Brain Activation During Compassion Meditation: A Case Study

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Abstract

Objectives: B.L. is a Tibetan Buddhist with many years of compassion meditation practice. During meditation B.L. uses a technique to generate a feeling of love and compassion while reciting a mantra. The aim of the present study was to investigate the neural correlates of compassion meditation in 1 experienced meditator.

Methods: B.L. was examined by functional magnetic resonance imaging during compassion meditation, applying a paradigm with meditation and word repetition blocks.

Results: The most significant finding was the activation in the left medial prefrontal cortex extending to the anterior cingulate gyrus. Other significant loci of activation were observed in the right caudate body extending to the right insula and in the left midbrain close to the hypothalamus.

Conclusions: The results in this study are in concordance with the hypothesis that compassion meditation is accompanied by activation in brain areas involved with empathy as well as with happy and pleasant feelings (i.e., the left medial prefrontal cortex and the anterior cingulate gyrus).

Introduction

Meditation is a conscious mental process that influences attention and emotional regulation.1 It has also been shown that meditation involves health-promoting benefits such as stress reduction,2 decreased blood pressure,3 and higher pain threshold.4 However, the biological mechanisms behind the body’s response to meditation are poorly understood. Neuroimaging is regarded as one of the most promising tools for investigations of the coupling between the mind and the body during meditation.1,5,6 A few single-photon emission computed tomography,7 positron emission tomography,8 and functional magnetic resonance imaging (fMRI),9–13 studies on the regional neural response to meditation have been published in the last decade. Previous neuroimaging studies have, however, reported mismatching results. Discrepancies among results have been interpreted to be caused by the lack of standardized designs and the varied experience among the participants.1 In addition, participants were recruited from different schools applying different meditational techniques (e.g., relaxation meditation [yoga nidra],8 mantra meditation [kundalini yoga],9 mindfulness meditation,10 concentration meditation [Tibetan Buddhist],11 and mindfulness of breathing [vipassana]).12 Despite this, some converging results have been reported in that several studies have shown activation in areas involved with attention regulation (i.e., frontal and prefrontal regions, and in hippocampal/parahippocampal formations).8 Meditational practice is commonly classified into two groups: (1) focused attention and (2) mindfulness meditation.1,6,14 Many meditational modes have features from both groups. Compassion meditation, on the other hand, is a common meditational practice among Buddhists, and it cannot be classified into either of the two groups. In this type of meditation, the meditator uses different techniques to generate a feeling of love and compassion. In a recent study by Lutz et al.,13 the emotional response to auditory stimuli was studied in subjects who were practicing compassion meditation. The authors found increased emotional-mediated activation in the insulae and the cingulate cortex during meditation. Since activation differences between novice and expert meditators were observed, the authors suggest that practice in compassion meditation could alter the neural circuitry of emotion. Diversities and similarities in previous neuroimaging studies of meditation techniques evoked the question of how different meditation modes affect brain activity. To our knowledge, no studies on the compassion meditation state have been reported in the literature. The aim of the present study was to investigate the neural correlates of compassion meditation in 1 expert meditator. A case study on the neural correlates to this kind of...
meditation might provide one further step toward the understanding of the biological mechanisms of different meditational modes and techniques.

**Methods**

One (1) active Buddhist (B.L., female, 59 years) participated in the study. B.L. meditates daily and is exceedingly well trained in the practice of meditation. She has, among other training, participated in two traditional Tibetan Buddhist retreats; each of them lasted for 3 years, 3 months, and 3 days. The subject gave informed consent to participate in the study according to the Declaration of Helsinki.

fMRI images were acquired using an echo planar imaging sequence on a 1.5-T Philips Achieva body scanner. Scanning parameters were: repetition time $= 2.7$ seconds, echo time $= 40$ milliseconds, matrix $= 80 \times 80$, field of view $= 24$ cm, number of slices $= 31$, slice thickness $= 3$ mm. The fMRI paradigm consisted of three alternating blocks of 30 seconds each with 5-second interstimulus interval. The subject was instructed to (1) repeat a sentence in Swedish, (2) repeat the same sentence translated into Sanskrit, and (3) perform compassion meditation while repeating the traditional Buddhist mantra, *Ohm mani padme hum*. B.L. used the mantra to visualize the deity Chenrezig, which is a technique to generate a feeling of love and compassion. The blocks were repeated 6 times, giving a total session time of 11 minutes 55 seconds.

The functional images were preprocessed applying movement correction, normalization, and smoothing and analysed with SPM5 software (Wellcome Department of Imaging Neuroscience, University College, London, UK). A threshold of $p < 0.05$ corrected for false discovery rate, and an extent threshold of more than 10 voxels were used in the analysis.

**Results**

**Mantra versus baseline**

Significant loci of activation were found in the left medial prefrontal cortex extending to the anterior cingulate gyrus (Fig. 1), the right caudate body extending to the right insula, the left midbrain close to hypothalamus, and the left post-central gyrus.

**Mantra versus Sanskrit**

Significant activation was found in the same areas as in the baseline comparison with addition to activation in the right rectal gyrus, the right superior frontal gyrus, and the left parietal–frontal lobe junction.

**Mantra versus Swedish**

Similar activation as in the baseline comparison was observed. In addition, the left inferior frontal gyrus and the right insula were activated.

**Swedish versus Sanskrit**

Significant activation in the orbital part of the left inferior frontal gyrus was found.

**Sanskrit versus Swedish**

A significant locus of activation was noted in the right insula.

**Discussion**

In this study on the compassion meditation state, we found a large significant activation cluster in the left medial prefrontal cortex extending to the anterior cingulate gyrus. Almost identical activation was reported in the meditation study by Höölzel et al., where subjects who were trained at a Vipassana center were practicing mindfulness of breathing during fMRI. The authors propose that activation in the dorsomedial prefrontal cortex reflects a strong emotional engagement during meditation. Previous neuroimaging studies have also identified the medial prefrontal cortex, especially the left hemisphere, as important for empathy. Other imaging studies have found anterior cingulate activation induced by happy and pleasant feelings.

It has been proposed that right-sided prefrontal activation is involved in inducing and maintaining sustained attention and regulation of emotional response during meditation. The subject in this study, however, did not elicit much activation in this area except for a small activation cluster in the superior frontal gyrus. The explanation for this nonoccurring
activation could either be that the subject, being an expert meditator, did not need to make efforts in attention and/or emotional regulation or that the right-sided activation was masked by the strong left-sided activation. Similar activation patterns, but not identical to those found in this study, have been observed in studies on Christian religious experience. In a study by Azari et al., 20 a frontal–parietal circuit was identified to be involved with religious experience. Beauregard and Paquette, 21 on the other hand, concluded that mystical experiences are mediated by several brain regions including the right orbitofrontal cortex, the left medial prefrontal cortex, the anterior cingulate cortex, insula, caudate, the parietal lobe, and the left brainstem. The most dominating feature in the present study was, however, the prevailing activation in the left medial prefrontal cortex, which is probably explained by the strong feeling of love and compassion experienced by the subject.

In conclusion, this study showed that compassion meditation in 1 experienced meditator is accompanied by activation in the left medial prefrontal cortex and the anterior cingulate gyrus. These areas are proposed to be involved with empathy as well as with happy and pleasant feelings.

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