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Pre-existing brain function predicts subsequent practice of mindfulness and compassion meditation

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ABSTRACT

While a variety of meditation techniques are increasingly employed as health interventions, the fact that meditation requires a significant commitment of time and effort may limit its potential widespread utility. In the current study, we ask whether baseline subjective reports or brain activity in response to a "Pain for Self and Others" paradigm predicts subsequent engagement in mindfulness and compassion meditation. The study also investigated whether compassion training would impact neural responses when compared to an active health education control group. Prior to training, activation of the left and right anterior insula, an area thought to be important for empathy, in response to the Other pain task was positively related to engagement with compassion meditation as measured by practice time (n = 13). On the other hand, activity in the left amygdala during the Self pain task was negatively correlated with mindfulness practice time. Following the study intervention, there was no difference between the compassion group (n = 13), and the control group (n = 8), in brain responses to either the Self or Other task. These results are the first to indicate that baseline neural responses may predict engagement with meditation training and suggest that pre-existing neurobiological profiles differentially predispose individuals to engage with disparate meditation techniques.

Introduction

Meditation is increasingly incorporated into clinical treatments for a variety of mental and physical ailments (Hofmann et al., 2011; Marchand, 2012) and is widely believed to enhance well-being even in individuals not suffering from any specific mental or physical disorder (Sedlmeier et al., 2012). However, despite its apparent promise, the commitment of time and effort required to learn meditative techniques may limit their potential widespread utility. This may be particularly true of meditative practices designed to enhance compassionate feelings and behaviors toward others since these practices pose the additional challenge of requiring trainees to contemplate deeply and for extended periods about the suffering of other people, including those they love. Because health-relevant emotional and physiological effects of compassion meditation appear to be positively associated with practice time (Fredrickson et al., 2008; Pace et al., 2009, 2010, 2012), identifying pre-existing variables that predict people's differential ability or willingness to engage with the practice has clear therapeutic relevance. The current study sought to identify whether self-report or neurobiological responses to suffering in oneself or others prior to learning compassion meditation would predict subsequent engagement with the practice over an 8-week training period. An additional aim was to investigate whether the training program impacted neural responses upon repeated exposure to "Pain for Self and Others" when compared to an active health education control group.

Cognitively-Based Compassion Training (CBCT), the protocol used in the current investigation, reduces stress responsivity (Pace et al., 2009), depression (Desbordes et al., 2012), and enhances empathic accuracy and related neural activity (Mascaro et al., 2012; Pace et al., 2009). Increased amount of practice time has also been shown to reduce levels of c-reactive protein—an important biomarker for disease development—in traumatized/neglected youth (Pace et al., 2012). CBCT is a secularized training derived from the 11th century Tibetan Buddhist *lojong* tradition. As such, it commences with two-weeks of training in focused attention (shamatha) and non-judgmental awareness (vipassana) prior to one week of self compassion training and five weeks of specific compassion training designed to enhance interpersonal equanimity, increase feelings of gratitude toward others, and finally to induce strong

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feelings of empathy toward all people. Importantly, these two aspects of the training (i.e. shamatha/vipassana during the first two weeks and compassion during the last five weeks), are widely divergent in terms of the meditative techniques they employ. Because of this, CBCT provided a novel opportunity to examine the specificity with which subjective and neurobiological responses to the suffering of self and others predict the ability to practice mindfulness based techniques (i.e. shamatha/vipassana) vs. compassion techniques.

The mindfulness-based technique employed in CBCT (i.e. shamatha/vipassana) has been a target of extensive scientific investigation in the last decade, in part because of its apparent promise as a relatively brief and cost-effective practice for alleviating anxiety as well as for enhancing well-being (Baer, 2003; Grossman et al., 2004; Marchand, 2012; Sedlmeier et al., 2012). In particular, it is thought that by promoting a type of awareness in which phenomena are experienced in a non-analytical and non-evaluative manner, mindfulness techniques allow individuals to experience aversive events with less emotional reactivity (Creswell et al., 2007). The mindfulness component of the protocol used in this study was designed to be explicitly devoid of any compassion related content and required that practitioners attend to their sensations, thoughts, and emotions in a non-evaluative manner. We therefore hypothesized that baseline aversiveness ratings and neural activity in regions important for the affective and evaluative response to pain, such as the mid cingulate cortex (MCC), anterior insula, and amygdala (Peyron et al., 1999; Price, 2000), would be inversely associated with the ability or willingness to subsequently engage with the mindfulness component of the CBCT protocol.

Given that the compassion-specific elements within CBCT require extensive contemplation of the suffering of others, we hypothesized that individuals with high levels of baseline empathy would be more likely to engage in this portion of the CBCT protocol. The neural systems related to empathy, defined as an affective reaction similar to, and evoked by, another's affective state (de Vignemont and Singer, 2006) have been investigated using an empathy for pain (EFP) paradigm. This paradigm, in which participants imagine or observe other people receiving a painful stimulus, commonly elicits neural activation in the affective component of the pain matrix, including the anterior mid-cingulate cortex (aMCC), as well as the bilateral anterior insula (AI) and the ventral frontal operculum (Botvinick et al., 2005; Jackson et al., 2005; Lamm et al., 2010; Simon et al., 2006; Singer et al., 2004). Activity in the AI may represent a simulated mapping of the observed individual's body state onto one's own (Singer et al., 2009), which is important for an empathic response. Importantly, activity in the AI predicts later helping behavior, suggesting that its activity is related to prosocial emotions and motivation rather than to the type of distress that has been shown to precede more self-serving behavior (Batson, 1998; Hein et al., 2010). We therefore hypothesized that the activity in the AI in response to an empathy inducing task as well as self-reported empathy levels would predict amount of subsequent engagement with the compassion-specific elements of the CBCT protocol.

Materials and methods

This study was approved by the Institutional Review Board of Emory University and all participants gave written informed consent prior to inclusion. To test the study hypotheses participants underwent functional magnetic resonance imaging (fMRI) while both receiving (Self) and watching videos of others receiving (Other) painful stimulations both prior to and upon completion of the study interventions (for design, see Supplementary figure S1).

Study participants

Twenty-nine (16 males) participants from the Atlanta area were recruited using a combination of fliers and electronic notifications posted at several local universities, as well as electronic advertisements on Craigslist as part of a larger study that assessed the effects of meditation on stress physiology and social cognition. Participants were aged 25–55 ($M = 31.0$; $SD = 6.02$) and were screened and excluded for (self-reported) use of any psychotropic medication within 1 year of screening, for regular use of any medications that might influence activity of the autonomic nervous system, HPA axis, or inflammatory pathways, and for any ongoing medical or psychiatric condition.

Compassion meditation

The compassion meditation training protocol used here (Cognitively-Based Compassion Training [CBCT]) was designed by one of us (LTN). Although secular in presentation, CBCT derives from the 11th century Tibetan Buddhist *lojong* tradition. In its operationalization, CBCT made two important modifications to traditional *lojong* teachings. First, all discussions of soteriological or existential themes (e.g. the attainment of Buddhahood, Karma) were omitted. Second, participants were taught one week each of concentrative (i.e. shamatha) and mindful-awareness (i.e. vipassana) practices at the beginning of the course. While not specifically included in traditional *lojong* curricula, these basic meditation practices were an assumed prerequisite for commencing *lojong* training in a traditional Buddhist context (HHDL, 2001). For simplicity, we have subsumed these attention practices under the term 'mindfulness practice', in accordance with the general Western and clinical understanding of *mindfulness*, although it is important to note that the attentional practices that are trained in the first two weeks of CBCT are different than those employed when MBSR training is taken as a whole, because they are without any compassion related content. A complete description of the weekly schedule can be found in the Supporting information.

The compassion meditation courses were taught by two graduate students from the Emory Religion department who are experienced meditators and who had undergone extensive training with Lobsang Tenzin Negi. Study participants were asked to attend 2 h of class time per week for eight weeks. Class sessions combined a didactic teaching and discussion section with approximately 20 min of meditation per hour class time. Participants were provided with a meditation compact disk to guide "at-home" practice sessions that reflected in-class material, and were asked to keep track of practice time each day. In calculating practice time for the current study, only "at-home" practice was included, as it was determined a priori that in-class practice did not reflect engagement with the material because participants did not know the specific techniques they would practice each week prior to attending class.

Health discussion control group

Participants randomized to the control condition attended 2 h of a discussion group per week. Classes were designed and taught by graduate students from the Emory Rollins School of Public Health. Topics included history of medicine, nutrition, sleep, mental health, exercise, stress, infectious disease, and complementary and alternative medicine. The health discussion group was designed to control for the non-specific effects of the meditation class, including education and social engagement with a collective group. Subjects were not asked to do any "at home" work.

Protocol for preparing the Other pain stimuli video

The empathy for pain video stimuli set was created using the following protocol. Twenty participants (10 males) were recruited from the Emory campus and we explicitly solicited a diverse population in terms of age and ethnicity (11 Caucasian, 9 non-Caucasian). Volunteers were seated such that they could both view a laptop computer and face directly toward the video camera. Participants were told that the video clips would be used as stimuli in an fMRI study of empathy and were asked to make facial expressions that came naturally.