# Meditation Induced Cortical Oscillatory Modulations: an MEG case study.

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## Objective

Meditation is both an ancient spiritual practice and a contemporary technique for relaxing the body and calming the mind. Meditative techniques originally came from Asian religious practices and have been widely adopted in western society, where health benefits have become widely recognised. Various disciplines of meditation are employed medically and are accepted methods of alleviating anxiety and stress related disorders[1]. Further studies suggest meditation is of therapeutic advantage in the treatment of complex disorders such as epilepsy[2], although the neurophysiological basis of this is unclear[3].

In this study it was our intention to explore the neurophysiological activity associated with experienced meditative practice, in terms of the spatially localised oscillatory modulations detectable using Magnetoencephalography (MEG).

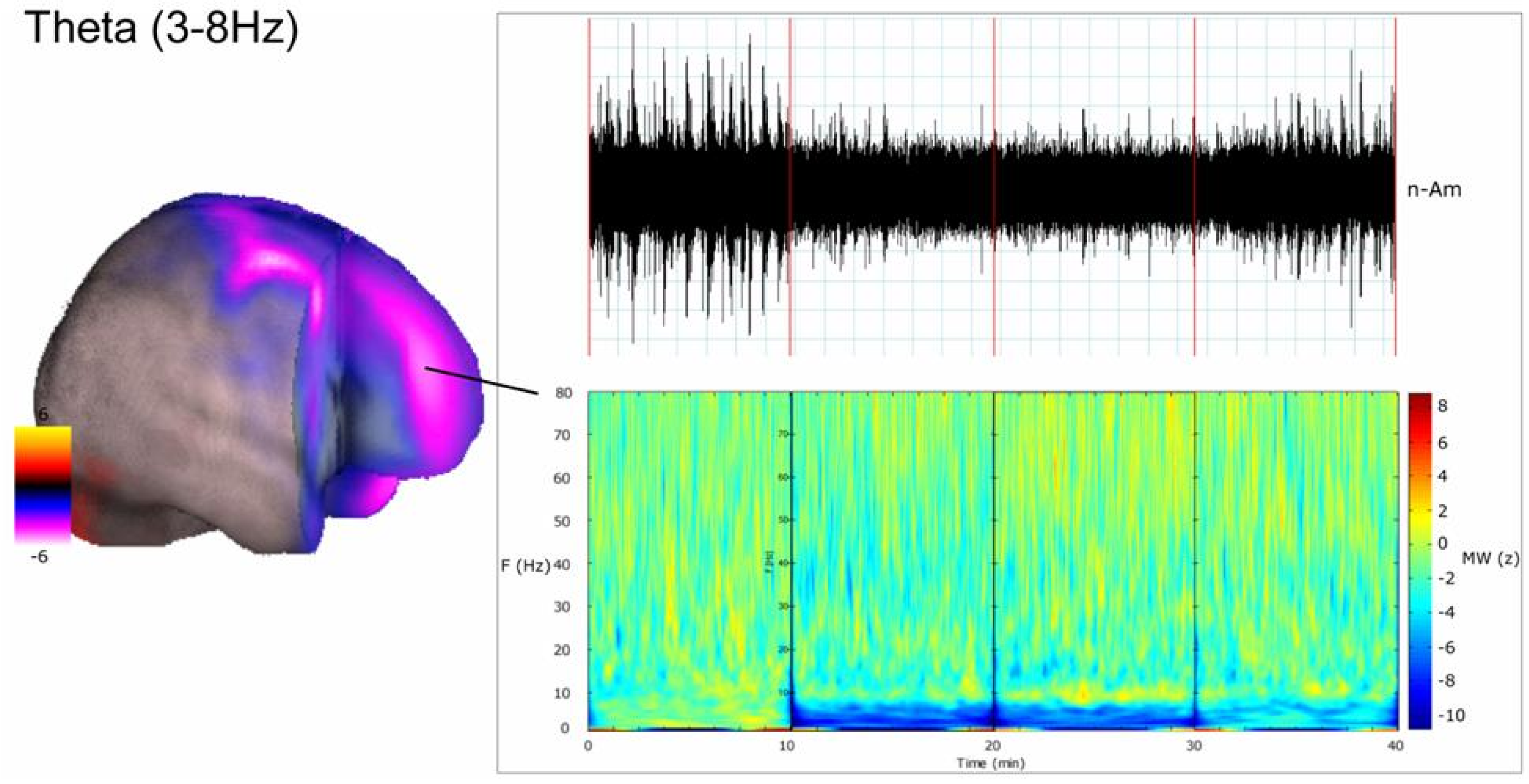
## Method

We used a passive MEG approach to measure changes in brain state during meditation. We invited an experienced meditator (SJK), a senior member of the Brahma Kumaris World Spiritual Organisation, with more than 30 years of expertise in meditative practice, to participate. Our subject was seated in a 151 channel MEG system (VSM Medtech, Port Coquitlam, Canada) for the duration of the experiment (40 minutes). This time comprised an initial 10 minute period of 'normal' non-meditation., which was followed by a 20 minute period of meditation and finally a 10 minute period of non-meditation. Data were then sectioned into the four 10 minute periods and analysed using the beamforming approach 'Synthetic Aperture Magnetometry' (SAM)[4]. The spatial location of frequency specific oscillatory power changes were computed for each of the periods, using the initial 10 minutes as a passive comparison. At these loci a set of weights were computed which allow the observation of spatially discrete electrical activity, providing a so called virtual electrode (VE)[5] . Subsequently, Morlett wavelet time frequency analysis and temporally filtered VE traces were computed to illustrate the envelope of the oscillatory power changes. Additionally, heart rate was monitored through the heart's magnetic signature on the MEG channels and recorded as beats per minute.

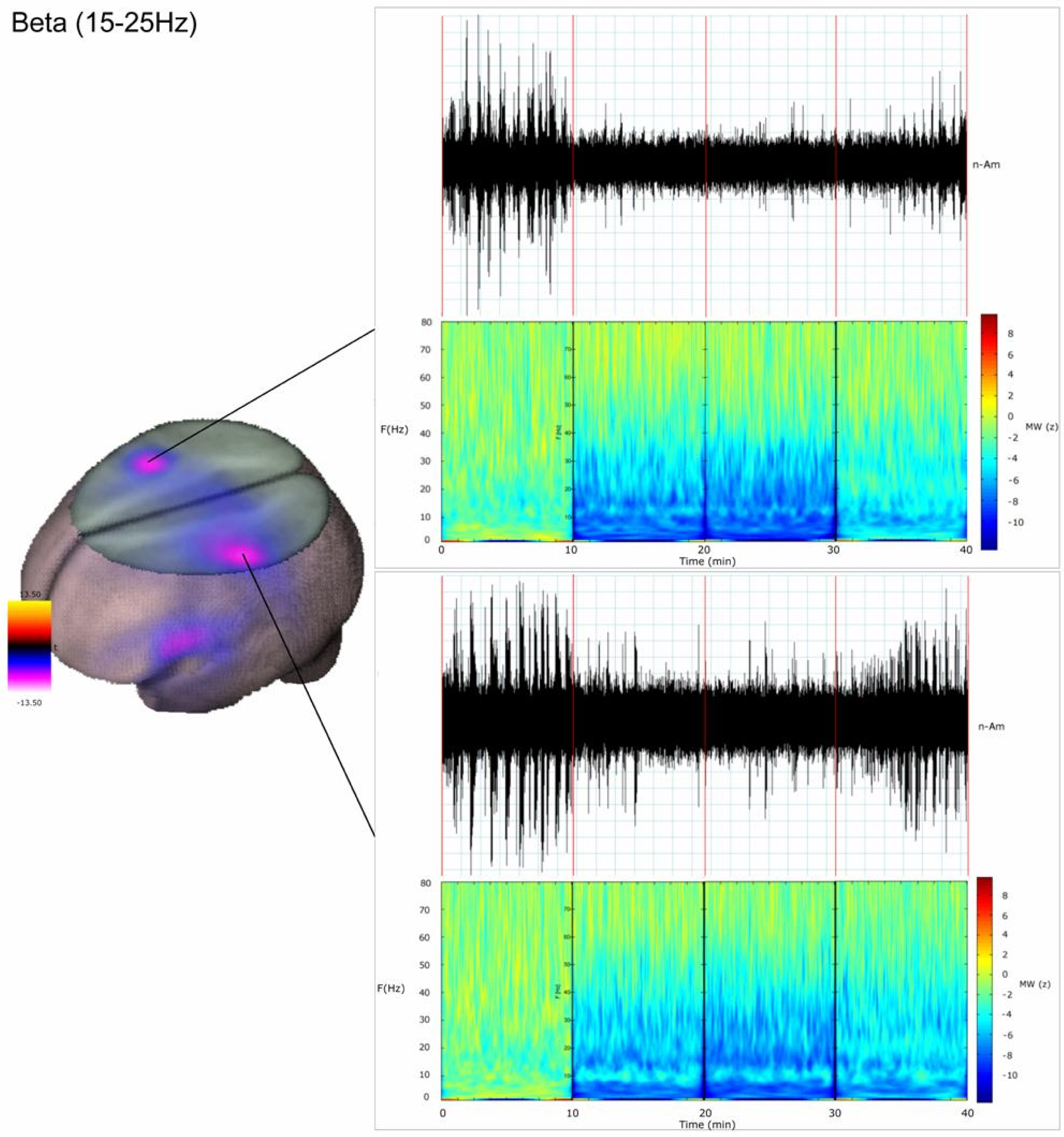
## Results

SAM analysis revealed oscillatory changes in various frequency bands at several locations, coincident with the duration of the meditative periods. A reduction of synchronous power in the theta frequency band (3-8Hz) was observed in the medial frontal region (peak t=-6.0), which remained constant for the duration of the meditiation phase and returned to near baseline during the second non-meditation phase (fig. 1). A more marked reduction in synchronous power was observed bilaterally in postcentral gyrus (t=13.3/11.0 (L/R)) in the beta frequency (15-25Hz) range, which again persisted for the duration of the meditation phase and returned rapidly to near baseline following cessation of the meditation phase (fig. 2). Additionally, an increase in synchronous power was observed was observed in right cerebellum (peak t=17.7) in the gamma frequency range, which increased greatly during the meditation phase and returned slowly to baseline during the second non-meditation phase. A profound increase in heart rate (~30 bpm) was observed during the meditation phase.

Theta (3-8Hz)




Beta (15-25Hz)




Gamma (25-80Hz)

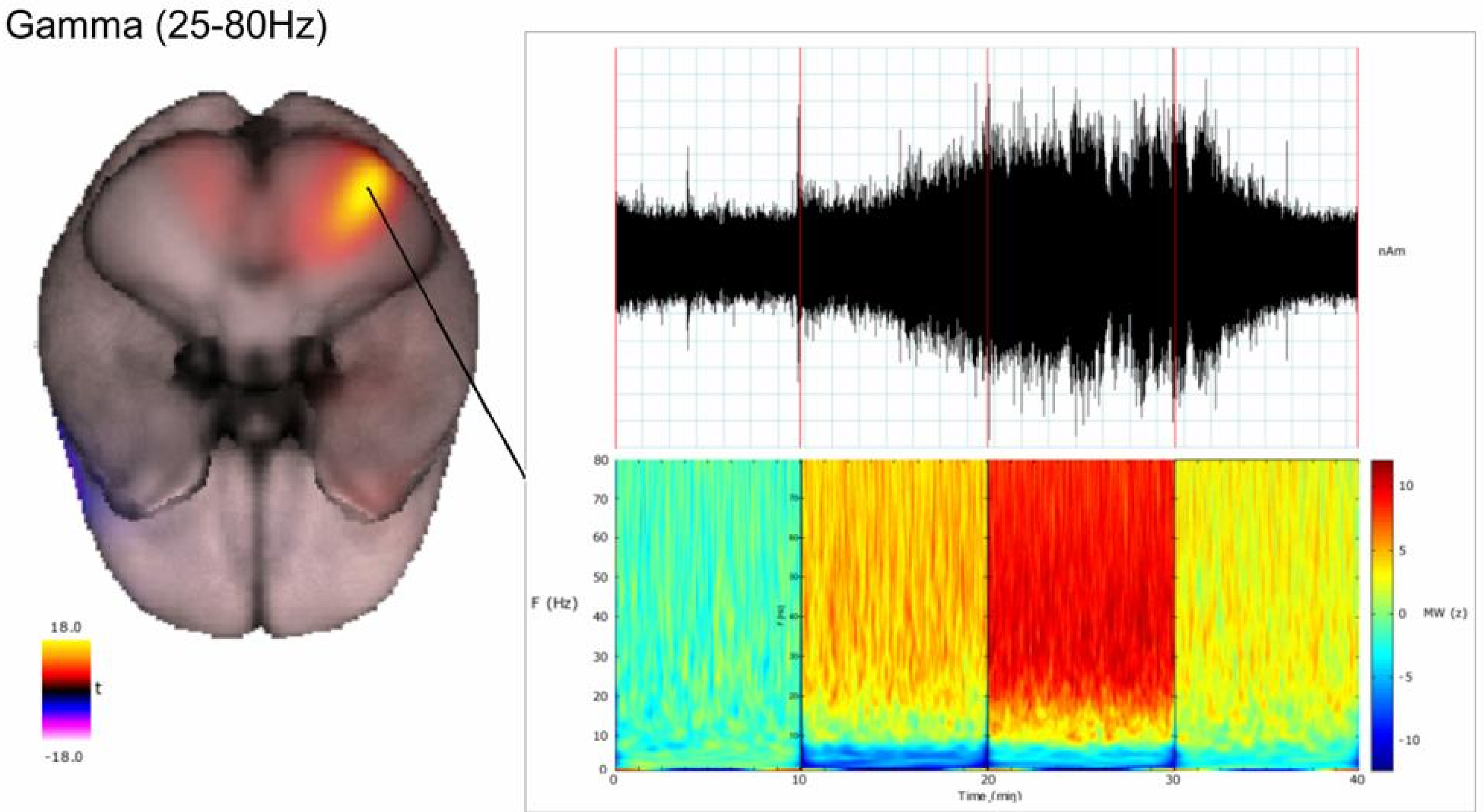



**Figure 1. Medial Frontal Theta**. (left) The 3D image demonstrates a reduction in synchronous power in the theta (3-8Hz) frequency range (t-6.0). This change occurs following onset of the meditation phase (10 minutes) and persists for the duration of the meditation phase (10-30 minutes) and returns to near baseline during the final non meditation phase (30-40 minutes).

**Figure 2. Postcentral Beta.** (top) The 3D image demonstrates a reduction in synchronous power in the beta (15-25Hz) frequency range (t=13.3/11.0 (L/R). This change occurs following onset of the meditation phase (10 minutes) and persists for the duration of the meditation phase (10-30 minutes) and returns to near baseline during the final non meditation phase (30-40 minutes).

**Figure 3. Cerebellar Gamma.** (bottom) The 3D image demonstrates an increase in synchronous power in the gamma (25-80Hz) frequency range (t=17.7). This change occurs following onset of the meditation phase (10 minutes) and persists for the duration of the meditation phase (10-30 minutes) and returns to near baseline during the final non meditation phase (30-40 minutes).

## Discussion

The results demonstrate that although meditation is a technique employed for relaxation, it stimulates a substantial increase in circulatory rate, which is likely to reflect an increase in neural metabolic demand. The reduction in synchronous power observed in somatosensory cortex is possibly a reflection of the mechanism of sensory suppression, reported to occur in meditative practice. The significance of the oscillatory modulations observed during meditation is unclear, particularly those in frontal and cerebellar areas. However, it is clear that this form of meditation represents an active rather than passive process and is more than just a state of hyper-relaxation and as such requires further investigation.

## References

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