Emotion

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Meditation practices purportedly help people develop focused and sustained attention, cultivate feelings of compassionate concern for self and others, and strengthen motivation to help others who are in need. We examined the impact of 3 months of intensive meditative training on emotional responses to scenes of human suffering. Sixty participants were assigned randomly to either a 3-month intensive meditation retreat or a wait-list control group. Training consisted of daily practice in techniques designed to improve attention and enhance compassionate regard for others. Participants viewed film scenes depicting human suffering at pre- and posttraining laboratory assessments, during which both facial and subjective measures of emotion were collected. At postassessment, training group participants were more likely than controls to show facial displays of sadness. Trainees also showed fewer facial displays of rejection emotions (anger, contempt, disgust). The groups did not differ on the likelihood or frequency of showing these emotions prior to training. Self-reported sympathy—but not sadness or distress—predicted sad behavior and inversely predicted displays of rejection emotions in trainees only. These results suggest that intensive meditation training encourages emotional responses to suffering characterized by enhanced sympathetic concern for, and reduced aversion to, the suffering of others.

Keywords: compassion, emotion, facial expression, meditation, FACS

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Many contemplative traditions promote the development of concern for the welfare of others (Salzberg, 2002; Wallace, 1999). Extended training in meditation that emphasizes values such as compassion and kindness is likely to affect one's emotional responses to the suffering of others. Short-term training in compassion meditation increases helping behavior among naïve practitioners (Condon, Desbordes, Miller, & DeSteno, 2013; Leiberg, Klimecki, & Singer, 2011; Weng et al., 2013) and leads to changes in neural and subjective responses to others' suffering (Desbordes et al., 2012; Lutz, Slagter, Dunne, & Davidson, 2008; Weng et al., 2013). To our knowledge, however, no one has examined the longitudinal effects of intensive meditation training on direct measurements of emotional behavior. Such training is expected to increase one's concern for others, which should manifest in how one responds emotionally to human suffering. In the study reported here, we examined the effects of intensive meditation training on emotional responses to filmed scenes of suffering.

Contemporary psychological accounts often conceptualize meditation practice as a process of mental development involving the cultivation of stable attention and improved behavioral regulation (Lutz et al., 2008; Slagter, Davidson, & Lutz, 2011). These accounts highlight an important class of meditation practices, *shamatha* meditation, which is traditionally thought to develop stable, focused, clear attention (Wallace, 2006). Training that incorporates shamatha and related focused-attention meditation techniques appears to improve perceptual discrimination (MacLean et al., 2010), attentional stability and vigilance (Lutz et al., 2009; MacLean et al., 2010; Zanesco, King, MacLean, & Saron, 2013), response inhibition (Sahdra et al., 2011; Zanesco et al., 2013), and the efficiency of working memory (van Vugt & Jha, 2011). This literature, however, often fails to contextualize this training in terms of supporting the compassionate behavior and psychological well-being of the practitioner, objectives that are central to the goals of traditional meditation training (Ricard, 2010).

Traditionally, meditation training occurs within an ethical context of nonharming and benevolent concern for others. This training often includes explicit practice of ancillary techniques aimed at developing altruistic aspirations for self and others (Goldstein & Kornfield, 2001; Trungpa, 2010; Wallace, 2006). Despite these elements, empirical research evaluating the effects of meditation practice has generally been concerned with characterizing cognitive outcomes (e.g., Hölzel et al., 2011; Lutz et al., 2008; Slagter et al., 2011), treating psychological disorders (Hofmann, Sawyer, Witt, & Oh, 2010), or the reduction of stress (e.g., Baer, 2003; Chiesa, & Serretti, 2009). Less acknowledged, but essential to the goals of contemplative practice, is the development of motivational and emotional traits relevant to compassion (Desbordes et al., 2014; Halifax, 2012; Shaver, Lavy, Saron, & Mikulincer, 2007). Meditation practitioners thus often engage in aspirational and emotion-generative practices intended to develop several qualities of emotional and moral engagement: loving-kindness, compassion, empathetic joy, and equanimity. These practices, known collectively in Buddhist literature as the *four immeasurables* (FI; Wallace, 1999), may each be important in promoting lasting changes in emotional and psychological functioning (Ekman, Davidson, Ricard, & Wallace, 2005; Wallace & Shapiro, 2006).

FI techniques employ visualizations and aspirations for the welfare of oneself and others with the aim of generating beneficent feelings and motivational states including empathy, joy, loving-kindness, and compassion. During practice, these benevolent aspirations are extended outward, moving from oneself to close personal acquaintances and attachment figures, then to strangers, adversaries, and eventually all beings (Salzberg, 2002; Wallace, 1999). The progressive expansion of the circle of individuals for whom one feels concern may aid the development of trait extensivity—the predisposition to feel empathic concern for all people (Einolf, 2010). As experience with these practices grows, empathic concern and compassion explicitly generated during practice should foster the development of enduring positive psychological traits and prosocial behavior. Thus, training in FI techniques may strengthen compassionate attitudes and motivate altruistic behavior, but the mechanisms of these changes are not well understood.

Consistent with studies of attachment-security priming (Mikulincer et al., 2001; Mikulincer & Shaver, 2007; Shaver et al., 2007), mental representations related to safety, care, and love may be activated during a session of FI meditation, which may prime feelings of connectedness and help establish motivations for compassion-relevant outcomes (Sahdra & Shaver, 2013; Shaver et al., 2007). In support of this idea, Hutcherson, Seppala, and Gross (2008) asked participants to engage in a brief, computerized loving-kindness exercise (based on Salzberg, 2002) involving imagining a loved one, feeling their love, and then directing their benevolent aspirations to a neutral stranger with whom one had no previous connection. Following this exercise, participants reported feeling greater levels of social connectedness toward this stranger than did control participants who were asked to focus only on the visual details of a picture of the stranger. Thus, aspirational meditations may activate mental representations related to loving-kindness that increase the salience of benevolent wishes for the welfare of others. Over time, such self-generated feelings toward others may have pervasive effects on the enduring mental representations that practitioners maintain of others. This may be one way in which contemplative training facilitates the development of stable psychological traits that promote the spontaneous or deliberate generation of compassionate responses in daily life and strengthen the intrinsic motivation to alleviate others' suffering.

FI practices, such as loving-kindness and compassion meditation, have received modest empirical attention in recent years. Both appear to affect emotional and prosocial outcomes (Hofmann, Grossman, & Hinton, 2011). Loving-kindness meditation reduces self-reported negative affect and increases ratings of positive emotion and perceived interpersonal connection (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Hutcherson et al., 2008), reduces implicit bias against commonly stigmatized groups (Kang, Gray, & Dovidio, 2014), and may be associated with a number of health-relevant physiological indicators, such as immune function (Pace et al., 2009), telomere length (Hoge et al., 2013), and vagal tone (Kok et al., 2013). Similarly, compassion meditation practice improves performance on emotion recognition tasks (Kemeny et al., 2012; Mascaro, Rilling, Tenzin Negi, & Raison, 2013), increases self-reported compassion for self and others (Jazaieri et al., 2012; Kemeny et al., 2012; Mascaro et al., 2013), and leads to improvements in self-reported emotion regulation (Jazaieri et al., 2014). Brief compassion training influences subjective reports of emotion to film depictions of individuals in distress (Klimecki, Leiberg, Lamm, & Singer, 2013).

Compassion meditation also influences various laboratory and real-life prosocial outcomes after brief or nonintensive training. Leiberg, Klimecki, and Singer (2011) developed a computer game to examine whether short-term compassion-based meditation training would increase helping behavior in meditation-naïve individuals. Following a day of intensive compassion meditation and several hours of practice at home, training participants demonstrated more helping behavior in the game than did controls. In another study, people who had just completed an 8-week compassion or mindfulness meditation course were more likely than controls to offer their seat to a person in need (Condon et al., 2013). Finally, Weng et al. (2013) had participants complete either 2 weeks of computer-based audio compassion meditation training or learn distress reappraisal techniques. Compassion training led to more altruistic behavior toward disenfranchised victims encountered outside the laboratory. Later, training participants engaged in a directed compassion meditation while viewing images of human suffering. Neuroimaging data revealed activations in brain regions thought to support empathy and perspective taking, which in turn predicted helping behavior.

One empirical challenge in such research is to distinguish immediate influences on behavior (e.g., social desirability to engage in helping behaviors) from underlying constitutional changes in the salience of and responsiveness to the welfare of others. We believe spontaneous emotional responses to the perception of suffering in others may reflect trait-level changes in affect that underlie helping-based outcomes. Training in shamatha meditation and the FI would be expected to encourage emotional responses that promote prosocial acts perhaps by influencing the ethical priorities brought forward during encounters with suffering. That is, such training should influence one's motivations toward action, which may be expressed in both affect and behavior.

Various affective antecedents to prosocial behavior have been described (e.g., Decety & Ickes, 2011; Penner, Dovidio, Piliavin, & Schroeder, 2005) and have been broadly conceptualized as *empathic concern* (Batson, 2009). Other-oriented feelings of empathic concern, such as sympathy and compassion, increase one's willingness to act to reduce another's suffering (Eisenberg et al., 1989; Goetz, Keltner, & Simon-Thomas, 2010). In contrast, aversive states such as personal distress increase emotional or physical distance between oneself and the individual in need (Batson, Fultz, & Schoenrade, 1987; Eisenberg et al., 1991) and reduce the likelihood of prosocial action. Overall, this literature has highlighted the critical role of emotional reactions to suffering in fostering prosocial behavioral outcomes.

Based on our interest in how meditation training might influence the affective antecedents of prosociality, we examined the effects of 3 months of intensive, full-time *shamatha* meditation training on emotional responses to human suffering. Primary training in shamatha techniques was complemented by practice of the *four immeasurables*. Pre- and posttraining we measured spontaneous emotional facial behavior and self-reported affect to evocative film scenes depicting perpetrators of violence and victims of violent acts. We expected intensive meditation training to increase the likelihood of emotions consistent with, and diminish emotions inconsistent with, compassionate concern for others. It is likely that attention training through meditation practice alters emotional processes as practitioners learn to attend to and regulate their internal states (Chambers, Gullone, & Allen, 2009; Rosenberg, 2013; Wadlinger & Isaacowitz, 2011; Wallace & Shapiro, 2006). Intensive focused-attention training, supported by an ethical framework based on the importance of reducing suffering and reinforced by FI practice, should alter patterns of emotional response to others' suffering.

Research on empathic concern suggests that concern for others manifests differently depending on whether one empathizes with, or is overly distressed by, a target's predicament. Self-reports of sympathy, sadness, and personal distress have been implicated as important motivators that either promote or forestall helping behaviors (Batson et al., 1987; Eisenberg et al., 1989; Hodges, Kiel, Kramer, Veach, & Villanueva, 2010). In particular, sympathy is characteristic of empathic concern, whereas reports of feeling "worried" or "perturbed" occur in individuals who are personally distressed by others' suffering but not necessarily motivated to offer active help. Behaviorally, the lifting of the inner corners of the eyebrows, a facial configuration long identified as a behavioral marker of sadness (Ekman et al., 1987), is associated with helping behavior and self-reported sympathy (Eisenberg et al., 1989), and has also been linked to states of felt compassion (Goetz et al., 2010; Haidt & Keltner, 1999). Specifically, we expected to observe more facial displays of sadness and more self-reported sympathy in response to scenes of suffering in individuals who underwent training.

Additionally, we expected training-related decreases in emotions that are presumably antithetical to prosociality, a group of affects we call *rejection emotions.* Operationally, we defined rejection emotions as anger, contempt, and disgust—a triad of emotions that has been recognized as relevant to hostility (Izard, 1977) and as moral emotions that reflect how a person regards others (Hutcherson & Gross, 2011; Rozin, Lowery, Imada, & Haidt, 1999). Such feelings of hostility run counter to the concerned, compassionate stance developed through contemplative training (The Dalai Lama & Ekman, 2008; Wallace, 1999). These rejection emotions also reinforce a strong separation between self and other (Lazarus, 1991), standing in stark contrast to the increased inclusiveness cultivated by FI practice. Based on the philosophical perspective of the teachings from which these practices originate (cf., The Dalai Lama, 1999), we use the term *rejection* as the opposite of *engaging with* what is at hand, however infuriating, immoral, or repulsive it might first appear to be. Intensive meditation training would be expected to enable one to remain engaged with the experience of observing suffering without becoming overwhelmed, a process that ultimately becomes a part of and is reinforced by meditation practice itself. We therefore predicted fewer rejection emotions in meditators compared with controls, as well as an inverse relationship between rejection emotions and self-reported sympathy following training.

Method

Participants

We recruited experienced meditators (requiring a minimum of three 5–10 day prior retreats) through advertisements in Buddhist magazines, postings at meditation centers, and via e-mail lists. Of 142 applicants, 60 participants met inclusion criteria (see Sahdra et al., 2011, for details), including absence of Axis I psychiatric disorders (Mini International Neuropsychiatric Interview screen;

Sheehan et al., 1998). Participants were assigned by stratified random procedures to either the training ($n = 30$) or wait-list control ($n = 30$) conditions. The groups were matched on sex (32 women), meditation experience ($M = 13$ years), and age ($M = 48$ years, range = 22–69) and did not differ in mean education level, marital status, or annual household income (see MacLean et al., 2010; Sahdra et al., 2011, for full demographics and group matching information). All procedures were approved by the Institutional Review Board of the University of California, Davis. Participants gave informed consent at study onset for all procedures including video recording and were debriefed at the end of each group's respective training period.

Design

All assessments and training occurred at Shambhala Mountain Center in Red Feather Lakes, CO, where training-group participants resided during the 3-month meditation retreat. All participants completed on-site laboratory assessments that included an extensive battery of cognitive and affective tasks over two days at the beginning, middle, and end of the 3-month period. At each assessment, control participants were flown to the retreat center for on-site testing and returned home between assessments. These wait-list control participants later received formally identical training at the same location, taught by the same teacher, 3 months following the completion of the first training period. Here we report data from the training and matched control groups obtained during the initial 3-month retreat.

Meditation Training

The meditation training included instruction and practice in both shamatha and FI meditation techniques taught by B. Alan Wallace, an established Buddhist teacher, contemplative, and scholar (Wallace, 1999, 2006, 2011). Participants met as a group with Dr. Wallace for instruction, guided practice, and discussion every morning and evening. They were instructed and encouraged to use their remaining time on meditation practice. Participants were free to determine the amount of time dedicated to each type of practice in consultation with Dr. Wallace. At the end of each day, they recorded the duration and type of practice for each meditation session in daily journals. Participants devoted the majority of their solitary meditation time to shamatha ($M = 5.67$ hr per day, $SD = 1.31$), and less time to the practice of the FI techniques ($M = 0.68$ hr per day, $SD = 0.30$). Shamatha practices entail relaxing and focusing one's attention on a sensory or mental object (e.g., the sensation of the breath at the nostrils). While mindfully sustaining attention on this object, one seeks to monitor the quality of attention, detecting distraction or lethargy when they occur, and then refreshing focus as necessary. Although the training was not a standardized, structured protocol, it drew on well-established Buddhist contemplative practices described in Dr. Wallace's books (Wallace, 1999, 2006, 2011; see also Sahdra et al., 2011, for a more detailed description of specific training techniques employed).

In addition to shamatha practice, training participants received instruction in and practiced four aspirational and emotion-generative exercises that comprise the four immeasurables (FI): loving-kindness, compassion, empathetic joy, and equanimity (Wallace, 1999). In the training of *loving-kindness* one uses imagery and repetitions of silent aspirational phrases of kindness (e.g., "May you find happiness and the causes of happiness") to extend wishes for well-being to the imagined targets. This practice is intended to promote aspirations of benevolence and counteract enmity. For the training of *compassion* one brings to mind the suffering of another, allows oneself to be moved by that suffering, and then cultivates wishes for this person's relief from suffering and its causes. This training is thought to counteract cruelty and aloof indifference. During the training of *empathetic joy* practitioners are instructed to bring to mind target individuals who are experiencing good fortune. The meditator's task is to delight in the good fortune of the target, which is intended to counteract envy. *Equanimity* practices involve seeing loved ones, strangers, and adversaries as fundamentally similar to oneself, while wishing them all to be free of suffering and to find happiness. The practice of equanimity is intended to cultivate an empathetic sense of interdependence with an ever-widening circle of people, working against bias and prejudice. These FI practices are rooted in empathy, which requires the cognitive basis of recognizing others as persons basically the same as oneself, who also wish for happiness and for freedom from suffering (Wallace, 1999).

Experimental Procedures

Each participant completed a film-viewing procedure at the beginning and end of the 3-month training period, as part of the pre- and posttraining assessment sessions. Films were presented using Presentation experimental control software (www.neurobs.com), on a 22" monitor (Viewsonic VX-22) with stereo speakers and subwoofer (Altec Lansing VS4221). Participants sat close to the monitor (54 cm) in a dimly lit testing chamber to create an immersive experience. They were video-recorded during film viewing using a hidden Panasonic AWE-350 camera and recorded on DVCAM tape (Sony DSR-11) for offline coding. Although participants were informed during consent that physiological measures, behavior, and facial expressions would be monitored, video recording was unobtrusive to reduce the likelihood of self-conscious behavior. Facial records of some participants were lost due to recording error, yielding a final sample of 56 for preassessment and 58 for postassessment. Participants passively viewed a practice film and then two experimental films. These were followed by a clip intended to induce a mildly pleasant mood on completion of this phase of the laboratory testing. Immediately after viewing each experimental clip, participants were cued to provide ratings of emotions they experienced during the video (see Measures: Subjective Ratings for details). Due to the time-intensive process of facial coding, we investigated the second experimental film shown at each assessment only, as initial review suggested that these films produced the most facial behavior and in pilot testing elicited the strongest self-reported sadness and rejection emotions. Concurrent noninvasive electrophysiological measures were also obtained, for analyses to be reported elsewhere.

Selection of Film Stimuli

Film stimuli depicted a range of themes relevant to human suffering, such as war, injury, death, decay, and socially undesirable acts such as threat of murder or glee in killing. To select a

subset of films for inclusion in the experiment, we showed a series of pilot clips to undergraduates and experienced meditators, after which E.R. coded all the facial behavior. Although we could not quantitatively assess these pilot data due to the sparseness of facial behavior, we inspected the data and selected films that elicited adequate variability of emotional displays to allow for testing of our hypotheses.

At preassessment the analyzed film segment (2:29 min) was taken from the film *Crash* (Haggis & Reimer, 2004). The clip consisted of scenes of a man threatening a father with a gun, the father witnessing what he thinks is the shooting of his young daughter in his arms, and the initial remorse of the gunman who also believes the child had been shot. The postassessment clip (2:12 min), selected from the documentary *Fahrenheit 911* (Moore & Weinstein, 2004), depicted scenes from the Iraq war. The clip showed young American soldiers explaining how they listened to heavy metal music to prepare to "kill the enemy," followed by scenes of bombing, injured children, rotting corpses, and, ultimately, different soldiers expressing remorse for their actions. Although thematically distinct, both clips presented diverse and powerful images of human suffering and included perpetrators and potential victims of violent acts.

Measures

Facial behavior. We coded all discernible facial behavior displayed during film viewing using the Facial Action Coding System (FACS, Ekman, Friesen, & Hager, 2002). FACS exhaustively describes all observable facial behavior in terms of the muscular actions that comprise it, using elements called *action units* (AUs). Each AU, designated by an arbitrary numeric code, denotes the movements of an underlying facial muscle group. FACS coders noted the occurrence of individual AUs displayed during the film-viewing period, as well as the timing of each AU's onset, apex, and offset. Coders did not make explicit judgments about emotions; rather, they indicated the incidence and intensity of all observable facial behavior on the basis of elemental actions of the facial musculature (i.e., any AU that occurred on the face). We used co-occurring apex time windows to determine which AUs occurred simultaneously on the face. All emotion interpretation was conducted postcoding (after all de-identified videos were coded) on these facial *events*; that is, the combinations of AUs that peaked simultaneously (as per Cohn, Ambadar, & Ekman, 2007; Ekman et al., 2002).

Emotion interpretation was conducted in a separate step, after completion of behavioral coding of all data for both films. We sorted the AU-based descriptions of facial events (compiled with no identifying information about participants or conditions) into emotion and nonemotion categories using guidelines published in the FACS Manual Investigator's Guide (Ekman et al., 2002) as well as a computerized dictionary of events[1] based on the guidelines of the Emotion FACS Dictionary (Ekman & Friesen, 1982). This dictionary and similar versions have been used for decades in both basic and applied studies of emotion and facial behavior across a number of different laboratories (cf., Berenbaum & Oltmanns, 1992; Ekman, Davidson, & Friesen, 1990; Keltner, 1995; Matsumoto & Willingham, 2006; Rosenberg & Ekman, 1994; Rosenberg, Ekman, & Blumenthal, 1998; Rosenberg et al., 2001; Ruch, 1995). We further refined interpretations based on theoretical and empirical developments regarding facial signs of sympathy and concern (Eisenberg, McCreath, & Ahn, 1988; Goetz et al., 2010; see Table 3, p. 359).

The prototypical sadness display involves a core configuration of upper face actions, which may or may not be accompanied by lower face actions (*FACS Investigator's Guide,* Ekman et al., 2002). A crucial component of this expression involves lifting of the inner corners of the eyebrows (*frontalis, pars medialis,* FACS *AU1*), which creates an oblique appearance to the brows. This may or may not be accompanied by pulling of the brows together (*corrugator supercilii, AU4*), depressed lip corners (*depressor anguli oris, AU15*), and pulling up of the chin boss (*mentalis, AU17*). Sad displays may also include lifting of the upper cheeks (*orbicularis oculi, pars orbitalis, AU6*) or deepening of the middle portion of the nasolabial furrow (*zygomaticus minor, AU11*). Although the prototypical sadness display contains all of these features, the full prototype is not required for classification in the sadness family of emotions (cf., Ekman et al., 2002). We utilized conservative classification criteria; all faces classified as sadness contained—at a minimum—contraction of *frontalis, pars medialis*, whether or not accompanied by lower face sadness actions. It is important to note that use of the "sadness" label for this set of facial configurations draws on literature showing that such displays are shown spontaneously in what are typically judged as sad situations (such as bereavement, cf., Bonanno & Keltner, 1997) and relate predictably to self-reports of sadness in various research contexts (e.g., Keltner, Moffitt, & Stouthamer-Loeber, 1995).

Anger is also observed in the upper and lower face. In anger, the brows are lowered and pulled together (*AU4*), the lower eyelid is tightened (*orbicularis oculi, pars palebralis, AU7*), and the upper eyelid is raised (*levator palpebrae superioris, AU5*). Lower face actions involve lip tightening, narrowing, or pressing together (*orbicularis oris, AUs 23* and *24*, respectively). Although the anger prototype contains both upper and lower face actions, facial events containing core actions in either the upper or lower face have been identified as anger in research contexts and occur spontaneously in anger-relevant situations (e.g., Keltner, Moffitt, & Stouthamer-Loeber, 1995; Krumhuber & Scherer, 2011). We categorized any occurrences of these core upper face and/or lower face actions as anger (Ekman et al., 2002). The most reliable marker for contempt is a unilateral or asymmetrical tightening of the lip corners (*buccinator; AU14*, Matsumoto & Ekman, 2004). We used these criteria to categorize contempt. Finally, we classified events as disgust expressions if they were marked by wrinkling of the nose (*levator labii superioris, alaeque nasi, AU9*), either alone or accompanied by lifting of the upper lip (*levator labii superioris, caput infraorbitalis, AU10*). This configuration has been linked with self-reports of disgust and disgust elicitors (Chapman, Kim, Susskind, & Anderson, 2009; Ekman, Friesen, & Ancoli, 1980; Rosenberg & Ekman, 1994; Rozin, Lowery, & Ebert, 1994).

Two certified FACS coders (A.P.Z. & B.G.K.) independently coded all facial behavior, with reliability assessed on a randomly selected subset of records (~30%) scored separately in their entirety by both coders. For this shared subset of records, we computed kappa coefficients on AU apices individually for each AU of

[1] Robert Levenson of U. C. Berkeley developed this program, the use of which is available to any researcher with FACS codes to interpret.

interest (i.e., AUs involved in sadness or rejection displays), using a continuous moving window with a tolerance of 60 frames (sampled at 30 frames-per-second; see Sayette, Cohn, Wertz, Perrott, & Parrott, 2001). We then calculated pooled kappas (De Vries, Elliott, Kanouse, & Teleki, 2008) across AUs relevant to each emotion category: sadness behaviors $kappa_{pool} = 0.69$; rejection behaviors $kappa_{pool} = 0.68$; pooled across all rejection and sadness behaviors, $kappa_{pool} = 0.67$. In addition to this reliability procedure, a FACS expert (E.L.R.) coded a subset of the records (10%) for accuracy checking and to resolve reliability disagreements. This checking procedure was conducted at regular intervals throughout the coding process to ensure that all coders were in agreement regarding FACS procedures. Following the assessment of reliability, all three coders arbitrated any disagreements from the subset of jointly coded clips, with the FACS expert, E.L.R., resolving any lingering disagreements. E.L.R. was completely blind to experimental condition. A.P.Z. and B.G.K. were involved in data collection and were not blind to experimental condition during coding procedures.

Subjective ratings. Following each film, participants rated their emotions using a modification of Rosenberg and Ekman's (1994) cued-review procedure. Participants viewed a visual storyboard of film scenes to cue film content and were instructed to use this visual guide to recall their emotional experience during film viewing. Each storyboard consisted of numbered still frames from the film, sampled every 2 s, to be used in conjunction with an emotion-rating grid. This rating grid consisted of 14 emotion terms (amusement, anger, confusion, contempt, contentment, disgust, distress, embarrassment, fear, happiness, relief, sadness, surprise, sympathy), which participants rated on a scale from 0 (*not at all*) to 8 (*extremely*). Participants were instructed to report on their experience at any frame they recalled feeling a change in the intensity or type of emotion experienced and to rate all pertinent emotion terms for each such frame. In all analyses, individual ratings were extended across unrated frames and averaged across the film to calculate summary ratings for each self-reported emotion. Thus, we obtained mean ratings for each emotion term for each individual for each film.

Data Analytic Approach

We expected differences between the training group and the control groups in measures of facial behavior and reports of emotional experience. We tested whether the groups differed at both pre- and postassessment, expecting differences at postassessment only. We computed counts of hypothesis-relevant facial configurations for each participant. Counts of behaviors commonly produce positively skewed distributions. Count data may also exhibit zero inflation, due to an excess number of zeros. For instance, many individuals may not display a particular type of emotional facial behavior at all, leading to an inflated number of nonresponses in the distribution. Therefore, we used Poisson regression models, generalized linear models that account for the discrete properties common to count data (Cameron & Trivedi, 1998). The Poisson model may be extended to include a second, binary logistic component to account for the zero inflation. In these two-part models, predictors may be included in both the zero-inflated logistic and Poisson count portions to predict: (a) the likelihood of belonging to the distribution of nonresponders, or (b) the frequency of behaviors that occurred, respectively.

To analyze emotional behavior we employed zero-inflated Poisson models using the *pscl* package in R (Zeileis, Kleiber, & Jackman, 2008). Parameters were estimated using maximum likelihood. First, we tested group differences in emotional behavior by including group membership (control = 0, training = 1) as a predictor in separate analyses for pre- and postassessment. For any significant group differences, we then tested associations between self-reported affect and emotional behavior. We included self-reported affect (sympathy, sadness, distress) and the interaction with group membership as predictors in separate models for each affect term. In all analyses we examined whether a standard Poisson model indicated a better fit to the data than a zero-inflated Poisson model using a Vuong likelihood ratio test of non-nested models (Vuong, 1989). The zero-inflated Poisson model yielded a better fit in all cases except for counts of overall emotional behavior. One participant was excluded from the preassessment analysis of sadness facial displays based on guidelines proposed for outliers in skewed and zero-inflated count distributions (Yang, Xie, & Goh, 2011). One participant was excluded from self-report analyses due to a failure to comply with instructions.

Results

Emotion Ratings

We first examined self-reports of emotion for each film. The films elicited a variety of emotions at varying intensities, as shown in Table 1. In general both films elicited relatively high levels of distress, sadness, and sympathy, and low levels of positive affect. In addition, the post assessment film elicited relatively high levels of anger and disgust. A MANOVA revealed no group differences in emotional ratings at either the preassessment, $F(14, 41) = 0.762$, $p = .701$, or the postassessment, $F(14, 42) = 0.884$, $p = .581$. Ratings and pairwise comparisons of individual emotion terms are reported in Table 1. No group differences survived correction (false discovery rate) for multiple comparisons.

Overall Emotion Behavior

To determine whether training affected emotional behavior generally, we examined group differences in a global measure of emotional expressivity. We summed all facial events classified as an emotional facial behavior (cf. nonemotional facial behavior) to create a total emotional behavior count for each participant. A Poisson regression, $\chi^2(1) = 6.992$, $p = .008$, revealed that group membership predicted the total number of emotion displays observed during the preassessment film. This parameter, $\beta = 0.194$, $p = .008$, indicates that the retreat group showed more emotion overall at the preassessment. The model at postassessment was not significant $\chi^2(1) = 0.821$, $p = .365$, in that groups did not differ on overall number of emotion displays after the training period, $\beta = 0.075$, $p = .365$. These analyses suggest that training participants showed more emotional facial behaviors at the preassessment (training group, $M = 16.86$, $SD = 14.42$; control group, $M = 13.58$, $SD = 11.26$) but not at the postassessment (training group, $M = 10.55$, $SD = 9.21$; control group, $M = 9.79$, $SD = 8.57$).

Table 1
Means and Standard Deviations for Self-Reported Emotions

Emotion	Preassessment				Postassessment			
	Training	Control	*t*	*p*	Training	Control	*t*	*p*
Amusement	0.15 (0.38)	0.29 (0.52)	1.13	.26	0.89 (1.88)	0.29 (0.51)	1.63	.11
Anger	1.18 (1.64)	1.01 (1.18)	0.43	.67	2.71 (2.19)	2.47 (1.57)	0.48	.63
Confusion	1.83 (1.74)	2.03 (1.75)	0.41	.68	1.28 (1.55)	0.73 (1.09)	1.54	.13
Contempt	0.50 (1.13)	0.73 (1.46)	0.67	.51	1.50 (1.67)	1.84 (1.55)	0.81	.42
Contentment	0.38 (0.57)	0.38 (0.48)	0.05	.96	0.36 (0.83)	0.35 (0.53)	0.08	.94
Disgust	0.70 (1.28)	1.00 (1.37)	0.86	.40	3.01 (2.00)	2.73 (1.31)	0.60	.55
Distress	2.95 (2.04)	3.15 (1.55)	0.40	.69	4.14 (1.94)	3.41 (1.72)	1.52	.13
Embarrassment	0.03 (0.16)	0.03 (0.07)	0.11	.91	2.18 (2.24)	0.98 (1.29)	2.46	.02
Fear	2.58 (1.78)	2.98 (1.65)	0.87	.39	1.83 (1.81)	1.41 (1.65)	0.93	.36
Happiness	1.08 (0.90)	1.34 (0.91)	1.06	.29	1.23 (1.87)	0.67 (0.97)	1.40	.17
Relief	1.33 (0.95)	1.59 (0.95)	1.03	.31	0.26 (0.47)	0.24 (0.52)	0.20	.84
Sadness	2.08 (1.71)	2.68 (1.71)	1.32	.19	4.26 (2.05)	3.58 (1.90)	1.31	.20
Surprise	2.09 (1.66)	2.13 (1.63)	0.07	.93	1.40 (1.55)	1.38 (1.43)	0.05	.96
Sympathy	2.89 (2.28)	2.89 (1.86)	<.01	1.0	3.37 (1.70)	2.55 (1.88)	1.73	.09

Note. Independent samples *t*-tests are reported for pre- ($N = 56$) and postassessment ($N = 57$) films. Standard deviations are reported in parentheses. Reported *p* values are uncorrected.

Sadness Behavior

At preassessment, the zero-inflated Poisson model that included group membership in both the logistic and count components of the model was not significant, $\chi^2(2) = 1.46$, $p = .48$. Group membership predicted neither the *likelihood* of not responding (i.e., not showing sadness), $\beta = -0.043$, $p = .95$, nor the *frequency* of sadness behaviors, $\beta = 0.362$, $p = .27$. At postassessment, group membership predicted the likelihood of not responding, $\beta = -1.364$, $p = .026$, but not the frequency of sadness behaviors, $\beta = -0.210$, $p = .47$. Thus, the logistic component of the model testing group membership was significant, $\chi^2(1) = 4.99$, $p = .026$ (see Figure 1 for count histograms and Table 2 for parameters). The logistic parameter ($\beta = -1.364$) indicates the group difference in log-odds of not displaying sadness. The model expected odds for a participant in the training group to not show sadness at postassessment were 0.94:1. For the control group the corresponding odds were 3.67:1. Thus, a participant in the training group was nearly four times (odds ratio = 3.91) more likely to show sadness than a participant in the control group. At the preassessment, a participant in the training group (1:0.97) was just as likely to show sadness as a participant in the control group (1:1.04).

To follow-up on these postassessment group differences in sadness expressions we examined the relation between self-reported sympathy, sadness, and distress and sadness behaviors. First, we examined whether self-reported sympathy predicted sadness facial displays by including mean sympathy rating as an additional predictor in both the logistic and count portions of the

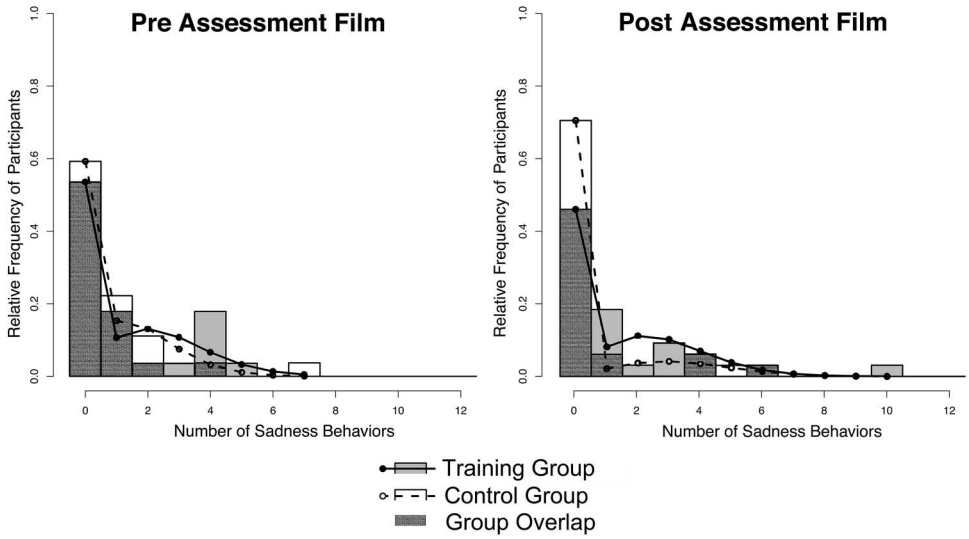

Figure 1. Histograms of the observed frequencies of sadness displays are plotted by group for preassessment and postassessment films, with histogram overlap shown in dark gray. The model-predicted distribution is overlaid as lines. The intercept reflects the likelihood of nonresponding and the slope represents the distribution of responses around the model-predicted mean.

Table 2
Zero-Inflated Poisson Model of Postassessment Sadness Behavior

	Logistic			Poisson count		
	Parameter (*SE*)	*z*	*p*	Parameter (*SE*)	z	*p*
Model 1						
Intercept	1.300 (0.464)	2.8	.005	1.220 (0.233)	5.24	<.001
Group	−1.364 (0.615)	2.22	.026	−0.210 (0.290)	0.07	.468
Model 2						
Intercept	1.252 (0.802)	1.56	.118	1.554 (0.553)	2.81	.004
Group	−20.606 (16.905)	1.22	.223	−4.237 (0.885)	4.79	<.001
Sympathy	−0.007 (0.272)	0.03	.979	−0.144 (0.227)	0.63	.527
Sympathy × Group	3.312 (3.097)	1.07	.284	0.927 (0.271)	3.41	<.001

Note. Logistic and Poisson parameter estimates are reported for models of postassessment sadness behavior for Model 1 ($N = 58$) and Model 2 ($N = 57$). Standard errors are reported in parentheses.

model, $\chi^2(4) = 19.45$, $p < .001$. As shown in Table 2, there was a significant interaction between group membership and self-reported sympathy in the count portion of the model, $\beta = .927$, $p < .001$. Group membership moderated the relation between self-reported sympathy and the number of sadness displays such that a positive relation was observed for trainees, $\beta = 0.783$, $p < .001$, but not controls, $\beta = -0.144$, $p = .53$. This parameter ($\beta = 0.783$) represents the relation between sympathy rating and the frequency of sadness behavior. At the group mean level of sympathy ($M = 3.37$) a training group participant would be expected to display about one (0.96) sadness behavior. Thus, higher ratings of sympathy were predictive of increased frequency of sadness expressions in the training group only.

Next, we examined whether group membership moderated the relation between self-reported sadness or distress and the likelihood of not responding or the frequency of sadness behavior at postassessment. Self-reported sadness did not interact with group to predict either likelihood of not responding, $\beta = -0.010$, $p = .98$, or counts of sadness behaviors, $\beta = 0.116$, $p = .703$. Similarly, in a separate analysis, self-reported distress did not interact with group to predict likelihood of not responding, $\beta = -0.240$, $p = .54$, or counts of behaviors, $\beta = 0.242$, $p = .12$. Thus, only self-reported sympathy, but not sadness or distress, predicted counts of sadness displays. Furthermore, this relation was moderated by group membership, with training group participants displaying more sadness behavior with greater self-reported sympathy.

Rejection Behavior

At preassessment, a zero-inflated Poisson model with group membership as the only predictor was not significant for rejection emotions, $\chi^2(2) = 3.27$, $p = .20$. Thus, group membership did not predict either the likelihood of not responding, $\beta = -1.047$, $p = .11$, or counts of facial displays of rejection emotion, $\beta = 0.097$, $p = .51$. At postassessment, however, the model predicting counts of rejection behaviors from group membership was significant, $\chi^2(1) = 4.471$, $p = .035$ (see Figure 2 for count histograms and Table 3 for parameters). For counts of behavior, the group parameter was significant, $\beta = -0.328$, $p = .033$, suggesting that training group participants showed fewer model-predicted counts of rejection emotions (3.77) at postassessment than did controls (5.24; see Figure 2). Group membership did not predict the likelihood of not responding, $\beta = -0.395$, $p = .51$. Thus, training group participants showed fewer rejection behaviors than controls at postassessment (training group, $M = 2.79$, $SD = 3.59$; control group, $M = 3.45$, $SD = 4.57$). No difference was observed at preassessment (training group, $M = 4.28$, $SD = 6.26$; control group, $M = 2.96$, $SD = 3.61$).

In line with analyses reported above, we examined whether the relation between self-reported sympathy and rejection displays at postassessment was moderated by group membership. This model, which included self-reported sympathy and the interaction between group and rating, was significant, $\chi^2(4) = 26.69$, $p < .001$. We observed an interaction between group membership and self-reported sympathy in the count portion of the model, $\beta = -0.361$, $p < .001$, but not in the likelihood of not responding, $\beta = -0.636$, $p = .086$. This indicates that group membership moderated the relation between self-reported sympathy and rejection behaviors at the postassessment. Specifically, self-reported sympathy was negatively related to the frequency of rejection behaviors in the training group, $\beta = -0.166$, $p = .007$, but was positively related in controls, $\beta = .194$, $p < .001$. At the combined group mean level of sympathy ($M = 2.96$) the model predicted values suggest that training group participants display four (4.06) rejection behaviors while control participants would display more than five (5.32).

Relating Emotional Behavior to Four Immeasurables Practice

Four immeasurables practice emphasizes the cultivation of compassionate attitudes and aspirations. For training group participants, we examined whether the total amount of time devoted to FI practice during retreat predicted facial displays of either sadness and/or rejection. Total FI practice time in hours across the 3 months ($M = 41.0$, $SD = 19.7$) was entered as a predictor of both likelihood of not responding and counts of behavior at the post-training assessment. The model predicting sadness behavior was significant, $\chi^2(2) = 7.52$, $p = .023$. We observed a positive relation between hours of FI practice and counts of sadness behaviors, $\beta = 0.037$, $p = .006$, which suggests that individuals who devoted greater time to FI practices during the retreat showed more sadness displays while viewing the postassessment film. Individuals who engaged in an average amount (41 hrs) of FI practice were expected to display almost three (2.66) sadness behaviors. Time spent on FI practices did not predict rejection behavior,

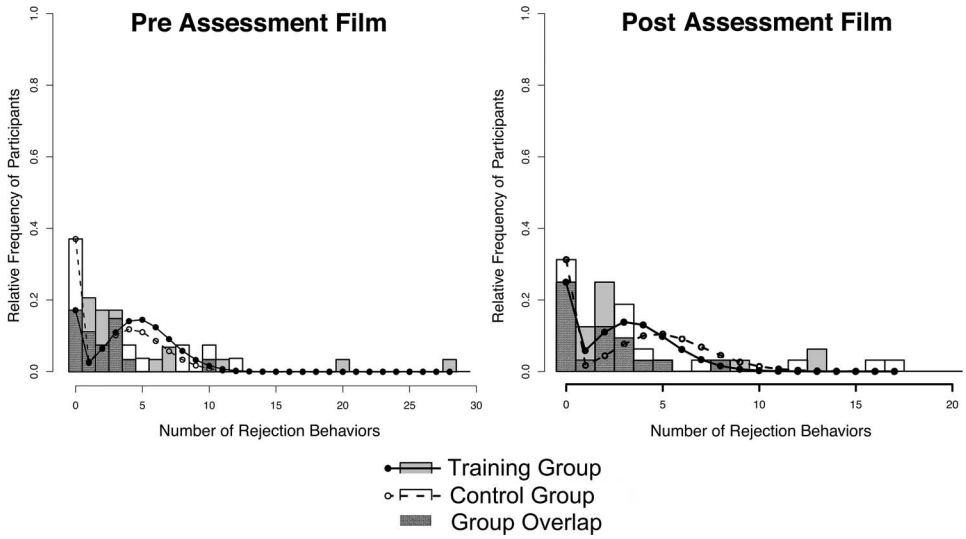

Figure 2. Histograms of the observed frequencies of rejection displays are plotted by group for preassessment and postassessment films, with histogram overlap shown in dark gray. The model-predicted distribution is overlaid as lines. The intercept reflects the likelihood of nonresponding and the slope represents the distribution of responses around the model-predicted mean.

$\chi^2(2) = 0.248$, $p = .88$. Next, we addressed whether individuals who may be prone to displaying sadness were more inclined to engage in FI practice during retreat. Specifically, we examined whether facial displays of sadness at the preassessment predicted total FI practice time. The number of sadness displays at the preassessment did not significantly predict FI practice hours during the retreat, $R^2 = 0.006$, $F(1, 26) = 0.150$, $p = .702$. Similarly, FI hours did not differ between those individuals who did and did not display sadness at the preassessment, $R^2 = 0.091$, $F(1, 26) = 2.594$, $p = .119$.

Discussion

This is the first study to apply detailed observational methods to investigate changes in emotional behavior accompanying intensive meditative training. We observed training-related differences in participants' facial and subjective emotional responses to film scenes depicting suffering, emotional pain, and remorse for violence. Participants who underwent 3 months of intensive meditation training were more likely to show sadness-related expressions and showed fewer rejection emotions when compared to controls. In the trainees, this pattern of facial responding—an increased likelihood of sadness displays and less frequent rejection displays—varied systematically with subjective ratings of sympathy, but not with ratings of sadness or distress. Further, participants who devoted more practice time to the four immeasurables exhibited more sadness displays in response to others' suffering after training. Taken together, these findings suggest that meditation training influences emotional responses in a manner consistent with the cultivation of concern for human suffering.

We did not find reliable group differences in the intensity of any self-reported emotion category at either assessment. Contrary to our hypotheses, training group participants did not report greater levels of sympathy or lower levels of rejection emotions than control participants at postassessment. Though we expected inten-

Table 3
Zero-Inflated Poisson Model of Postassessment Rejection Behavior

	Logistic			Poisson count		
	Parameter (*SE*)	*z*	*p*	Parameter (*SE*)	*z*	*p*
Model 1						
Intercept	−0.657 (0.395)	1.665	.096	1.654 (0.101)	16.32	<.001
Group	−0.395 (0.595)	0.664	.506	−0.328 (0.154)	2.13	.033
Model 2						
Intercept	−1.160 (0.745)	1.556	.120	1.096 (0.182)	6.000	<.001
Group	1.456 (1.200)	1.213	.225	0.796 (0.289)	2.750	.005
Sympathy	0.201 (0.223)	0.905	.365	0.194 (0.045)	4.282	<.001
Sympathy × Group	−0.636 (0.370)	1.71	.086	−0.361 (0.076)	4.687	<.001

Note. Logistic and Poisson parameter estimates are reported for models of postassessment rejection behavior for Model 1 ($N = 58$) and Model 2 ($N = 57$). Standard errors are reported in parentheses.

sive training to differentiate groups based on their reports of sympathy, the similarity between groups on this measure is not altogether surprising. Both training and control group participants had meditation experience prior to random assignment. Furthermore, participants generally held values consistent with the ethical motivation to alleviate the suffering of others. Thus, both training and control participants might be expected to report strong feelings of sympathy and concern for individuals experiencing suffering. Similarly, many meditation practitioners may feel obligated to temper aversive responses to suffering or to the perpetrators of suffering. We speculate that there may have been demand characteristics in the context of this study for both groups to selectively report certain emotions in response to these films, as long-term exposure to Buddhist teachings may influence the value placed on experiencing certain affective responses (Tsai, Miao, & Seppala, 2007).

Self reports of emotion have on some occasions been responsive to meditation interventions (e.g., Fredrickson et al., 2008) and in other cases have not (Koopmann-Holm, Sze, Ochs, & Tsai, 2013). Koopmann-Holm, Sze, Ochs, and Tsai (2013) found that a short-term meditation intervention did not alter reports of experience of high arousal (excitement) or low arousal (calm) positive affect compared to inactive and active control conditions. After the short-term training, however, participants' reports indicated an increased value placed on low arousal positive states, such as calmness. Thus, rather than influencing levels of felt emotion, meditation training influenced how much people *wanted* to experience calmer positive affects after training, perhaps as an ideal of the potential of contemplative training.

Despite a lack of differences between groups in film-averaged self-reports of emotion, it is unlikely that this reflects an actual lack of differences in emotional responses to the films. We found systematic differences in another emotion measure—facial expressions of emotion. Further, in conjunction with the facial variables, self-reports of emotion helped to clarify that the facial expressions of "sadness" may signify feelings of sympathetic concern in this context. Specifically, self-reported sympathy related positively to sadness displays and negatively to rejection displays in those who underwent the training, but not in wait-list controls. This underscores the importance of using multiple metrics in emotion measurement (Rosenberg & Ekman, 2000).

Following training, meditation group participants showed more facial displays of sadness than control group participants in response to a film depicting scenes of human suffering, tragedy, and violence. Critically, felt sympathy was related to the frequency of sadness displays among the training group, but not in the control group. Following training, facial displays of sadness may thus reflect concern and sympathy for the suffering depicted in the film rather than sadness evoked by personal loss. In contrast, control group participants reported similar levels of sympathy as the training group, but these feelings were unrelated to the likelihood or frequency of sadness displays. Furthermore, we observed that practitioners who engaged in more emotion-generative and aspirational meditations (i.e., FI practices) exhibited more sadness displays. These findings suggest that, when confronted with suffering, the internalization of compassionate aspirations through training may affect the way in which concern and sympathy manifest in spontaneous emotional expression.

We observed fewer facial displays of rejection emotion (anger, contempt, and disgust) in the training group than in the control group at postassessment. Further, at postassessment, training-group participants who reported greater levels of sympathy showed fewer rejection displays. The inverse relation between rejection emotion and sympathy suggests that those individuals who report greater sympathy may be more likely to engage emotionally with others when confronted by suffering. In tandem with the greater likelihood of sadness displays among training participants, these findings suggest a pattern of emotional responding indicative of compassionate concern for the welfare of others. When encountering scenes of violence and human suffering, practitioners of meditation may experience feelings of sympathy and concern that accompany sadness and reductions in aversive emotional responses. This pattern of emotional responding constitutes an emotional profile of compassionate concern trained through the combined effects of shamatha and practice of the FI. This pattern of findings might also reflect greater authenticity in the self-reports of the training group after retreat, because when they say they feel more sympathetic they show less rejection. On the other hand, the control group's self-reports of sympathy are positively related to displays of rejection. This latter lack of concordance might reflect greater presentation bias on behalf of the control group.

Some might ask whether participants might have deliberately posed certain facial expressions to appear concerned or sympathetic. There are several reasons why we believe it is unlikely that deliberate efforts to pose expressions biased our findings. In response to implicit demands to appear concerned about the welfare of others, training group participants would have had to transiently pose the display(s) of sadness that met our definitional criteria and to inhibit spontaneous displays of rejection emotions to produce the group differences we observed. Further, training participants would have had to voluntarily implement these emotional expressions through movements of required action units while suppressing action units that are not part of sadness displays.

Although the Duchenne smile, the so-called marker of *true enjoyment*, can be voluntarily posed when participants have an example to model (Gunnery, Hall, & Ruben, 2013), it is well documented that facial behavior is difficult to voluntarily control, both in terms of people's ability to pose certain actions (cf., DePaulo, 1992; Ekman, 2003; Ekman, Levenson, & Friesen, 1983; Ekman, Roper, & Hager, 1980), and in their ability to inhibit unintended expressions (Ekman, 2003; Ekman & O'Sullivan, 2006; Hurley & Frank, 2011). Further, to pose the sadness displays that discriminated between groups, participants would have to voluntarily pose AU1, which involves raising the inner corners of the brows and is a core upper face component of most prototypical sadness displays. AU1 is an action that few can control accurately, especially without involvement of AU2 (which lifts the lateral portion of the brow) (Ekman, Roper, & Hager, 1980; Ekman, 2001). Finally, although participants consented to having their facial expressions monitored at the project outset, they were recorded unobtrusively and were likely unaware of the authors' specific interest in facial behavior during the film-viewing paradigm. The film-viewing session was embedded in a battery of laboratory tasks administered across two days of testing, the camera was concealed from view, and all participants were wearing high-density EEG caps and sensors for concurrent physiological assessment.

The observed group differences in patterns of emotional responding may reflect qualitatively different patterns of appraisal in response to the same set of film scenes (Lazarus, 1991). Indeed, contemplative traditions would suggest that meditation training incorporating compassion and loving-kindness practices would promote compassionate responses to both the victims and the perpetrators of suffering observed in the films (Wallace, 1999). It is difficult to characterize the exact film content that may have triggered the observed facial responses, however. The categories of displays for which we found systematic group differences were distributed fairly evenly throughout the films. Although it is possible to link the occurrence of any facial display exhibited to a location in each film segment, there were insufficient incidences of facial displays of emotion distributed at various film locations to allow for statistical analyses. Future work should explore whether meditation training influences emotional responses to both the victims and perpetrators of suffering by explicitly contrasting emotional responses to these two categories.

Although the emotional responses observed among training participants may be suggestive of prosocial motivation, we did not measure actual helping behavior. Research concerning affective states preceding instances of helping behavior suggests that the emotional profile we observed following training would be conducive to actual pro-social behavior. There is considerable evidence that sadness and sympathy precede helping behavior (e.g., Eisenberg et al., 1989). Aversive responses to others' suffering have received less attention, yet this affective element is critical to understanding why and when people help. Self-reported sadness increases the likelihood of choosing to offer welfare assistance, whereas anger reduces it (Small & Lerner, 2008). Aversive responses such as disgust and contempt may interfere with people helping others, even in dire situations, such as real-world responses to victims of terrorist attacks (Conejero & Etxebarria, 2007), though recent evidence suggests that visceral or gustatory forms of disgust might support rejection more than socioemotional disgust (Rubenking & Lang, 2014). Clearly, more work is needed on spontaneous emotional behavior in helping contexts, particularly to determine whether reductions in rejection emotions in response to real or simulated suffering actually increase the likelihood of helping.

Although anger may promote prosocial tendencies in cases in which it motivates righting an injustice (van Doorn, Zeelenberg, & Breugelmans, 2014), anger is an emotion that involves an appraisal of insult and/or goal-obstruction that is personalized (Lazarus, 1991), and reduces concern with the suffering of others (Salzberg & Thurman, 2014). Buddhist contemplative training explicitly encourages—through a combination of values and meditation techniques—reappraising potential threats and insults as less personal, with reduced selfish motivations and an increased concern for the welfare of all others (Rosenberg, 2013). Our investigation of rejection emotions is a novel contribution to the understanding of the emotional antecedents of prosociality and requires follow-up in future research.

The training assessed in the present study involved both focused attention (shamatha) and aspirational and emotion-generative (four immeasurables) meditation practices. Although we observed relations between FI practice and emotional outcomes, it is not possible to isolate the direct influence of FI techniques from the overall intervention. The attentional practices, which typically comprised more than 80% of an individual's meditation practice time, likely supported the development of, and commitment to, an ethical framework reinforced by the full contemplative training. Further, improved attentional capacity may contribute to sustained engagement with graphic aversive film content, facilitating emotional appraisal and regulation processes.

Although the groups differed in the likelihood of displaying sadness at postassessment, it should be noted that approximately half of training participants did not show any sadness. Facial displays of emotion are notoriously difficult to elicit with picture or film stimuli (Rosenberg & Ekman, 2000). We therefore attempted to select strongly evocative film stimuli so as to elicit facial displays of emotion. It is possible that our findings were influenced by our film stimuli not providing a strongly evocative viewing experience for all participants. In general, participants self-reported both films as primarily inducing low to moderate amounts of distress, sadness, and sympathy. More powerful film stimuli would have allowed us to differentiate training participants on not only the probability, but also the frequency, of sadness displays.

Given that sad displays related to self-reports of sympathy, but not to self-reports of sadness following training, the use of *sadness* as a label for these displays may be questioned. Despite controversy in the emotion literature as to the choice of categorical labels for facial expressions in recognition studies (e.g., Barrett & Kensinger, 2010), evidence from studies of spontaneous facial displays in sad-evocative situations and their relation to self-reports of sadness suggests that the set of actions including oblique lifting of the brows (possibly pulled together, with or without downturned lip corners and lifting of the chin boss) is a reliable facial marker of felt sadness (e.g., Keltner, Moffitt & Stouthamer-Loeber, 1995; Marsh, Beauchaine, & Williams, 2008). There is evidence that upper face elements of this configuration may also occur in situations of compassionate concern, however (Eisenberg, McCreath, & Ahn, 1988; Eisenberg et al., 1990). Considered alongside data on the various prosocial contexts in which this facial configuration appears, our findings further suggest that displays involving lifting the inner corner of the brow, with or without also pulling them together (*AU1* or *AUs 1 + 4*), may not be *unique* to sadness. This set of movements might also signal other affective states in which someone is moved deeply by concern for others' suffering and distress or signal the need for a prosocial response (Denham, Renwick-DeBardi, & Hewes, 1994).

An important limitation of our design was that film stimuli were not counterbalanced across assessments, and we report on only one pre- and one postassessment film. Although the pre- and postassessment films both depicted a range of themes relevant to human suffering, including war, injury, death, decay, and the tragedy of murder, the exact circumstances and situations depicted in the films differed. Therefore, comparisons between films are confounded by differences in film content and style. It is possible that the findings we observed at postassessment might in part reflect preexisting group differences in sensitivity to particular film content. We think this is unlikely because we employed a wait-list design wherein experienced meditation practitioners were randomly assigned to a training or control group, which were rigorously matched on numerous demographic, psychological, and cognitive performance measures (see MacLean et al., 2010; Sahdra et al., 2011). Additionally, postassessment emotional behavior was

predicted by the amount of time training participants dedicated to compassion-related meditation techniques, demonstrating the sensitivity of the emotional outcome measures to specific aspects of the meditation training intervention.

These limitations highlight some of the challenges in conducting research on intensive contemplative practice. Presenting emotionally provocative films to individuals either in or entering meditative retreat may adversely affect their ability to engage in sustained meditation practice. Indeed, the potential psychological impact of the film stimuli was one concern that influenced our decision to order film presentations as we did. For example, emotionally intense and graphic film footage may adversely affect the psychological state of participants at the onset, preventing one from drawing strong inferences about change from pre- to postassessment.

In addition to the effects of intensive practice in meditation techniques, the worldview and values of the experienced contemplative practitioners in this study may have affected emotional responses to suffering. The adoption of ethical, religious, or spiritual values is a precursor to meditative training in many contemplative traditions (The Dalai Lama, 1999). Also, meditative training is often concerned with the pursuit and maintenance of ethical behavior related to the alleviation of suffering in oneself and others. The present study is unable to distinguish the effects of such a value system from the meditation practice itself. It is possible that the effects of meditation training, such as those reported here, might be mediated by training-related changes in the moral value systems held or adopted by practitioners. Although participants who hold such values may be susceptible to demand characteristics that encourage compassionate responses when witnessing suffering, it is likely that participants in both groups in the present study held such values regarding the benefits of compassion and meditation in promoting prosocial growth. All participants were experienced meditation practitioners in the Buddhist tradition prior to group assignment, and groups were matched on lifetime meditation experience. Nevertheless, we observed differences in their emotional responses at the end of three months of intensive meditation training.

For studies utilizing less experienced practitioners, the use of active control groups might address the problem of separating held values and beliefs from training-specific effects, as well as bolster the ability to attribute group differences to effects of practicing the meditation techniques themselves. While theoretically possible, incorporating an active control design in a long-term residential setting such as the present study (e.g., contrasting the benefits of a residential didactic intervention with a practice-oriented intensive retreat) is unfeasible due to participant burden. For instance, an active control group would have required experienced meditators to reside at the retreat center for the full 3 months without engaging in more than their normative daily amount of meditation practice. Additionally, many aspects of the intervention that might be conceptualized as confounds, such as group discussion of themes relevant to compassion, are explicitly involved in the implementation of contemplative training broadly (Ekman et al., 2005). It was therefore not a realistic goal of the present study to investigate the benefits of specific meditation techniques in isolation of the philosophy that supports them. Finally, we found that the amount of time participants devoted to certain meditation practices predicted their posttraining emotional behavior, which strongly suggests that the effects were specifically related to practice, rather than simply driven by involvement in an active intervention. As reported, individuals who spent more time on compassion-relevant practices showed more expressions of sadness and fewer rejection emotions at the posttraining assessment, a pattern which is consistent with manifesting a more prosocial response to suffering.

Two characteristics of the present study population raise questions about the generalizability of our findings: prior meditation retreat experience as an inclusion criterion and the requirement to dedicate 3 months to training away from work and home. The study population was limited to experienced meditators because of concerns regarding the demands of intensive meditation retreats. Participants were required to have attended a minimum of three retreats of 5 to 10 days in length prior to study inclusion; similar criteria are used at major retreat centers in the United States that regularly hold 3-month retreats (e.g., Insight Meditation Center in Barre, MA). People may be unable to benefit from prolonged training until they have had considerable experience with meditation and have made a commitment to the importance of this practice in their lives. In addition, we recognize few have the flexibility and freedom from responsibility required to devote 3 months to a retreat and accommodate the logistical demands of random assignment to retreat. Within these constraints, our sample included considerable age and socioeconomic diversity. Also, we offered partial scholarships to some of the individuals who met all the inclusion criteria but who could not fully afford the cost of the training, which expanded the range of socioeconomic classes who could participate in the research. A final limitation of the generalizability of our findings concerns the comparability of our effects of intensive training with studies incorporating less intense, shorter duration interventions that form the bulk of research on contemplative practice.

Even in light of these limitations, this research contributes substantively to the literature on meditation and emotion. First, this is the only study to longitudinally (or cross-sectionally) examine online facial behavior in emotionally evocative situations in individuals who have undergone extensive meditation training. Although there have been several studies on the effects of meditation training on emotion (e.g., Fredrickson et al., 2008; Koopmann-Holm et al., 2013), none have measured emotional behavior as it unfolds in real time or have studied the emotional effects of long-term, intensive meditation training. Second, we observed variations in the *type* of emotional behaviors displayed in response to scenes of suffering. This is important, as much of the current research on meditation and emotional responding has focused on the down-regulation of negative affects as a primary consequence of meditation training (e.g., Hölzel et al., 2011). Rather, our findings suggest that, in some situations, meditation training may increase the incidence of affects such as sadness or sympathetic concern, indicating an increase in the willingness to engage sympathetically with suffering. When confronted with unpleasant images and scenes of suffering, rather than recoil, participants display sadness; when confronted with potentially immoral behavior, the amount of rejection emotion is reduced. Finally, associations between felt sympathy and emotional behavior in training participants support the notion that that the observed patterns of emotional behavior may indicate a shift toward a more prosocial emotional response to suffering.

Although we have described a training-induced pattern of emotional responding likely associated with the growth of concern for others, the observed displays of sadness do not necessarily indicate *compassion*. Several researchers have characterized compassion as a unique emotional response with an identifiable facial configuration that shares features with a prototypical sadness display (Goetz et al., 2010; cf., Ekman, 2014), and our data further bolster that conclusion. In line with Halifax (2012), however, we view compassion as an emergent phenomenon that arises out of several constituent processes, including affective, cognitive, motivational, and physiological factors, none of which constitutes compassion by itself. The corollary, on a measurement level, is that we view compassion as a latent construct that cannot be measured directly, but rather can only be approximated by assessing the elements that comprise it, including specific patterns of emotional responding.

Future work should explore whether the pattern of emotional responding observed in this study is predictive of prosocial behavior and generalizes across contexts. Studies such as ours that investigate the effects of meditation training on compassionate responding will need to be based on careful consideration of the complexity of meditation training in both intensive retreat and novice training contexts (Condon et al., 2013; Klimecki et al., 2013; Weng et al., 2013). In the present study, we chose to investigate the presumed affective antecedents of compassionate responses in experienced meditation practitioners undergoing intensive training. We describe a trainable pattern of sympathetic concern that is marked by an increased ability to be moved by painful realities without avoiding them—a quality that seems crucial for experiencing compassion when confronted with suffering.

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