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RESEARCH ARTICLE

# Effect of Mantra Chanting on Power Spectral Density

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## Abstract

**Objectives:** Mantra chanting a spiritual form of meditation helps to calm the human brain. Mantra chanting is a meditative practice known to influence brainwave activities that are linked to increased theta and alpha brain rhythms. This paper investigates the variations in Power Spectral Density of experienced Mantra chanting individuals and evaluates the paired t-test before and during mantra chanting. **Methods:** The research is inspired by existing works on how meditation affects the activities of brain waves. This paper particularly emphasizes the effect of "OM" mantra chanting on experienced subjects. 11 experienced subjects (3 to 8 years) EEG data was taken using the Emotiv Flex 32 channel noninvasive device of subjects before and during mantra chanting in the age group of $37 \pm 6$ years for a duration of 3 minutes. This method deviates from the traditional collection of data immediately after mantra chanting as our subjects are well experienced and have been practicing mantra chanting. We aim to study the influence on experienced subjects during mantra chanting. Statistical analysis was performed using the Welch method to calculate the oscillatory power of each band and a paired t-test was evaluated. **Findings:** The results demonstrate significant changes in specific EEG frequency bands, including an increase in Alpha (10%), Gamma (13%), Beta (23%), and Delta (16%) during mantra chanting, suggesting a deeper state of relaxation and focus. The result shows how mantra chanting impacts the cognitive processes and brainwave activity during meditative states. **Novelty:** Findings were similar to existing works on temporal dynamics. This study argues the potential effect of mantra chanting on experienced individuals. This study provides a new perspective on mantra chanting on experienced individuals.

**Keywords:** Mantra Chanting; Power Spectral Density; EEG; Relaxation; Meditation

## 1 Introduction

The human brain, being the most intricate organ, has been a focus of increased study in biological phenomena. Coping with stress has become a significant focus, with practices like chanting mantras and transcendental meditation gaining popularity as effective methods. Research highlights that chanting can bring about positive changes in the

brain, making it a form of self-healing. In today's world, characterized by mounting work pressures and mental health challenges, issues like depression, anxiety, and stress are on the rise. This study explores the importance of maintaining harmony between the mind and body, emphasizing the vital role meditation and mantra chanting play in achieving mental peace. Rooted in tradition, mantra chanting is regarded as a holistic practice that regulates both physical and mental states. Known for its calming effects, chanting has the potential to transform mental states and influence brain wave patterns. Electroencephalography (EEG) is introduced as a non-invasive and cost-effective technique to study brain signals, making it a valuable tool in fields such as medicine, psychology, and neuroscience. EEG analysis is particularly significant in understanding brain activity and has been extensively used to explore the effects of practices like mantra chanting. Recent studies have shown promising results, indicating that mantra chanting can reduce stress, enhance cognitive functions, and improve overall well-being. This growing body of research underscores the potential of this traditional practice to contribute positively to mental and physical health [1,2]. The influence of Mantra chanting plays an important role in improving the quality of life [3]. Apart from this, previous research shows that mantra chanting can influence EEG oscillations, indicating its impact on brain activity [4]. Furthermore, the chanting of mantras has been linked to improvements in memory, attention, and synchronization of cardiovascular rhythms [5]. These findings suggest a potential correlation between mantra chanting and cognitive functions, which can be further explored through EEG analysis. Moreover, EEG analysis has been instrumental in various medical applications, including the detection of epilepsy, monitoring brain activity during anesthesia, and studying neurological disorders such as Alzheimer's disease [6–8]. The use of EEG in detecting neurological conditions highlights its sensitivity to subtle changes in brain activity, making it a valuable tool for investigating the effects of mantra chanting on cognitive functions.

Furthermore, the synchronization of brain hemispheres through mantra-based chanting has been ventured to have an impact on cognitive functions [9]. This suggests that EEG analysis provides insights into the neural mechanisms underlying the effects of mantra chanting on brain activity. Additionally, the influence of chanting on cardiovascular oscillations and breathing frequency further emphasizes the potential physiological and psychological effects of mantra chanting, which can be studied using EEG analysis [10,11]. Studies have reported positive effects on stress reduction, cognitive functions, and overall well-being. Chanting mantras has been shown to decrease activity in brain areas responsible primarily for emotions and behavioral regulation, such as the orbitofrontal, anterior cingulate, Para hippocampal gyri, thalami, and hippocampi [6]. The chanting of mantras has been linked to unexpected cardiovascular oscillations, adding an aesthetic and spiritual dimension to the physiological effects. Research has also indicated that mantra chanting has a positive impact on both physiological and psychological functions of the body, suggesting potential benefits for cognitive functions [10–12]. EEG analysis plays a crucial role in understanding the effects of mantra chanting on brain activity and cognitive functions. The existing literature provides evidence of the positive impact of mantra chanting on stress reduction, cognitive functions, and overall well-being, with potential implications for brain activity [13].

**Table 1. Brain wave frequencies and their characteristics**

| Type | Frequency (Hz) | Psychological state |
|---|---|---|
| Alpha | 8 to 13 | Relaxed, Calm, Conscious |
| Beta | 13 to 30 | Alertness, Focused |
| Gamma | 30 to 100 | Thinking, Integrated Thoughts |
| Delta | 0 to 4 | Deep Sleep, Trance |
| Theta | 4 to 8 | Creative, Drowsy |

This study aims to investigate the effects of mantra chanting on brainwave activity by analyzing EEG data using Power Spectral Density (PSD). This research seeks to explore how mantra chanting influences different brain regions and EEG frequency bands such as Delta, Theta, Alpha, Beta, and Gamma.

## Objectives

1. To analyze the changes in brainwave activity for various frequency bands before and during mantra chanting.
2. To explore how PSD can reveal insights into the cognitive and relaxation effects of mantra chanting.

# 2 Methodology

## 2.1 Data Collection

EEG data were collected from N=11 experienced subjects during two conditions: before and during mantra chanting (F =11, M = 39.7, SD = 2.89, 37-43 years). Subjects were chosen from an organization practicing mantra chanting and were briefed about capturing the brain signals for study. They were all right handed with no history of neurological disorder. All subjects had been practicing Mantra chanting for a period of minimum 3 years. All experiments were performed with the informed consent of each individual. This study is presented and applied to the concerned ethical committee of Gauhati University, Guwahati, Assam, India. Data were recorded from 32 channels Emotiv Flex. The sampling frequency of the recordings was at 128 Hz. The electrodes were placed in standard positions including frontal (Fz, F3, F4), parietal (Pz), central (C2), and occipital (Oz) regions, which are associated with cognitive functions and relaxation and are our primary focus channels.

**Table 2. Data collection parameters**

| Subject Type | Sex | Age (Years) | State |
|---|---|---|---|
| Experienced | Female | $37 \pm 6$ | Before Mantra Chanting |
| Experienced | Female | $37 \pm 6$ | During Mantra Chanting |

At the very first, subjects were asked to sit in their comfortable mantra chanting posture that they had been practicing with. Subjects with eyes closed and in a relaxed state. EEG recording was recorded for 1 minute. This new recorded data is an EEG signal before mantra chanting. Subsequently, Audio input of Om Mantra was provided to the individuals and recorded for a time of 2 minutes. This EEG recorded data is new data of EEG signal during mantra chanting. Since our purpose is to analyze the power spectrum of various bands on EEG signal during OM mantra chanting, the EEG data was used to access the control state and the next 2 minutes during OM mantra chanting to access the state achieved during mantra chanting.

Figure 1 shows the broad methodology of signal acquisition from the experienced mantra chanting individuals.

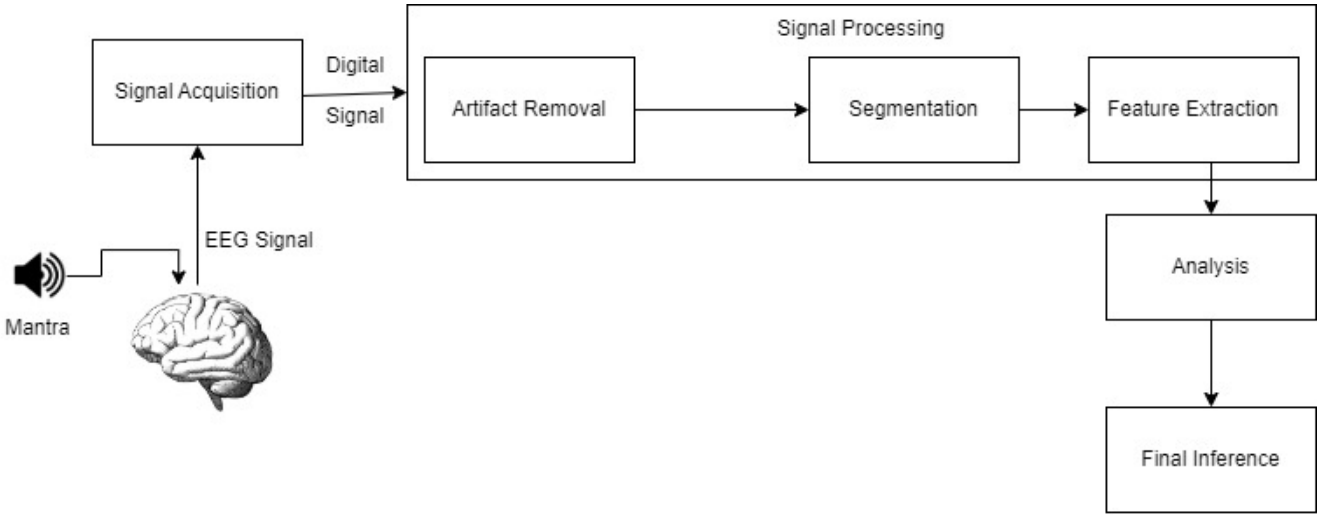


**Fig 1. EEG Analysis Methodology**

## 2.2 EEG Data Preprocessing

EEG data were processed using MATLAB 2022b (The MathWorks, Inc., Natick, Massachusetts, U.S.A.) and EEG LAB. Butterworth Bandpass Filter at 0.5 Hz was applied to isolate frequency bands as shown in Figure 2. Artefacts were removed using the Independent Component Analysis (ICA)[6].

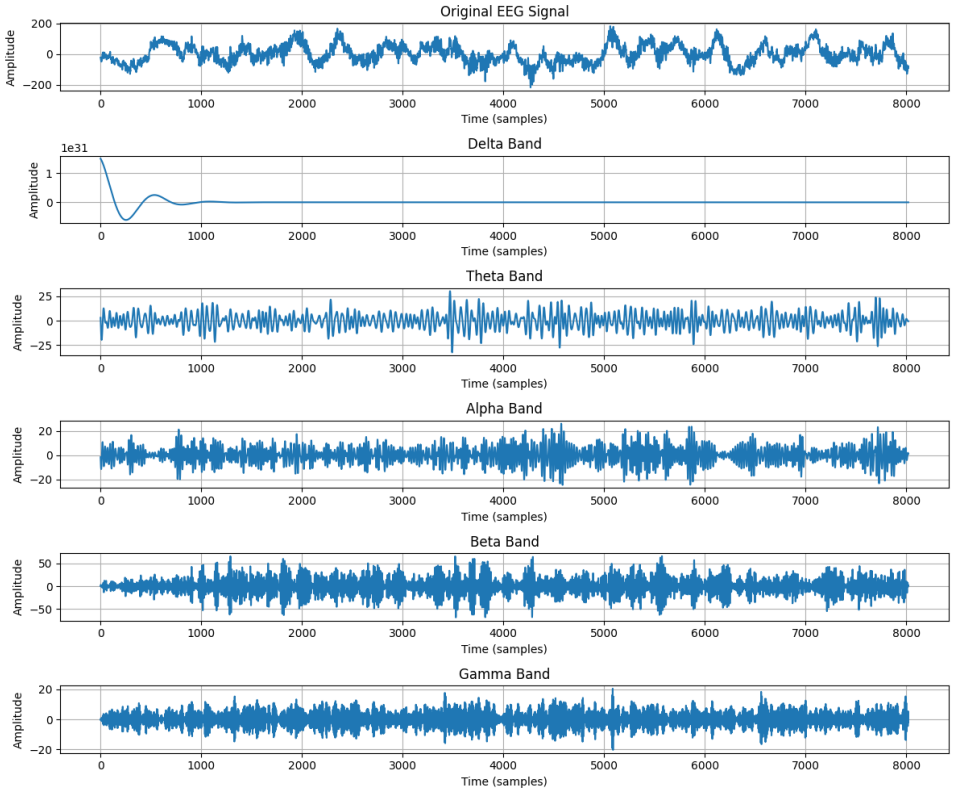


**Fig 2. Bands extracted from the original EEG Signal using Bandpass Filter (0.5 Hz)**

## 2.3 PSD Analysis

Power Spectral Density quantifies the power across various frequency components. PSD quantifies how the power of a signal is distributed across different frequency components. The signal's power content is calculated as a function of frequency. The band-power was further computed from each PSD to compare the relative power in the subject quantitively. The power in each band (Delta, Theta, Alpha, Beta, Gamma) was compared between the before and during mantra chanting conditions, focusing on key brain regions (Fz, F3, F4, Pz, C2, and Oz channels).

PSD was computed using the Welch Method as stated in Equation (1) for both EEG data before and during mantra chanting using the Hann window. Each segment containing 1024 samples was derived for maintaining a balance between frequency resolution and variance reduction.

$$P_k(f) = \frac{1}{M. \parallel w \parallel^2} \left| \sum_{n=0}^{M-1} x_k[n].w[n].e^{-j2\pi fn} \right|^2 \tag{1}$$

Here:

- M is the segment length.
- $\parallel w \parallel^2 = \sum_{n=0}^{M-1} w[n]^2$ is the normalization factor for the window, adjusting for the window's effect on the amplitude.
- The PSD estimate $P(f)$ is obtained by averaging the periodograms of all $K$ segments:

$$P(f) = \frac{1}{k} \sum_{K=1}^{K} P_k(f) \tag{2}$$

- This averaging reduces the variance of the PSD estimate and provides a smooth frequency.

The EEG signal bands are further isolated using the Butterworth bandpass filtering Equation (3). Figure 2 shows the different frequency bands viz. Alpha, Beta, Gamma, Theta and Delta bands extracted from the original EEG signal. Each band corresponds to different neural activities as stated in Table 1.

$$\text{b,a=butter(order,}[f_{\text{low}} / \left(\frac{f_s}{2}\right), f_{\text{high}}/(\frac{f_s}{2})], \text{btype} =' \text{band}') \tag{3}$$

# 3 Results and Discussion

## 3.1 PSD Analysis

The results from the PSD analysis revealed a clear increase in Alpha, Gamma, Delta and Beta waves band power during mantra chanting, particularly in the frontal (Fz, F3, F4) and occipital (Oz) regions, compared to the pre-mantra chanting state as seen in Figure 3. A decrease in Theta power was observed, indicating a reduction in deep relaxation. Gamma power, associated with higher cognitive functions, showed minor fluctuations during mantra chanting as seen in Figure 3.

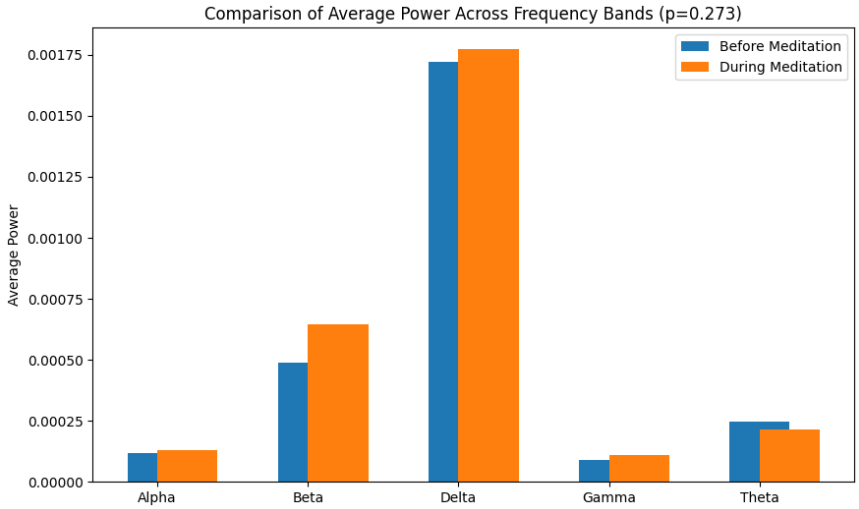


**Fig 3. Comparison of Average Power across Frequency Bands**

## 3.2 Key Observations

The results are similar to previous study on naïve meditators [14] that reports similar EEG analysis for before and after Loud OM mantra chanting. The study was done on naïve mantra chanting individuals and ANOVA repeated-measure was evaluated.

### *3.2.1 Delta Band and Beta Band*

Both ”Before mantra chanting ” and ”During mantra chanting ”indicate no strong difference in power in the Delta. This is expected because the Delta band is often associated with deep relaxation or sleep states

### *3.2.2 Alpha Band*

a) The Alpha band shows a significant difference in power in both conditions.

b) Alpha waves are usually associated with relaxation and calm. This result suggests that Alpha activity is not particularly dominant in this dataset.

### *3.2.3 Theta Band*

a) Theta band shows significant differences before and during mantra chanting.

b) Theta waves are related to deep relaxation and meditative states. The decrease in Theta during mantra chanting might suggest less engagement in this frequency range, depending on the type of mantra chanting performed.

### *3.2.4 Gamma Band*

a) Both conditions show impressive differences in Gamma power, indicating that high-frequency brain activity is prominent here.

b) Gamma waves are often associated with high-level information processing and cognitive functioning.

To evaluate the statistical difference in the PSD of the different EEG bands, we evaluate the paired t-test for each band as depicted in Table 3.

Closer examination depicted that Gamma, theta and Alpha power show a significant difference before and during mantra chanting. Though there is no significant study on the PSD analysis of OM mantra chanting on experienced mantra chanting subjects, it signifies the importance of mantra chanting and its effect on the human brain. The results of this study show that the Gamma waves associated with higher cognitive functions show a significant difference with $p < 0.05$. this indicates a reduction in Gamma power. The theta wave linked to deep sleep and relaxation or sleep shows a notable $p < 0.01$. Moreover, Alpha wave which is linked to calmness and relaxation shows a significant change before and during mantra chanting $p < 0.05$.

This study concentrates on experienced Mantra chanting individuals. The results obtained are convincing to draw the positive effects of OM mantra chanting. Further, a more detailed study can be conducted to test the spectral analysis with respect to various regions of the brain.

**Table 3. Results of paired t-test for EEG bands before and during mantra chanting**

| Band | Mean Difference | Median Difference | Std Error Mean | t-Statistic |
|---|---|---|---|---|
| Alpha | -0.000033 | -0.00004 | 0.000018 | 1.814608 |
| Theta | -0.000076 | -0.000082 | 0.000031 | 2.491914 |
| Gamma | -0.000049 | -0.000048 | 0.000022 | 2.239125 |
| Beta | -0.000231 | -0.000273 | 0.00017 | 1.36283 |
| Delta | -0.000178 | -0.000401 | 0.000176 | 1.009543 |

## 4 Conclusion

This study presents the effect of mantra chanting on Power Spectral Density of EEG signals. OM mantra chanting has been believed to calm the human brain and it signifies a state of relaxation. In conclusion, the effect of Mantra chanting-OM mantra on experienced subjects based on power spectral density analysis for before and after mantra chanting was examined. The result shows that mantra chanting on experienced subjects alters the Gamma ($p < 0.05$), Theta ($p < 0.01$) and Alpha band ($p < 0.05$). These findings are for experienced mantra chanting individuals. These changes suggest a shift toward a relaxed and focused mental state during mantra chanting. The complementary use of Power Spectral Density provides a deeper understanding of how brain activity evolves during mantra chanting, contributing valuable insights to the growing body of mantra chanting research. Further studies are required to analyze aspects of mantra chanting in different areas of the brain.

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