is known about the specific *emotional* changes that may result from meditation practices (see Special Section on Mindfulness, 2010, for a set of recent studies that are relevant to this issue). Such investigations are needed since emotional changes likely play an important role in mediating longer-term effects of meditation practice on mental and physical health symptoms and conditions. Furthermore, while changes in "basal" affective states are important outcomes of such interventions, capturing the critical dimension of affective

psychophysiological reactivity and recovery under emotionally provocative circumstances is an essential next step. Finally, since a primary aim of such practices across cultures is to promote prosocial states of mind such as compassion (Dalai Lama & Ekman, 2008), it is important to determine if these practices can in fact enhance prosocial behavior and decrease destructive social behavior in an emotionally provocative context.

Interventions featuring meditation practices have not yet explicitly incorporated up-to-date knowledge from the behavioral sciences, in particular, the tremendous wealth of information that has been derived from the study of emotions and emotion regulation (Davidson, 2010; Ekman et al., 2005). Recognizing the potential benefit of integrating perspectives on this topic from contemplative traditions and behavioral science, emotion researchers, and Buddhist practitioners and scholars, including the Dalai Lama, met in 2000 to bridge their respective traditions' conceptualizations of "destructive emotions" (Goleman, 2003). This intensive examination led the Dalai Lama to ask whether a secular version of Buddhist practice could be beneficial in the modern world in reducing destructive emotions. As a result of this discussion, one of the authors (P.E.) collaborated with a Buddhist contemplative scholar (B.A.W.), emotion researchers, and others to develop a short-term but intensive training program, suitable for people engaged in modern life, that integrated secular meditation practices with knowledge and techniques derived from the scientific study of emotion. The training was designed to reduce emotional experiences "destructive" to oneself or others and to promote skills in experiencing and expressing emotion constructively.

The 42-hr training program, delivered over 8 weeks, integrated didactic presentations, discussion, and practice related to both meditation and emotional skills (see Table 1 for an outline of the training). Three categories of meditative practice were included: *concentration* practices involving sustained, focused attention on a specific mental or sensory experience; *mindfulness* practices entailing the close, experiential examination of one's physical presence, feelings, and other mental processes; and *directive* practices designed to promote empathy and an orientation toward the benefit of others, including compassion. The training also included instruction in understanding the features of emotions and their elicitors and consequences; methods for recognizing emotions in self and others; understanding relations between emotion and cognition; and techniques for recognizing one's own emotional patterns.

Two studies were conducted. An initial pilot intervention/feasibility study was conducted with a community sample of 15 female schoolteachers involving a 5-week, 52-hr training program. Based on the pilot study, the intervention format and content were modified somewhat, and a two-arm, randomized, controlled trial was conducted with a sample of 82 female schoolteachers randomly assigned to the training condition or a wait-list control condition. In addition to well-validated affective and cognitive

Table 1
Training Program

Features	Content
Training Program Structure	
Training period	8 weeks: 4 all-day sessions/4 evening sessions (42 hr)
Session structure	Group format with two trainers (a meditation expert; a psychological trainer with expertise in leading support groups and meditation groups)
Session format	Didactic presentations, practice related to meditation and to emotional awareness/ understanding, assignment of home practice (meditation, emotion), discussion of home practice
Training Program Components	
Highlights of secular meditation component (recommended meditation practice: 25 min/day)	• Concentration training
	• Mindfulness training
	• Promotion of empathy and compassion
	• Yoga and other movement practices
	• Conceptual discussion including a focus on values, life meaning
Highlights of emotion component	• Knowledge of functions, sensations, triggers, automatic appraisals, and cognitions associated with specific affective states (e.g., anger, fear, sadness)
	• Recognizing one's own emotions
	• Understanding one's own emotional patterns
	• Recognizing emotion in others (face, verbal) to promote empathy

self-reports completed at home using an online assessment procedure at baseline, immediately after the end of the training period, and 5 months following completion of the training, several behavioral, social interaction, and psychophysiological assessments were administered in a 3-hr laboratory session held at one or more of the assessment periods.

Method

Participants

Eighty-two female schoolteachers who met the following criteria were enrolled in the study and completed the baseline assessment: between the ages of 25 and 60 ($M = 41.05 \pm 10.48$), no major physical and psychiatric disorders, living with an intimate partner, not taking medication or engaging in behavior that could affect physiological systems (e.g., recreational drug use), and not already having a meditation practice. Female schoolteachers were chosen as study participants for two reasons: (a) their work situation is stressful (e.g., Farber & Wechsler, 1991) and thus emotional skills training could be immediately useful to their daily lives, and (b) because of the secondary benefit the training could have on their pupils. Given that some of the primary outcome measures (e.g., autonomic nervous system responses) can differ by sex, the study was limited to a single sex, given that subsample sizes would be insufficient to perform subgroup analyses if both sexes had been included. Women were chosen over men because they are more highly represented in the target population (teachers; National Education Association, 2010). Furthermore, we required teachers to be in intimate relationships because we wanted to test whether the intervention affected both personal well-being as well as behavior that would affect the well-being of others—in this case, intimate partners.

Given that the pilot study yielded a large effect size (Cohen's $d \geq 1.0$) for psychological outcomes, the sample size for the clinical trial was selected because a minimum of 30 per group was required to obtain 80% power to detect a significant ($p < .01$,

two-tailed) Group x Time interaction effect of this size ($d = 1.0$), with 10% attrition overall and a .4 correlation estimated between adjacent time points. Participants were randomly assigned to a training condition or a wait-list control condition after the baseline assessment using a randomization scheme generated in SAS in blocks of 10 cohorts (random seed No. 565623). The individuals assigned to the training condition received the 8-week training, whereas those assigned to the control condition received the full training only after all the follow-up assessments were completed. Six participants dropped out and did not complete the post and follow-up assessments (three intervention and three wait-list control participants), leaving a total of 76 participants. The study was approved by the Institutional Review Board of the University of California, San Francisco, and consent was obtained from all participants after a full explanation of the procedures, randomization, and potential side effects.

Measures

Self-report measures were completed at home using an online assessment procedure before (preassessment), immediately after (postassessment), and 5 months following (follow-up) the end of the training program. The battery of questionnaires took approximately 1 to 2 hr to complete and included the following: the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), the Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1977; pilot study used state version), the PANAS Negative Affect and Positive Affect Scales (Watson, Clark, & Tellegen, 1988; past few weeks version), Mindful Attention Awareness Scale (Brown & Ryan, 2003), the Rumination subscale from the Rumination and Reflection Questionnaire (Trapnell & Campbell, 1999), and the short version of the Marlowe Crowne (Reynolds, 1982) Social Desirability scale (baseline only). Reports of number of minutes of meditation practiced each day were collected from training participants via weekly online logs. Total days meditated 20 min or more were aggregated across the entire 8-week training period from these daily assessments.

The tasks were administered in a 3-hr laboratory assessment session. First, the Micro-Expression Training Tool (METT; Ekman, 2004), a computerized task that assesses the ability to recognize facial expressions of seven basic emotions (e.g., anger, happiness), displayed very briefly (40 ms) on a computer screen (administered preassessment and postassessment), was administered. Second, the 18-min Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which involves developing a speech on a preselected topic (8 min), performing the speech (5 min), and doing a mental arithmetic task (5 min), was administered. TSST tasks were performed in front of trained "evaluators," unfamiliar to the participants. This commonly utilized stress task presents a threat to one's sense of social esteem and value (Dickerson & Kemeny, 2004; Kirschbaum et al., 1993). At the end of the task, participants sat quietly for 5 min, after which a questionnaire was administered (at post and follow-up sessions) to assess ruminative thoughts induced by the task (including modified items from two rumination measures: Nolen-Hoeksema, 1991, and Trapnell & Campbell, 1999; Cronbach's alpha = .75). The nature of the specific speech and math tasks, and the number and location of evaluators, varied across the three assessment points to reduce habituation. Specifically, the speech task was made more difficult across assessments by increasing the emotional content of the speech topics: (a) preassessment—a mock job interview; (b) postassessment—description of personal strengths and weaknesses and how well they measure up to their own and others' expectations; (c) follow-up assessment—critique and justification of the strengths and weaknesses of their performance at the baseline assessment after watching the video. Different math tasks were used across assessments: (a) preassessment—counting backward from 989 in steps of 17; (b) postassessment—counting backward from 2095 in steps of 13; (c) follow-up assessment—while listening to an audiotape of a series of single digit numbers presented at varying rates, adding the last two digits presented and then adding the next presented number to the last number heard. Alternative lists of number series of various difficulty levels were available at all assessments if the task was too easy or hard (or the subject became disengaged). Finally, the numbers of TSST evaluators and/or their behaviors also varied across assessments: (a) preassessment—no evaluators were physically present but participants were told that their taped behavior would be judged later by a set of evaluators; (b) postassessment—two evaluators were present with each making two to five evaluative comments during the speech task and providing instructions and comments on performance during the math task; (c) follow-up—two evaluators played very similar roles as in postassessment, and a mirror was also placed under the camera, which the participant was required to look into while performing both tasks. Researchers can obtain individual TSST protocols by contacting the first author (M.E.K.).

Autonomic nervous system (ANS) measurements were recorded during the TSST using Biopac MP150 amplifiers and leads. Blood pressure (BP) measures (diastolic [DBP] and systolic [SBP]) were used as primary indices of cardiovascular reactivity during stress. Respiratory sinus arrhythmia (RSA) was used as an index of parasympathetic activity, and respiration rate was measured to investigate possible respiratory confounds on RSA change. BP was recorded using the Medwave Vasotrac APM205A, with the cuff placed on the participant's nondominant wrist. The electrocardiograph (ECG) was recorded using a Lead II position, and cardiac impedance was measured with band electrodes. Respiration was derived from cardiac impedance recordings, measured with band electrodes according to the guidelines in Sherwood et al. (1990). All ANS measurements were derived as averages across each task minute; task effects were computed as total averages across the 5 min of rest, speech, math, and recovery components of the TSST.

The third task was a computerized lexical decision procedure (e.g., Mikulincer, Gillath, & Shaver, 2002) to measure compassion implicitly, administered at the follow-up point only. Participants were asked to indicate, as quickly as possible, whether a letter string appearing on a computer screen was or was not a correctly spelled English word. Each letter string was proceeded by the subliminal presentation of three images or pictures, each with a different prime: neutral (a woman with a neutral facial expression), suffering (a woman crying that, in a pretest, elicited mainly compassion), and suffering and disgust (a picture of a baby with a tumor on one eye that elicits both compassion and disgust). Four groups of letter strings were chosen based on a pretest: (a) compassion-related words (e.g., empathy, compassion), (b) disgust-related words (e.g., disgust, sickening), (c) neutral words (e.g., magazine, briefcase), and (d) nonwords (e.g., ypmateh).

Each trial began with an "X" shown in the center of the screen for 500 ms, followed by a 30-ms presentation of one of the three possible prime pictures. To prevent the afterimage of the prime from remaining active on the retina or in the optic nerve, the prime was immediately followed by a mask (a scrambled picture) for 500 ms. Immediately after the mask, a letter string was presented until the participant pressed either the "1" or "3" key on the number pad to indicate whether the string was a word or not. Participants were told to decide quickly, but accurately, whether the string correctly spelled a word and indicate their response using the appropriate number key (rehearsed previously in 10 practice trials). Mean reaction times (RTs) were computed for correct responses for each word type (compassion, disgust, neutral, nonword) appearing after each prime type (compassion, disgust, neutral). This procedure is designed to tap unconscious processes and thus avoids some of the social presentation biases of self-report.

The fourth task completed by the participants was the Marital Interaction Task (Gottman, 1995), which was used to measure compassionate and hostile behavior at baseline and at postassessment. Each participant and her spouse or intimate partner discussed and attempted to resolve a difficult problem in their relationship during a 15-min period. Trained coders used the Specific Affect Coding System (SPAFF), originally created by Gottman (Gottman, 1995; Gottman & Levenson, 1999) and modified for use in the Stanford Coding Lab by Giese-Davis, Piemme, Dillon, and Twirbutt (2005), to code participants' behavior for specific affect from video recordings. The James Long System (hardware/software) was used to complete the coding. Coding of the pilot data ($N = 15$) insured that coders in this lab could reliably code marital interactions in the clinical trial phase. Coders were blind to hypotheses, study condition, and session. Each tape was coded at least twice (Kappa $M = 0.68$, $SD = 0.07$). For a Kappa of .60 or higher, a coin toss determined which coder's data was used. If Kappa was below .55, the tape was recoded by a third and/or fourth coder until Kappa values above .60 were obtained (27 tapes were recoded by a third coder, and five tapes were recoded by an additional fourth coder). Each tape took approximately 2.06 (.75 to 3.50) hr of coding time. Seventeen segments (11%; Kappa be-

tween .55 and .60) were consensus coded to maintain thresholds. Expressions of hostility and contempt in this context have been shown to predict divorce 2 years later (Gottman, 1995; Gottman & Levenson, 1999). The newly developed compassion composite code comprised SPAFF low-intensity positive affect codes, specifically interest, validation, and affection.

Participants were reimbursed $100 for completing each of the three assessments (pre, post, and follow-up). They also received three continuing education credits for the training. Their partners were compensated $50 for participating in the marital interaction task at preassessment and postassessment.

Statistical Analyses

The analysis was based on an intent to treat approach, with all 82 individuals randomly assigned to groups, including dropouts ($n = 6$). Except as indicated, the primary outcome analyses involved a repeated measures, mixed linear model analysis of covariance (MLM) via SAS's PROC MIXED procedure, with outcomes from each assessment visit as the dependent variable and Time (preassessment, postassessment, follow-up), Group (training vs. wait-list control), and their interaction as fixed effects, to address immediate and 5-month postintervention effects (specifying a unstructured variance-covariance matrix and using a restricted maximum likelihood estimation method). All significant Group x Time interactions were followed by three post hoc tests to examine the group effect at each time point separately. In cases where baseline values were not available, the main effect of Group rather than the Group x Time interaction was interpreted because we did not necessarily expect improvement or deterioration between the postassessment and follow-up assessments. Analyses were adjusted for annual family income and positive affect (PANAS), both of which showed group differences at baseline, and social desirability from baseline. Any outcome that was poorly distributed at one or more time points was normalized using natural logs or square-root transformations.

The analysis of the ANS metrics employed the same analytic model, except that (a) the outcome variables from the post- and follow-up assessments were residualized from the pretreatment values so there were only two levels of time; and (b) outliers (greater than 2 SDs) were excluded from the analyses. Both are standard approaches to analysis of ANS data.

The analysis of the lexical decision measure of compassion utilized a 2 (group: training, wait—list control) × 3 (prime image: compassion, compassion/disgust, neutral) × 4 (word type: compassion, disgust, neutral, nonword) mixed model analysis of covariance, adjusting for social desirability (since social desirability can predict response to these types of tasks and because social desirability was correlated with RTs in the current study). Income and positive affect were not covaried because reaction-time variables did not correlate with these measures (all rs < .08).

The analysis of the coded emotional expression from the marital interaction task also utilized a mixed models approach to examine change over time, although, here, time was entered as a random effect (days from baseline to the postassessment), given the inclusion of only two time points, and an autoregressive error covariance matrix was used (which fit these behavioral data better here). Two participants did not have a marital interaction at baseline and could not be included in these analyses. We found no baseline

differences in coded variables. We examined whether the three covariates used throughout this study might be proxies for the significant change in behavioral hostility and found a lack of correlation, so we conducted no further tests using covariates.

The data from the pilot study were analyzed using paired t tests. Zero-order Pearson correlations were used to determine the relationship between meditation practice time and outcomes assessed at the postassessment point.

Results

Pilot Intervention

In the initial pilot intervention ($N = 15$), training participants self-reported large decreases in depression, $t(13) = 5.27, p < .001$, and state anxiety, $t(12) = 3.64, p = .003$, from pretraining to posttraining. The training sessions were well attended, and the participants reported, during both debriefing and follow-up interviews, that the training content was understandable and highly beneficial to their personal and work lives.

Clinical Trial

In the randomized, controlled clinical trial ($N = 82$), dropout was low (6/82 or 7%) and equivalent across groups; attendance was substantial across all eight sessions ($M = 6.66$ sessions; $SD = 2.28$).

Basal Self-Reports

Self-reported depression, as predicted, declined strongly in the training group compared with the control group from pretraining to posttraining, and effects were retained at the 5-month follow-up assessment (MLM with covariates, $F[2,72.4] = 17.91, p < .0001$, Figure 1A). Effect sizes were large for the group difference, based on unadjusted means both at the postassessment and follow-up assessment, Cohen's $d = .81$ and .90, respectively. Using clinically defined cut-off scores (≥ 10; Beck, Steer, & Garbin, 1988), 46% of the total sample had depression levels in the mild to moderate range at baseline (no group baseline difference, $p = .27$). Only 14% of the training participants who were depressed at baseline remained depressed after the training (vs. 83% of the controls), a significant shift in classification, McNemar's χ^2 (1, $N = 38$) = 15.21, $p < .0001$. Similarly, self-reported trait anxiety, $F(2,72.6) = 11.14, p < .0001$ and overall trait negative affect, $F(2,73.3) = 8.10, p = .0007$ decreased significantly in the training group compared with controls, and the effects were maintained at follow-up (online supplementary Figure 1A and B). Much less is known about the impact of psychological interventions on trait positive affect, and in some well-controlled studies of mindfulness-based interventions, effects on positive affect were not demonstrated (Davidson et al., 2003). The results suggested that self-reported positive affect was greater for those in the training group versus the control group averaged across posttest and follow-up, $F(1, 71.3) = 5.09, p = .03$ (Figure 1B).

We predicted that specific cognitive processes relevant to emotional experience would be affected by the training. In particular, we hypothesized that rumination would decrease and mindfulness would increase. Rumination is a cognitive process that involves
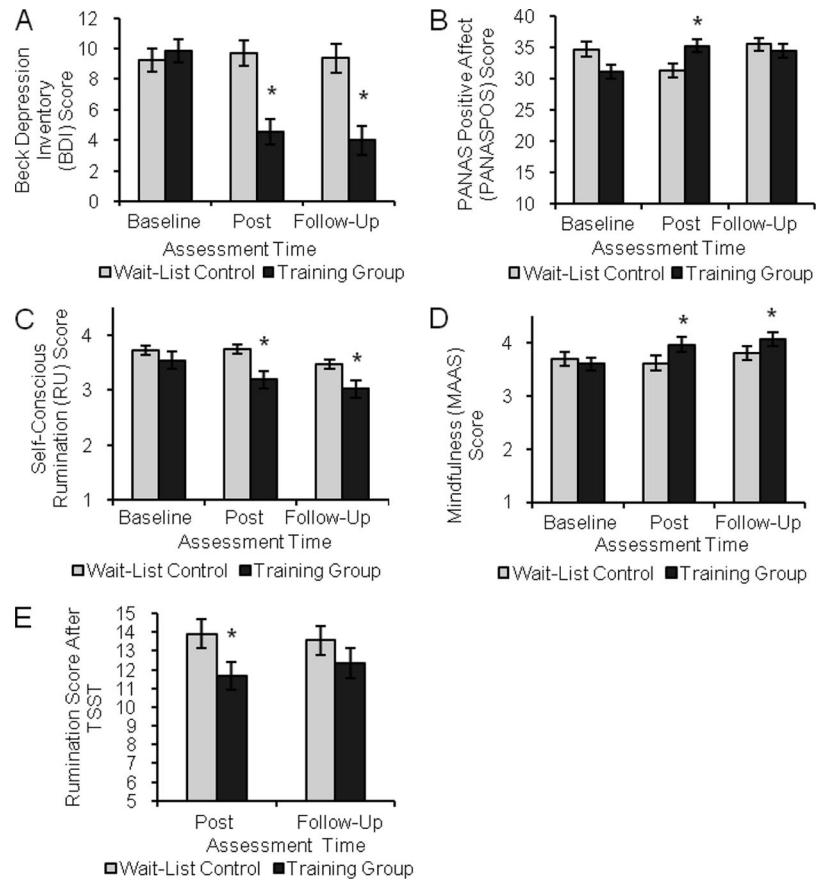
Figure 1. Comparison (mean ± *SE*) of the training and wait-list control groups on baseline, post, and follow-up (5 months following completion of the training) assessments. (A) Beck Depression Inventory (Beck et al., 1988; MLM, $p < .0001$, $N = 82$). (B) PANAS Positive Affect Scale (Watson et al., 1988; MLM, $p = .03$, $N = 76$). (C) Rumination subscale of the Rumination and Reflection Questionnaire (RRQ (3); MLM, $F[2,72.1] = 5.20$, $p = .008$, $N = 82$). (D) Mindful Attention Awareness Scale (MAAS (4); MLM, $F[2,73.1] = 3.94$, $p = .02$. (E) State rumination scale administered during the recovery phase 5 min after the end of the TSST at the post and follow-up assessment points (MLM, $p = .01$, $N = 76$; the Group effect, rather than the Group x Time interaction, was interpreted since this measure was not administered at baseline, and changes in this score from post to follow-up were not hypothesized).

repetitive negative thoughts, including a particular focus on past negative experiences and failures (Martin & Tesser, 1996). Rumination can have serious negative emotional consequences, including depression (Nolen-Hoeksema, 1991; Watkins & Teasdale, 2004). We predicted that the mindfulness component of the training would promote attention toward immediate, rather than past or future experiences, including present thoughts, feelings, and sensations, with a less evaluative focus on what arises in the mind. Compared with controls, training group participants demonstrated decreased trait rumination, $F(2,72.1) = 5.20$, $p = .008$, and increased mindfulness, $F(2,73.1) = 3.94$, $p = .02$, and maintained both improvements over time (Figure 1, C and D). The greater the number of days individuals reported practicing meditation for the requested amount of time at home (20 min or more) across the 8-week training period, the lower their trait anxiety, $r(37) = -.51$, $p = .001$, and the higher their mindfulness, $r(37) = .37$, $p = .02$, at the posttraining assessment, but these predicted relations did not occur with other self-report measures (absolute rs range from .05 to .31).

Emotion Tasks

Laboratory stressor-ruminative response. To assess responses to challenge in "real world" contexts, a number of emotionally provocative tasks were employed. First, participants underwent the TSST at all three measurement points. The TSST involves performing difficult, uncontrollable cognitive tasks in front of an evaluative audience (Kirschbaum et al., 1993). This frequently used stress task is designed to create a heightened sensitivity to being evaluated by others in a stressful performance context (Dickerson & Kemeny, 2004) and reliably elicits negative cognitive and emotional responses and physiological arousal (Kirschbaum et al., 1993). After completing the task performance (reactivity) phase, participants were given 5 min with no required activity (the recovery phase), providing an opportunity for them to ruminate about their performance on the task. As predicted, those in the training condition reported less ruminative thoughts after this self-threat compared with those in the control condition, averaged across posttest and follow-up, $F(1, 70.4) = 6.44$, $p = .01$

(Figure 1E). These results extend previous research showing that styles of thinking change following a mindfulness intervention (Teasdale et al., 2002) and indicate that the training can reduce negative self-evaluative thinking following a real threat to one's social esteem.

Laboratory stressor-physiological reactivity and recovery. Sympathetic and parasympathetic activity were measured both during the task performance reactivity phase of the TSST and during the 5-min recovery phase, immediately after the task. Blood pressure measures were used as indices of sympathetic cardiovascular response and were predicted to decrease in the training group. RSA was used as an index of parasympathetic activity, and was predicted to increase in the training group.

No group differences were found in DBP or SBP reactivity during the TSST. However, participants who practiced meditation more showed diminished BP reactivity during the task, compared with those who practiced less. Using residualized BP metrics to control for reactivity at baseline, greater reported meditation minutes was correlated with decreased DBP, $r(31) = -.51$, $p < .01$, and SBP, $r(31) = -.43$, $p < .05$, during the speech task at posttraining, and with decreased DBP, $r(30) = -.36$, $p < .05$, during the math portion of the TSST at follow-up (SBP nonsignificant). Note, however, that only the first correlation passes strict control for multiple comparisons (False Discovery Rate [FDR] threshold) at $p < .05$. All other correlations with meditation time were nonsignificant.

During TSST reactivity, no group differences were found in RSA reactivity. However, greater meditation practice was associated with decreased RSA in response to the math task at follow-up, $r(34) = -.58$, $p < .01$ (FDR corrected, $p < .01$), absent any association with respiration rate, $p = .19$. Decreased RSA during challenge may be reflective of an adaptive autonomic response, whereby effective parasympathetic withdrawal precedes the need for sympathetic increase (Porges, 2007). See Figure 2, A through D, for meditation minutes correlated with raw BP and RSA values, which are nearly identical to residualized values.

In relation to the TSST recovery period, the training group unexpectedly demonstrated greater DBP during the recovery period at the posttraining assessment, but lower DBP and SBP, as expected, at follow-up compared with the control group. The Group x Time interaction was significant for both DBP, $F(1, 47) = 7.22$, $p < .01$, and SBP, $F(1, 47) = 4.03$, $p = .05$, absent any main effects (Figure 3, A and B). In addition, during the TSST recovery period, RSA values displayed a trend toward a main effect for group, $F(1, 54.3) = 3.67$, $p = .06$. Post hoc tests revealed that differences in posttraining were significant, $F(1, 55) = 6.69$, $p = .01$, with the training group displaying a higher RSA residual than the control group, with effects appearing to normalize at follow-up (Figure 3C). These RSA effects were independent of change in respiration rate.

Overall, the training group was characterized by accelerated recovery from autonomic arousal due to a threat task (although
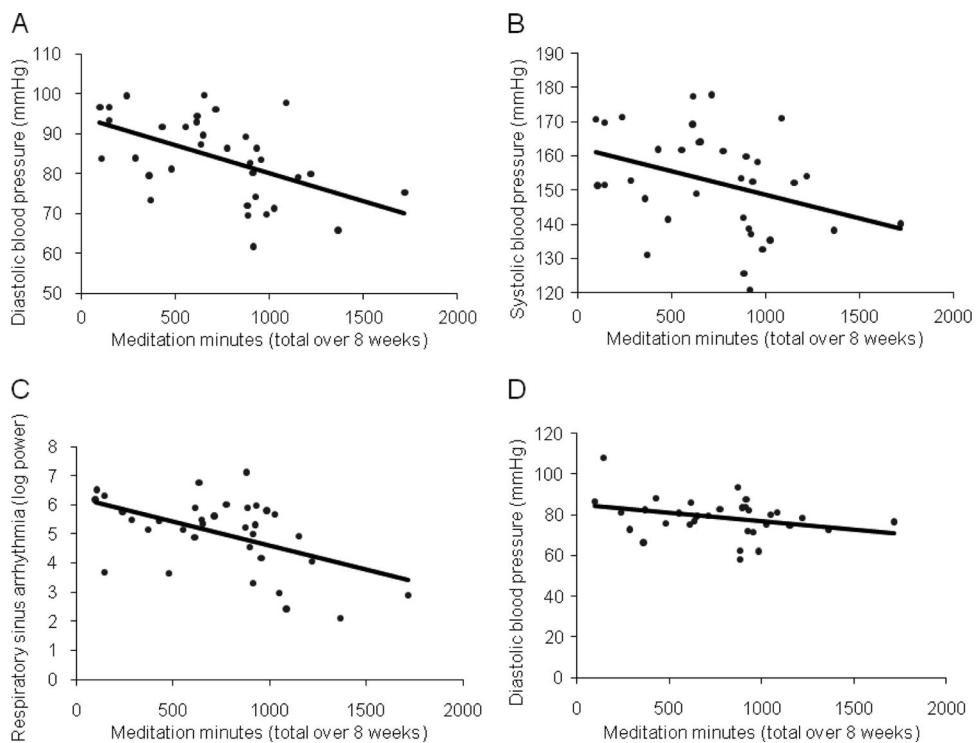
Figure 2. Scatterplots of (A) meditation minutes and diastolic blood pressure (DBP; mmHg) during speech task at posttest, $r(31) = -.51$, $p < .01$; (B) meditation minutes and systolic blood pressure (SBP; mmHg) during speech task at posttest, $r(31) = -.43$, $p < .05$; (C) meditation minutes and respiratory sinus arrhythmia (RSA; log power) during math task at 5-month follow-up, $r(34) = -.58$, $p < .01$; and (D) meditation minutes and diastolic blood pressure (DBP; mmHg) during math task at 5-month follow-up, $r(30) = -.36$, $p < .05$.
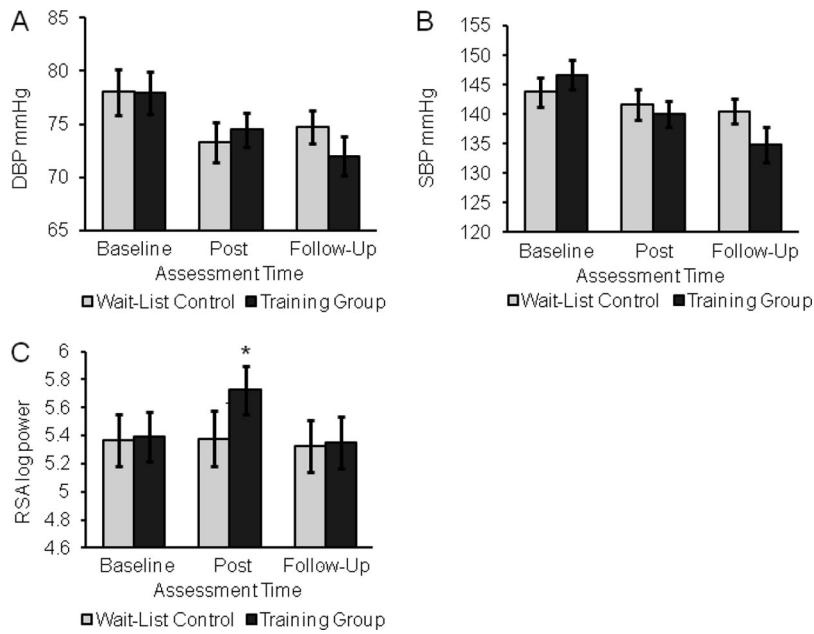
Figure 3. Comparison of the training and wait-list control groups during the *recovery* phase of the Trier Social Stress Test (Kirschbaum et al., 1993). Mean ($\pm SE$) of psychophysiological variables during baseline, post, and follow-up assessments in training and wait-list control conditions are displayed for (A) diastolic blood pressure (DBP), mixed linear models (MLM) interaction, $p < .01$; (B) systolic blood pressure (SBP), MLM interaction, $p = .05$; and (C) respiratory sinus arrhythmia (RSA), MLM main effect for group, $p = .06$, with post hoc tests demonstrating a significant difference at the post time point, $p = .01$, but not at follow-up, $p > .10$.

there was variation in the significance of the effect by task and time point), and also, for those who meditated more, diminished reactivity. While prior mindfulness interventions have shown effects on blood pressure, no randomized controlled trials of a mindfulness-based intervention have demonstrated accelerated recovery of blood pressure following an emotionally provocative social encounter.

Empathy, compassion, and hostility measures. A set of tasks were designed to capture changes in compassion, a prosocial response that involves both recognizing that another person is suffering and being motivated to reduce the suffering (Gilbert, 2005). To foster the first component of compassion—recognizing that another is suffering—the training program included instruction in recognizing microexpressions of emotion on the face (Ekman, 2004). Training participants increased their ability to recognize these subtle facial expressions of emotion, while the control group did not, $F(1, 76) = 7.30$, $p = .009$ (Figure 4A).

To measure the motivational component of compassion, a computerized lexical decision RT task (Mikulincer et al., 2002) was administered at the 5-month follow-up. The task involved subliminal presentation of images of suffering, called primes, which are images designed to elicit compassion only, compassion plus disgust, or neither or these. After each image, a letter string was presented (suggesting words related to compassion, disgust, neutral objects, or nonwords). The nature of a significant three-way interaction between Prime Type, Word Type, and Group, $F(6, 65) = 2.28$, $p < .05$, was clarified by contrasting RTs for identifying compassion-related words as words with RTs for identifying

disgust-related words as words, for the training versus control group, separately for each prime-type. The two-way interaction was significant only in the compassion prime condition, $F(1, 70) = 6.32$, $p < .05$: Following presentation of the subliminal compassion prime images, the training group was faster than the control group at recognizing compassion-related words (e.g., empathy, compassion) as words and slower than the control group at recognizing disgust-related words (disgust, sickening) as words. While the two-way effect was not significant for the disgust prime condition, as mentioned previously, the training group ($M = 708$) was faster than the control group ($M = 732$) in recognizing compassion words as words, $p < .05$ (Figure 4B). These findings suggest greater activation of a semantic network related to compassion in the training participants.

To capture the behavioral component of compassion, and its inverse, hostility and contempt, the Marital Interaction Task, developed by Gottman (Gottman, 1995; Gottman & Levenson, 1999) was conducted at baseline and at the posttraining assessment. For 15 min, each participant and her spouse or intimate partner discussed and attempted to resolve a difficult problem in their relationship while being videotaped. Trained raters coded these nonverbal expressions from the videotaped interactions using a standard procedure (Giese-Davis et al., 2005; Gottman, 1995). We predicted that two standard codes, behavioral hostility and contempt, would decrease in the intervention group compared with the control group, while a compassion composite code would increase. The intervention group remained relatively stable in behavioral hostility over time, while the control group increased in this
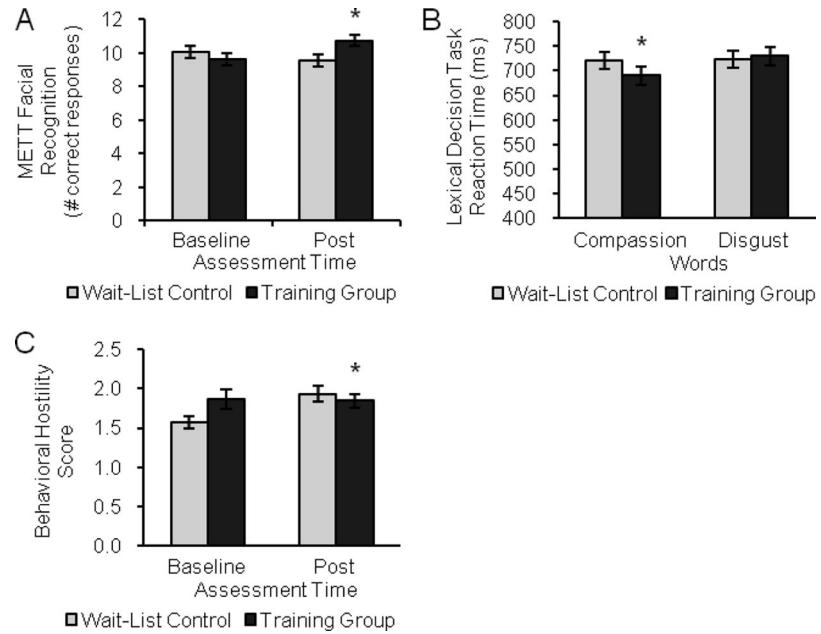
Figure 4. Comparison (mean $\pm$ *SE*) of the training and wait-list control groups on assessments of (A) Micro-Expression Training Tool at baseline and post (METT; Ekman, 2004), Mixed Linear Models (MLM), $p = .009$; (B) Lexical Decision Task at the follow-up assessment point (MLM, $p < .05$; reaction time was computed for correct responses in each word type [compassion, disgust, neutral, nonword] appearing after each prime type [images eliciting compassion, compassion and disgust, neutral]); and (C) behavioral hostility demonstrated during the marital interaction task at baseline and post assessments using SPAFF coding (MLM, $p < .05$). Note that this baseline difference is not significant. The analysis was conducted on the individual slopes of change (Gibbons et al., 1993) from the baseline to post using a hierarchical linear model; thus, the significant group differential change is not perfectly represented by the group means at each time point.

behavior from pretraining to posttraining, $F(1, 68) = 4.40$, $p = .04$ (Figure 4C). There was a similar trend for contempt, $F(1, 68) = 3.78$, $p = .06$. Having participated in one conflict task appeared to sensitize or prime the control group—but not the intervention group—to express more hostility when asked to discuss the same or similar issues a second time. We did not demonstrate significant differences between groups in compassionate behavior, and time meditating did not predict benefits.

Discussion

The evidence presented here indicates that a novel, intensive 8-week training program integrating secular forms of meditation practice, with information and techniques derived from the scientific study of emotion, can alter cognitive and emotional states and traits relevant to personal well-being and social cohesion. The current results also suggest that such an intervention is beneficial to individuals in the community (in this case, female schoolteachers), that individuals stay engaged over an intensive 8-week period (including four all-day sessions), and that the program can have lasting behavioral and physiological benefits.

Most of the effects observed at posttest that were also examined 5 months after the end of the training period were maintained. A number of recent randomized controlled clinical trials of meditation/mindfulness interventions have demonstrated psychological

benefits that extend beyond the immediate postintervention period (e.g., Grossman, D'Souza, Mohr, Penner, & Steiner, 2010; Segal et al., 2010; see Teasdale et al., 2002, for a series of clinical trials on long-term prevention of depression relapse). The current work complements and extends these findings, and suggests that such interventions can also have long-term behavioral and biological effects in healthy individuals (see also Davidson et al., 2003, for a randomized controlled trial with longer term neurophysiological effects). These extended emotional and physiological effects may explain some of the immune and other health benefits that have been observed in other studies of mindfulness-based interventions (e.g., Carlson, Speca, Patel, & Goodey, 2003).

This sample of healthy female schoolteachers had fairly high levels of self-reported negative affect when they enrolled in the study—in particular, depression. Negative affect was significantly reduced in those who received the training, and the effects were maintained 5 months after completion of the training program. For example, depression scores dropped by more than half in the training group from pretraining to posttraining. Similar changes were observed in the pilot study. These effects were complemented by demonstrated benefits with regard to other affective experiences (e.g., anxiety), as well as cognitive processes that elicit negative affect, specifically, rumination. Thus, this training program had effects on negative affect that are comparable to, or greater than, commonly employed techniques for reducing nega-

tive affect (e.g., cognitive–behavioral therapy; Dobson, 1989; Haby, Donnelly, Corry, & Vos, 2006).

The training program affected psychological and biological responses following a social self-threat (the TSST). Most individuals exposed to this task ruminate about their experience after the task ends and exhibit prolonged activation of stress-related physiological systems (Kirschbaum et al., 1993). At the posttraining assessment point, participants reported less ruminative thoughts following the threatening task. These findings extend prior work showing that mindfulness interventions can reduce basal levels of rumination (Jain et al., 2007) by demonstrating benefits even under conditions that strongly increase negative self-evaluative cognitions (the major form of ruminative thought during a self-threat; Kemeny, 2009).

Training participants also showed a quicker recovery of their sympathetic nervous system response by the follow-up point 5 months after the completion of the training. Thus, while training participants' relatively increased DBP at posttest is puzzling (yet the raw values are similar to the control group), there were long-term benefits of the training. Those who practiced meditation more frequently also showed lower blood pressure reactivity to a number of components of the stressor task. A number of mindfulness interventions have shown effects on basal blood pressure levels (Sudsuang, Chentanez, & Veluvan, 1991) and reactivity to less provocative tasks; however, much less is known about whether psychophysiological responses to real-world, strongly evocative social contexts, such as those included in the TSST, can be moderated by such interventions (see Pace et al., 2009, for a study that did not yield main effects on biological outcomes in response to this stressor paradigm of a less intensive intervention using different forms of meditation).

In addition, evidence for the induction of greater levels of restorative physiology (i.e., greater RSA) was demonstrated in the training group during the recovery period following the emotion provocation, although these effects were not maintained 5 months later. Immediate effects on basal RSA have been demonstrated in studies of short-term meditation-based interventions (Tang et al., 2009), but there is limited evidence that RSA responses during recovery from an emotional experience can be altered with these approaches.

The present findings add to the literature by suggesting plasticity in the recovery trajectory following stressors and emotional threats that is amenable to augmentation via meditation-based interventions. It is important to note that findings point to a greater impact of such interventions on recovery rather than reactivity to emotional provocation. These findings are consistent with very early studies conducted by Davidson, Goleman, and Schwartz (Goleman & Schwartz, 1976; Davidson & Schwartz, 1976) supporting the impact of meditation on recovery, habituation, and related processes. This pattern of results may be due to enhanced emotion regulation, involving a reduction in strong identification with the task-induced emotional reaction, thereby reducing its prolongation following termination of the emotional provocation (see Davidson, 2010). Reductions in overidentification with emotional experience is described in the meditation literature as a major goal of the practice of meditation (Wallace, 2005). Given the physical health consequences of maladaptive patterns of psychobiological responses to stress, including impaired recovery (McEwen, 1998), these findings could have health implications.

They also suggest that some forms of stress-related biological dysregulation may be amenable to prevention and/or treatment, thereby potentially ameliorating the long-term "wear and tear" that such repeated biological insults can have on the body, brain, and health (McEwen, 1998; Seeman, McEwen, Rowe, & Singer, 2001).

The intervention was also capable of increasing positive states of mind and positive behaviors. For example, the training group increased in trait positive affect and mindfulness. While the training participants reported significant gains in mindfulness, which were maintained through the 5-month follow-up, it is important to point out that the MAAS measure of mindfulness only captures awareness of the present moment. This measure does not assess nonjudgmental acceptance, which is another key aspect of most definitions of mindfulness. In this regard, the current study does not provide a comprehensive test of the intervention's effect on mindfulness.

The intervention also increased prosocial responses, including compassion, and affected negative social responses as well. Those who received the training demonstrated a greater ability to recognize facial expressions of emotion—a critical component of compassion—and, when presented with an image of a suffering individual, were more likely than controls to activate a semantic network related to compassion rather than disgust. This automatic form of responding is relevant to the motive to reduce others' suffering and may be amenable to enhancement through training. Compassion is valued within the Buddhist tradition, and meditation practice is believed to be capable of promoting such responses; these data support this premise. In the context of a provocative marital interaction task, hostile behavior was significantly less likely in the training group than in the control group at posttest. When instructed to resolve a difficult relationship problem, the training group appeared less susceptible to responding with enhanced negative behavior during the second encounter. These findings are important because hostile expressions during such marital interactions have been shown to be strong predictors of divorce (Gottman, 1995). Thus, prosocial responses can be enhanced and destructive emotional responses can be reduced with a meditation-based intervention.

Practice did not predict social behavior in the marital task or compassionate responding. Thus, these changes may not be dependent on amount of practice per se, or may have derived from the instruction in recognizing emotions in others or from other aspects of the curriculum that were drawn from emotion research. However, those who meditated more demonstrated greater reductions in physiological arousal to the self-threat task as well as lower trait anxiety and higher mindfulness.

One limitation of the study was the use of a wait-list control group rather than an active control condition. It is possible that other aspects of the intervention, such as the social aspects of class meetings, accounted for the intervention effects. The very large effect sizes for some variables, and the maintenance of many effects 5 months after training completion, may weaken the likelihood of this alternative explanation. That is it seems more likely that the specific skills and techniques taught during the training sessions would have such enduring effects rather than the social aspects of the class, which should be more transitory and dependent on continued social interaction. How-

ever, the lack of an active control condition is clearly a limitation of this study and should be employed in future studies. In addition, since the behavioral tasks were administered multiple times, it is possible that practice, sensitization, or other carry-over effects may have influenced the results. These issues are shared by most clinical trials using measures of behavior. Also, we suspect that such effects would depress or mute task responses over time, thereby reducing power to detect effects.

Overall, these findings support the results of recent neurophysiological research indicating that increased *awareness* of emotional experience may attenuate emotional arousal in a laboratory context (Herwig, Kaffenberger, Jancke, & Bruhl, 2010) and suggest that longer-lasting effects may derive from more extended training and practice in the skills and techniques that support greater awareness of mental experience. These findings are consistent with the theoretical premise that meditation practice can change one's *relationship* to one's mental experience and facilitate greater awareness that mental experiences are transient and are not fundamental reflections of the self (Watkins & Teasdale, 2001; see also Shapiro, Carlson, Astin, & Freedman, 2006). While traditional cognitive therapies emphasize the importance of *changing* dysfunctional or irrational cognitions in order to improve emotion and behavior, the fundamental premise in mindfulness-based therapies is that experiential avoidance of emotional experience is at the root of many psychological disorders (Teasdale et al., 2002). Effective therapy is believed to center on the acceptance of thoughts and feelings, a process facilitated by enhanced attention to, and awareness of, mental experience. Relating to thoughts and feelings as passing events in the mind—rather than identifying with them or treating them as necessarily accurate reflections of reality—allows individuals to disengage from automatic dysfunctional cognitive routines and reduce or prevent rumination, thereby reducing the likelihood of persistent negative affective experience (Segal, Teasdale, & Williams, 2004). The current findings extend this body of work by demonstrating that mindfulness-based interventions can directly impact emotional behavior, including in the context of emotional provocation. Future work is needed to determine if such benefits extend to other groups, such as males, individuals in professions other than teaching, and so forth.

Our findings indicate that secular versions of Buddhist meditation practices can be combined with knowledge and techniques derived from the scientific study of emotion to benefit individuals living outside the Buddhist tradition. In particular, the training appears capable of reducing "destructive" emotions and emotional behaviors, and the cognitive processes that provoke such responses, as well as increasing positive states of mind, such as positive affect, and prosocial responses, such as compassion. The very large effect sizes for some of the affective changes induced by this training suggest the potential utility of including a variety of contemplative practices into multimodal training programs, since practices, in addition to mindfulness, may play a key role in supporting and augmenting effects of mindfulness practice. Specifically, in accord with traditional Buddhist definitions of mindfulness, practices were included in this training that emphasized the cultivation of metacognitive discernment of beneficial and harmful states of mind. Such evaluative recognition may enable one to take steps to ameliorate harmful states and enhance beneficial ones. These findings are particularly timely because natural opportunities for reflection and contemplation may be diminishing in fast-paced, technology-focused urban cultures.

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Call for Papers: Special Section on Motor and Non-Motor Dysfunctions in Parkinson's Disease: Advances and Controversies

Guest Editor: Alice Cronin-Golomb

Behavioral Neuroscience is seeking papers for a special section highlighting recent progress in our understanding of the motor and non-motor symptoms of Parkinson's Disease (PD) and its subtypes. PD is characterized by the cardinal motor symptoms of tremor, rigidity, akinesia or bradykinesia, and impairments of posture, gait, and balance, as well as less ubiquitous but nevertheless disabling motor abnormalities such as dyskinesias. The non-motor symptoms of PD have been receiving increased attention in recent years in acknowledgment of their significant impact on the quality of life of patients with this disorder. Examples of these symptoms include disturbances of cognition, sensation and perception, mood, motivation, behavioral inhibition, sleep, and autonomic function.

Much remains to be learned about the etiology, clinical presentation, course, treatment, and neurological substrates of these motor and non-motor symptoms. One approach to their investigation is consideration of PD subtypes. Subtypes that are currently being studied include side of disease onset or side of current symptom predominance, type of initial motor symptom (e.g., tremor, rigidity, disturbances of posture and gait), predominant cognitive profile (frontal-type, parietal-type, with or without dementia), gender, and presence or absence of specific genes (e.g., parkin, LRRK2, COMT, MAPT).

The special section will focus primarily on the relation of motor and non-motor symptoms of PD to disease subtypes. This section will provide an international forum for researchers to report their most recent findings in the area. Topics to be covered may include, but are not limited to:

- Motor symptoms, including tremor, rigidity, akinesia or bradykinesia, disturbances of posture, gait, and balance, dyskinesias
- Cognition, including dementia as well as cognitive function in the absence of dementia
- Sensation
- Perception, from lower-level to higher-level processes, including hallucinations
- Depression, anxiety, apathy, and other aspects of mood and motivation
- Behavioral inhibition, including impulse control disorders
- Sleep, including sleep quality and REM behavior disorder
- Autonomic function
- Prodromal appearance of non-motor symptoms
- Pathological substrates
- Relation to neurotransmitters or sex hormones

Manuscripts should be submitted as usual through the APA Online Submission Portal (http://www.apa.org/pubs/journals/bne). The cover letter should indicate that the authors wish the manuscript to be considered for publication in the special section on Parkinson's Disease. Reviewer suggestions are strongly encouraged. Manuscripts must be received by **June 1, 2012**.

Inquiries can be directed to the Guest Editor, Alice Cronin-Golomb, at alicecg@bu.edu.