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EEG Spectral Analysis on OM Mantra Meditation: A Pilot Study

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Abstract
Mantra meditation is easy to practice. "OM" Mantra is the highest sacred symbol in Hinduism. The present study investigated the temporal dynamics of oscillatory changes after OM mantra meditation. Twenty-three naive meditators were asked to perform loud OM chanting for 30 min and the EEG were subsequently recorded with closed eyes before and after it. To obtain new insights into the nature of the EEG after OM chanting, EEG signals were analyzed using spectral domain analysis. Statistical analysis was performed using repeated measures of analysis of variance. It did not reveal any specific band involvement into OM mantra meditation. But significantly increase in theta power was found after meditation when averaged across all brain regions. This is the main effect of OM mantra meditation. However, the theta power showed higher theta amplitude after condition at all regions in comparison to the before condition of meditation. Finding was similar to other studies documenting reduction in cortical arousal during a state of relaxation. The study argues for the potential role of loud 'OM' chanting in offering relaxation. It provides a new perspective of meditation to the naive meditators. This information may help to demystify meditation and encourage those considering this as beneficial practice.

Keywords Mantra meditation · EEG · OM

Introduction

Yoga is the holy science on philosophy that has universal, non-sectarian and timeless appeal (Madanmohan 2008). Meditation, being one of the aspects of yoga, can be defined as willfully and purposefully regulating one's own attention either for relaxation, exploring oneself or personal growth. It can operationally be divided into two categories: on focusing attention on a particular external, physical, or mental object, while ignoring all irrelevant stimuli or on an unchanging repetitive object, is constantly held in focus such as mantra mediation (Schmidt et al. 2013). It has been claimed that Mantra meditation is easy to practice (Burke 2012). Om Mantra is the highest sacred symbol in Hinduism and is the ancient sound from which all other sounds and creation emerge signifying the Supreme Power (Kumar et al. 2010). Hence, in the present study, meditation with OM mantra has been chosen.

Related Work

OM meditation brings psycho-physiological relaxation on the basis of galvanic skin response (Das and Anand 2012). The autonomic and respiratory variables were examined during OM meditation and control session (Telles et al. 1995). The repetition of "OM" is compared with repetition of "One" (Telles et al. 1998). But the repetition of OM only reduced the skin resistance, suggesting a refined change in the mental state. A subsequent study examined middle latency auditory evoked potentials before and during the practice of it. It is a comparative study between experienced meditators and aged matched naïve subjects. Reduction in the peak latency of the Nb wave during Om meditation suggests neural activity (Telles et al. 1994). Functional magnetic resonance imaging (fMRI) study (Kalyani et al. 2011) has shown significant deactivation of limbic brain regions during OM meditation. The immediate effect of 20 min of mental chanting with effortless defocusing on syllable 'OM' has been observed on the Stroop task using fNIRS technology (Deepeshwar

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et al. 2014). The protocol employed in this study consisted of random thinking, OM meditation and eight states. This study reported increased Oxy-hemoglobin concentration and cerebral blood flow in the prefrontal area during meditation compared to random thinking. It suggests that OM meditation induce a state of reduced psycho-physiological arousal with enhanced awareness and attention. Initially the author attempted to investigate the effect of OM chanting on brain by checking the complexity of EEG signal after this meditation on the basis of Higuchi fractal dimension, but OM chanting was not of fixed duration for each subject. Statistical analysis was absent in this work (Harne 2014). Even listening to the OM sound affects the neural cortex (Kumar 2015).

The time–frequency analysis on the "OM" chant signal has found that "OM" chanting reduces the stress from human mind and gives calm and peace to a stressed mind (Gurjar and Ladhake 2008).

Our Approach

All these studies related to OM meditation vary in experimental setup and methods to observe the response of meditation. It has been found that EEG analysis to investigate the effect of loud OM chanting on the brain has not been studied so far. Hence effort has been taken to examine the changes in EEG associated with OM chanting. The aim is to compare oscillatory changes in the standard frequency bands (delta, theta, alpha, and beta) before and after OM chanting. In all studies related to different meditations (Cahn and Polich 2006; Baijal and Srinivasan 2010; Chan et al. 2008; Huang and Lo 2009; Lagopoulos et al. 2009; Cahn et al. 2010) examining EEG measures reported an increase in theta power. Since other meditations have shown modulation in the theta band, it has been therefore hypothesized that like other meditation OM chanting would result in changes in theta activity.

The second purpose of this study is to explore with a group of naive meditators how OM meditation as a lifestyle-based activity effectively reduces stress for improved mental and physical health and well-being because they can present a valuable source of knowledge of the early stages of meditation practice. Hence, engineering students have been chosen as a naive meditator group.

Many studies confirm that the state changes in EEG during meditation. In this study, the objective was to verify what changes could be expected in baseline trait EEG patterns outside meditation. Hence we employed before-after without control group experimental design to particularly examine the trait changes in EEG patterns.

The rest of this paper is organized as follows. The materials and methods are discussed in first section. Second Section presents results. The discussion part is covered in third section. The conclusion is given in last section.

Materials and Methods

Subjects

A total of N = 23 naive meditators (F = 14) were assessed (M = 20.99, SD = 0.99, 18–22 years). Subjects had no meditation training. They were chosen from a college of engineering through word of mouth and were also informed that their brain activity would be recorded before and after OM chanting. They all were right-handed and blind to the experimental hypotheses with no history of neurological illness. They were nonsmokers and medication-free and none of them was a habitual drinker. Nobody had previously practiced any form of meditation techniques. All experiments were performed with the informed and explicit consent of each subject. This study is presented and applied to the concerned ethical committee of Government Medical College, Akola, Maharashtra, India.

Design of Study

This is a single group repeated measure study, in which all the subjects were asked to perform OM chanting for the duration of 30 min. Assessments were performed before and after the intervention. For this study, the following is the experimental setup (Fig. 1).

At the very first moment subject was asked to relax just laying down and with eyes closed, during which EEG of the respective subject for more than 2 min was recorded. This recorded new data is an EEG signal before OM chanting. After recording first data, he/she was asked to sit down in relax state with erect posture and closed eyes and was asked to chant OM mantra for 30 min. While chanting, first we have to inhale smoothly and hold the breath; soon we have to release the air (exhale) by chanting OM. There was no light in the room during chanting. The surrounding was made silent in order to maintain calm and peace which helped subject to concentrate fully. The respective subject was then asked to relax by laying down and eyes closed. EEG was

Fig. 1 Experimental setup

recorded for more than 2 min. This recorded data is an EEG signal after OM chanting. The subjects provided detailed descriptions of the experiences in written form when asked about the experience of it.

EEG Recording

EEG recording was performed in an electrically shield room of Bilala hospital under the guidance of Dr. Saurabh Bilala, Akola. EEG signals were recorded according to international standard 10–20 from 16 channels using RMS India system with 256 Hz sampling frequency for monopolar montages. These electrodes are Fp1, F7, T3, T5, O1, F3, C3, P3, Fp2, F8, T4, T6, O2, F4, C4, P4 (Fig. 2). The electrodes in right hemisphere were referred to the right earlobe (A2) and electrodes in left hemisphere were referred to the left earlobe (A1) with the ground at the forehead.

Analysis

Since the purpose was to explore brain dynamics as a result of OM chanting, the EEG data of the first 1 min before OM chanting was used to assess the control state and the first 1 min data after OM chanting to assess state achieved after meditation. 1 min data should be used for trustworthy spectral analysis (Nuwer et al. 1999). The EEG signals were filtered between 0.1 and 60 Hz. Since EEG is not a stationary signal for duration longer than 3.5 s (Gasser and Molinari 1996), 256 data points epoch was filtered. The FFT was then performed to the selected data for every 1 s segment. The power spectral density (PSD) of delta (0.3–4 Hz), theta (4.1–8.0 Hz), alpha (8.1–12.0 Hz), and beta (12.1–30.0 Hz) and gamma (30.1–55.0) frequency band were obtained by using Welch technique, Hanning windowing function. The resulting values were afterwards normalized into a relative power (Amodio et al. 2009; Aftanas and Golocheikine 2001) as follows:

$$Relative\_power = \frac{\int_{f_L}^{f_H} S_b(f)df}{\int_0^{f_{\max}} S_T(f)df} \times 100 \quad (1)$$

where f_L is the lower frequency of particular band, f_H is lower frequency of particular band, $f_{\max} = 55$ Hz, S_b is EEG signal of particular band, S_T is the EEG signal of particular band.

Finally, mean relative power was computed for every electrode. For statistical analysis, all 16 electrodes were divided into 10 brain regions which are as follows: right occipital (O2), left occipital (O1) right parietal (P4) and, left parietal (P3), right central (C4), left central (C3), right frontal (F8, F4, and Fp2), left frontal (F7, F3 and Fp1), right temporal (T4 and T8) and left temporal (T3 and T7). Under each region, power values of the constituent electrodes were averaged, and the procedure was repeated for all the frequency bands.

Statistical Analysis

IBM SPSS, version 22 was used for statistical analysis. The normality of the relative power data distribution through a Kolmogorov–Smirnov test was preliminarily tested. It revealed a normal distribution of the data, justifying the subsequent use of ANOVA analyses. Two analyses of variance (ANOVAs) were performed on the relative power values. To verify the specificity of a band involved into the OM chanting effect, two way repeated ANOVA with factor bands (5: delta, theta, alpha, beta and gamma) and condition (2: before and after). For documenting the specificity of a location involved into the OM chanting effect, each frequency band was submitted to a within-subjects design, analysis of variance (ANOVA) over the factors of condition (before and after), hemisphere (2: left and right) and region (5: F—frontal, C—central, P—parietal, O—occipital, T—temporal). A p value less than 0.05 was considered statistically significant. Greenhouse-geisser corrected values were reported.

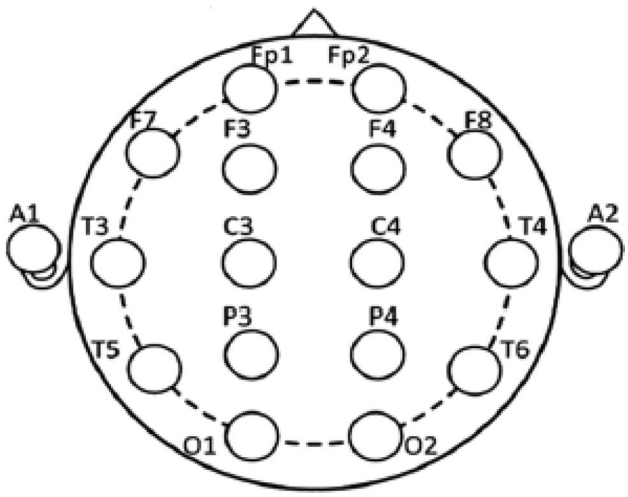

Fig. 2 Electrode placement

Results

First two-way ANOVA analysis is conducted to test the hypothesis stated in introduction. The analysis revealed only band significant effect [$F(4, 88) = 102.3$, $p = 0.00$]. This analysis failed to show significant condition main effect and band × condition interaction effect. Research results are the opposite of what was expected. No specific band involved into the OM chanting effect (Fig. 3).

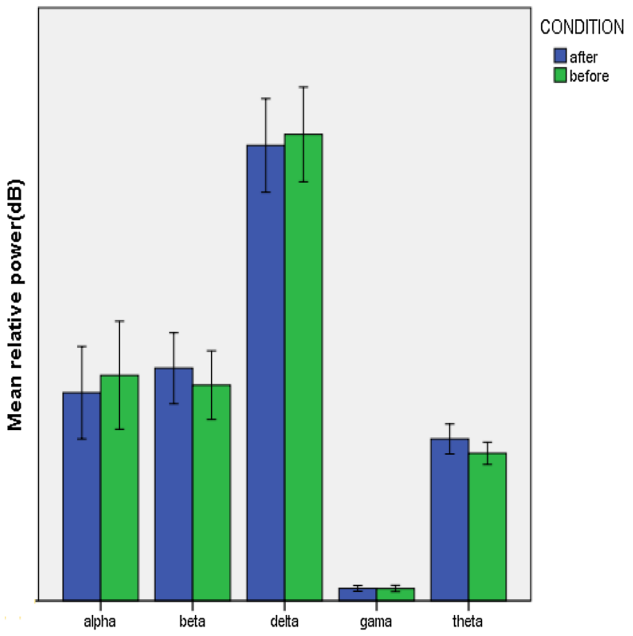

Fig. 3 Relative power before and after OM mantra meditation (N = 23). No any band exhibited a significant effect

To evaluate the association between hemisphere, region and condition after OM chanting, three-way repeated ANOVA with hemisphere (left and right), region (5) and condition (2) as factors was performed for relative power values separately for all the five types of bands (delta, theta, alpha, gamma and beta). Main effects (conditions, regions and hemisphere) and interaction effect for each frequency band are given in Table 1.

Theta Band Analysis

Repeated-measures ANOVA demonstrated significant main effects for condition for theta band only. Hence, there was a significant increase in theta power in the after condition compared to the before condition, when averaged across all brain regions. Figure 4 shows the relative power for all ten regions for before and after condition. The results clearly depicted the increase of relative theta power at all regions in after condition.

Alpha Band Analysis

Interaction effect (hemisphere × region × condition) is significant for alpha band. Post-hoc were conducted for same band. Our interest lies in only one simple main effect involves determining the mean difference in relative power between conditions at different regional levels for different hemispheres. But comparisons reflected no significant difference in before and after power in any region (Table 2).

Delta Band Analysis

Hemisphere × region × condition interaction effect is present for delta band. The same analysis is carried out as for alpha band. No significant results are found for any region for different conditions as depicted in Table 3.

Discussion

This study aimed to examine the effects of OM mantra meditation on baseline EEG brainwave patterns. Any band oscillations as a trait of 30 min OM chanting was not observed but an overall EEG wide band theta increases after this meditation significantly which is just 30 min effect of OM mantra meditation. This result is similar with previous study on experienced acem meditators (Lagopoulos et al. 2009), reporting similar EEG patterns for theta. Theta band changes are linked mostly with level of meditation experience (Kasamatsu and Hirai 1966). Hence the results are very promising with naïve meditators and only with 30 min practice of OM mantra meditation.

The closer examination showed theta activity rises insignificantly on all regions of the brain. Increased theta power across all cortical regions indicate widespread reductions in cortical arousal (Canteros et al. 2002; Jacobs and Lubar

Table 1 Results of ANOVA for relative power for two hemisphere, five regions and two conditions in all frequency bands between before and after condition of experimental group (n = 23)

Frequency band	Condition main effect	Condition × region interaction effect	Condition × hemisphere interaction effect	Condition × region × hemisphere interaction effect
Delta	F(1,22) = 0.211, p = 0.65	F(4,88) = 0.661, p = 0.621	F(1,22) = 0.147, p = 0.705	F(4,88) = 4.036, p = 0.005
Theta	F(1,22) = 4.851, p = 0.038*	F(4,88) = 0.431, p = 0.786	F(1,22) = 0.365, p = 0.552	F(4,88) = 0.962, p = 0.433
Alpha	F(1,22) = 0.5, p = 0.487	F(4,88) = 1.135, p = 0.345	F(1,22) = 1.774, p = 0.197	F(4,88) = 4.242, p = 0.003
Beta	F(1,22) = 1.164, p = 0.292	F(4,88) = 1.92, p = 0.114	F(1,22) = 1.721, p = 0.203	F(4,88) = 0.159, p = 0.959
Gam-ma	F(1,22) = 0.016, p = 0.9	F(4,88) = 0.577, p = 0.68	F(1,22) = 0.648, p = 0.43	F(4,88) = 041, p = 0.997

*Significant (p < 0.05)

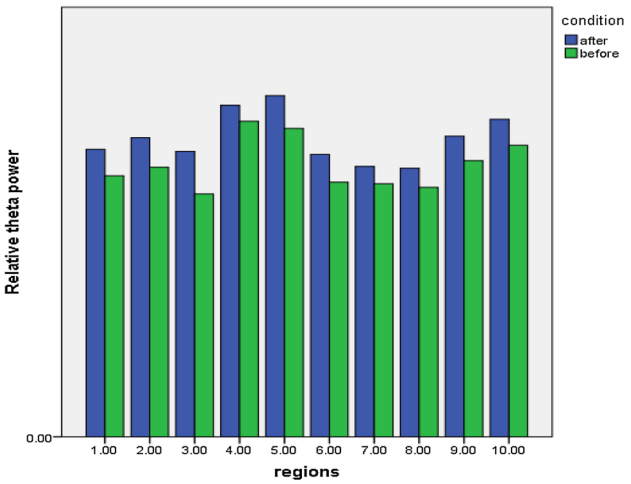

Fig. 4 Bar graph showing changes in relative power in theta band in all ten regions at before and after conditions: region: *1* left frontal; *2* left temporal; *3* left occipital; *4* left parietal; *5* left central; *6* right frontal; *7* right temporal; *8* right occipital; *9* right parietal; *10* right central

1989; West 1980; Jacobs and Friedman 2004). The state of deep relaxation is accompanied by reduction in cortical arousal (Dean and Cosic 2011). Though there is no previous report on the effect of loud 'OM' chanting on brain with EEG, an earlier study (Kalyani and et al. 2011) had observed the impact of same on brain using fMRI. Remarkably, our study findings are in tune with this previous study; OM mantra meditation offers relaxation.

As this study includes naïve meditators, subject was allowed recitation of OM mantra according to his\her vocal strength and at random frequencies. A further more detailed study can be conducted to test whether recitation of OM mantra at specific frequencies and with experienced meditators, induces enhanced effect on brain. The significance of 30-min acute session of OM chanting will result in an increased of theta activity, thus achieving relaxation.

Conclusion

In conclusion, the effect of OM meditation on brain on the basis of spectral analysis of EEG signal before and after OM chanting was examined. The results show that a 30 min OM mantra meditation practice alter theta EEG patterns significantly more than baseline EEG brainwave patterns. The findings in the present study are related to naive meditators. Thus a 30 min OM chanting serving as an introduction to meditation that provides naive meditators with the opportunity to experience the phenomenon of meditation, and then share their experiences in focus groups immediately thereafter. Further studies are required (i.e., randomized controlled trials) engaging a larger sample size, using advanced techniques to evaluate its precise physiological effects and underlying mechanisms.

Table 2 Results of paired t-test for relative alpha power for before and after condition for each region (n = 23)

Hemisphere	Region	Difference in conditions	Paired differences					
			Mean	Std. deviation	Std. error mean	95% confidence interval of the difference		
						Lower	Upper	p
Left	Frontal	Before–after	0.0195	0.0928	0.0194	−0.0207	0.0596	0.325
	Temporal	Before–after	0.0371	0.1067	0.0223	−0.009	0.0832	0.110
	Occipital	Before–after	0.0147	0.1088	0.0227	−0.0324	0.0617	0.525
	Partial	Before–after	0.0233	0.1153	0.024	−0.0266	0.0731	0.344
	Central	Before–after	0.0162	0.103	0.0215	−0.0284	0.0608	0.459
Right	Frontal	Before–after	0.0135	0.1278	0.0267	−0.0418	0.0688	0.617
	Temporal	Before–after	0.0056	0.1231	0.0257	−0.0476	0.0589	0.828
	Occipital	Before–after	0.0406	0.1306	0.0272	−0.0159	0.0971	0.150
	Partial	Before–after	−0.0256	0.1392	0.029	−0.0858	0.0347	0.388
	Central	Before–after	0.0059	0.1244	0.0259	−0.04791	0.0597	0.823

Table 3 Results of paired t-test for relative delta power for before and after condition for each region (n = 23)

Hemisphere	Region	Difference in conditions	Paired differences					
			Mean	Std. deviation	Std. error mean	95% confidence interval of the difference		
						Lower	Upper	p
Left	Frontal	Before–after	0.0169	0.1076	0.0225	−0.0297	0.0634	0.460
	Temporal	Before–after	−0.0102	0.1288	0.0269	−0.0659	0.0455	0.707
	Occipital	Before–after	0.04834	0.1572	0.0328	−0.0196	0.1164	0.154
	Partial	Before–after	−0.0000	0.1448	0.0302	−0.0626	0.0626	1.000
	Central	Before–after	0.0248	0.1272	0.0265	−0.0308	0.0792	0.372
Right	Frontal	Before–after	0.0099	0.1453	0.0303	−0.0529	0.0728	0.746
	Temporal	Before–after	−0.0006	0.1616	0.0337	−0.0705	0.0693	0.986
	Occipital	Before–after	−0.0079	0.1841	0.0384	−0.0875	0.0718	0.840
	Partial	Before–after	0.038	0.1782	0.0372	−0.0391	0.1151	0.317
	Central	Before–after	0.0031	0.1518	0.0316	−0.0625	0.06868	0.922

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or Indian Council for Medical Research or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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