Saggar et al. BMC Neuroscience 2010, 11(Suppl 1):O7
http://www.biomedcentral.com/1471-2202/11/S1/O7

BMC Neuroscience

ORAL PRESENTATION **Open Access**

A computational approach to understanding the longitudinal changes in cortical activity associated with intensive meditation training

Manish Saggar[1*], Stephen R Aichele[2,3], Tonya L Jacobs[3], Anthony P Zanesco[3], David A Bridwell[4,3], Katherine A Maclean[6,3], Brandon G King[3], Baljinder K Sahdra[2,3], Erika L Rosenberg[3], Phillip R Shaver[2], Emilio Ferrer[2], B Alan Wallace[5], George R Mangun[2,3], Clifford D Saron[3], Risto Miikkulainen[1]

From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

Meditation involves focusing one's attention on an object or a phenomenon. Numerous studies have discovered beneficial effects of meditation. However, very few scientific studies have attempted to formally understand the underlying mechanisms. In the present study, two 3-month retreats were conducted. 88-channel EEG data was collected while participants rested with their eyes closed before and after engaging in focused attention meditation. Second-order blind source separation was used for artifact removal. Reference-free data was obtained by estimating current source density. Changes in spectral power were assessed using a nonparametric cluster-based approach. Within-session (pre-meditation rest vs. meditation) results, in the alpha band, suggest that after 3-months there is a generalization of overall cortical activity during rest, such that the "default" mode of resting came to resemble the meditation mode. To formally understand the underlying mechanisms responsible for such a cortical change during rest, a computational model was employed. Attention regulation during focused meditation is hypothesized to involve cortico-thalamo-cortical interactions. Thus, to model EEG data during rest, the presented model architecture includes cortico-thalamic and thalamo-cortical interactions (Figure-1a). This model was initially developed by [1] and is capable of modeling both spatial and temporal dynamics of cortical activity using a 2-D continuum approach with inputs from sub-cortical structures. Three computational modeling experiments were run to examine – (1) if the model can fit the 88-channel EEG

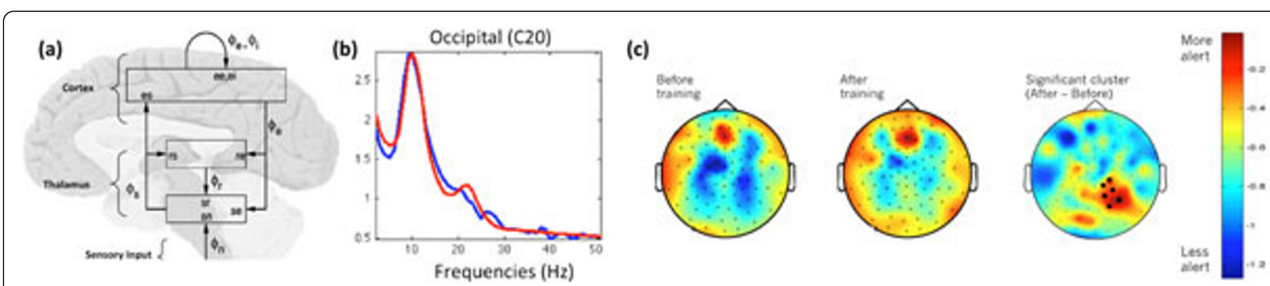

Figure 1 **(a)** Model architecture for a single site (adapted from [1]). **(b)** Model estimated (in red) and experimental (in blue) spectra for a sample channel and subject. **(c)** Topographic map of the intrathalamic gain parameter before and after training. Reduction in intrathalamic gain has been linked to increase in alertness [2]. Thus, the model not only fits experimental data but also provides a concrete and testable hypothesis about the changes seen on the scalp.

* Correspondence: mishu@cs.utexas.edu
[1]Department of Computer Science, University of Texas at Austin, Austin, TX 78712, USA

data, (2) if the inverse computational modeling can provide insights about the patterns observed on the scalp, and (3) if the stability analysis of model equations can explain for the observed cortical activity changes on the scalp. As shown in Figure-1b, the model-estimated spectrum is in accordance with the experimental spectrum without crossing physiologically plausible limits for the parameter set. Further, inverse computational modeling of the estimated spectral data indicates that after three months of training intrathalamic gain was significantly reduced in the right-parietal location (Figure-1c). This reduction suggests that participants after training were more alert even during rest. This sustained alertness during rest may be reflected as a change in the “default” mode after three months of training. Lastly, the stability analysis of model equations showed that reduction in the intrathalamic gain parameter provided more overall stability to the system. Altogether, these computational experiments along with the spectral analysis provide a more insightful formal theory of what might be happening inside the brain than does the spectral analysis alone.

Author details
[1]Department of Computer Science, University of Texas at Austin, Austin, TX 78712, USA. [2]Department of Psychology, University of California-Davis, Davis, CA 95618, USA. [3]Center for Mind and Brain, University of California-Davis, Davis, CA 95618, USA. [4]Department of Cognitive Science, Univ. of California-Irvine, Irvine, CA 92697, USA. [5]Santa Barbara Institute for Consciousness Studies, Santa Barbara, CA 93130, USA. [6]Department of Psychiatry and Behavioral Sciences, JHU School of Medicine, Baltimore, MD 21224, USA.

Published: 20 July 2010

References

1. Robinson PA, Rennie CJ, Rowe DL: **Dynamics of large-scale brain activity in normal and arousal states and epileptic seizures.** *Phys Rev E Stat Nonlin Soft Matter Phys* 2002, **65(4 Pt 1)**:041924.
2. Steriade M: **Corticothalamic resonance, states of vigilance and mentation.** *Neuroscience* 2000, **101(2)**:243-276.

doi:10.1186/1471-2202-11-S1-O7
Cite this article as: Saggar *et al.*: A computational approach to understanding the longitudinal changes in cortical activity associated with intensive meditation training. *BMC Neuroscience* 2010 **11**(Suppl 1): O7.