Introduction

The amygdala has been repeatedly implicated in emotional processing of both positive and negative valence stimuli [9]. Previous studies suggest that amygdala activation is lower in the meditative state. However, the longitudinal effects of meditation training on amygdala responses to emotional stimuli have not been reported when participants are in an ordinary, non-meditative state. It has been proposed that meditation training may induce learning that is not stimulus- or task-specific, but process-specific, and thereby may result in enduring changes in mental function [7,8]. In this study, we investigated how eight weeks of training in either mindfulnessattention meditation or compassion meditation affects amygdala responses to emotional stimuli and autonomic functioning in subjects when in a non-meditative state.

Longitudinal study of meditation

The Compassion Attention Longitudinal Meditation (CALM) study is an ongoing randomized controlled trial of the effects of an eight-week meditation training intervention on healthy adults without prior meditation experience.

• 8-week intervention, 2 hours/week
• 3 randomized groups:
  – Compassion meditation
  – Mindful-attention meditation (aka: shamatha)
  – Active control
• Homework: meditate 20–30 min every day
• No physical exercise (e.g., yoga) or dietary change involved; people keep their habitual lifestyle.

First group: Mindful-attention Training (MAT)
Designed by Alan Wallace. Meditation practices:
• Setting the body and respiration in their natural state
• Mindfulness of breathing with:
  – relaxation
  – stability of attention
  – vividness
• Setting the mind in its natural state
• Awareness of awareness

Second group: Cognitive-Based Compassion Training (CBCT)
Designed by Geshe Lobzang Tenzin Negi
Mediation practices based on Tibetan lo-jong (mind training) techniques:
• Attention and stability of mind, as in MAT
• Compassion for oneself through mindfulness of sensations, feelings and emotions
• Equanimity and appreciation for others
• Affection and empathy
• Wishing and aspirational compassion
• Active compassion

Third group (control group): Health discussions
• Active control intervention
• Also meets for 2 hours a week:
  – One hour talk on a health-related topic
  – One-hour active participation in small group discussions

Brain imaging assessments

Methods
fMRI experiment: Passive viewing of emotionally- evocative stimuli
• Photographs of human beings in various situations, from the International Affective Picture System (IAPS) database
• 3 emotional valences: positive, negative, neutral, presented in random order. Subjects never saw the same image twice
• Subjects instructions: “Watch the images and let yourself react to them naturally.”
• Siemens 3T scanner with 32-channel head coil
• Simultaneous recordings of autonomic physiological data: ECG, breathing belts, pulse oximeter, skin conductance
• 12 subjects in each of the 3 groups (MAT, Compassion, Control)

Region-of-interest analysis
Two anatomically defined regions of interest (ROIs), the left and right amygdala, were automatically segmented from each subject's high-resolution (1×1×1 mm) anatomical scan using the FreeSurfer software suite.

Results: Amygdala
We found that eight weeks of training in meditation yielded reduced brain activation in the right amygdala in response to emotionally- evocative images in an ordinary, non-meditative state.

• (1) Meditation yielded reduced [-1.93(5):1043]
  • (2) Meditation yielded reduced [-1.93(5):1043]

Results: TPI
We also found that eight weeks of training in meditation yielded reduced brain activation in the temporoparietal junction (TPJ) in response to emotionally- evocative images in an ordinary, non-meditative state:

These findings in the TPI are counterintuitive. TPI is involved in Theory of Mind, and cognitive perspective taking. It was a priori expected that TPI response to images of other people would increase (rather than decrease) after Compassion training.

Further analyses of our data will elucidate what happens in other brain areas related to empathy and compassion, and what patterns of functional connectivity exist between them and TPI. Autonomic assessments

Measures of heart rate variability (HRV) and respiratory sinus arrhythmia (RSA) which are the healthy fluctuations in heart rate that reflect autonomic influences on cardiac activity—have been proposed as indicators of physical and psychological health [1]. Previous studies suggest that HRV increases during some meditative states, but it is not clear how autonomic tone is affected either in the short term during meditative states, nor as a long-term result of meditation practice. Here we test two hypotheses:

(1) Eight weeks of meditation training will improve autonomic tone, in the form of increased overall HRV and decreased low-frequency HRV to high-frequency HRV (LF/HF) ratio;

(2) RSA increases during the meditative state compared to rest.

Methods
We collected electrocardiogram (ECG) recordings while the subjects were lying supine in the MR scanner, in two different conditions:

• active (for 3 groups)
  – in a meditative state (for the mindfulness-attention meditation group only).
• passive (for 4 groups)
  – in a meditative state

These findings suggest that measures of RSA might be useful markers of the meditative state, and encourage further investigation on the efficacy of HRV measures to indicate a general improvement of autonomic health after meditation interventions.

Conclusions

Overall, our neuroimaging and autonomic results suggest that meditation training may affect emotional processing and autonomic function outside periods of formal meditation practice. This is consistent with the overarching hypothesis that the cultivation of temporary meditative states can result in enduring changes in mental and physiological function [8].

References