SAKARYA UNIVERSITY JOURNAL OF COMPUTER AND INFORMATION SCIENCES
http://saucis.sakarya.edu.tr/
e-ISSN: 2636-8129
Publisher: Sakarya University
Vol. 8, No. 4, 651-663, 2025
DOI: 10.35377/saucis...1692343
RESEARCH ARTICLE

Bridging Science and Spirituality: Investigating the Effects of OM Chanting on Brain Waves

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Article History:
Received: 06.05.2025
Revised: 07.06.2025
Accepted: 27.07.2025
Published Online: 13.10.2025

ABSTRACT
In Hindu tradition, the syllable "OM" holds significant spiritual and cultural value in Hindu tradition and is believed to produce positive psychological and physiological effects. Despite its prominence in spiritual practices, the neurophysiological basis for these benefits remains underexplored. In this study, electroencephalography (EEG), a non-invasive method for measuring electrical activity in the cerebral cortex, was employed to investigate the physical changes in brain wave patterns that occur when listening to OM chanting. Five frequency bands, namely delta, theta, alpha, beta, and gamma, are associated with brainwaves recorded through EEG, which define different states of cognitive and emotional nature. With these, this research analyzes EEG signals before and after chanting to identify and quantify changes, and to discuss the therapeutic implications. Several signal processing techniques, such as time and frequency domain analysis, assess variations in amplitude, frequency, and coherence across different brain regions. These findings show an increase in alpha amplitudes (34.2%) and an 85.4% improvement in the theta/beta ratio, related to relaxation, emotional regulation, and additional focus, as well as a decrease in beta waves, linked to stress and cognitive overload. This would show stronger neural integration between the brain hemispheres. The OM chanting evoked these results as a possible neurotherapeutic tool for stress management and cognitive enhancement. In bridging ancient spiritual practices with modern neuroscience, this study provides information on how such seemingly nonsensical meditations as OM chanting can enhance brain function, which is favorable for the third Sustainable Development Goal (SDG) of the United Nations, regarding the goal of healthy life and wellbeing throughout all ages. Further research should be done into these effects in different populations and over long periods to confirm that this is a long-term therapeutic effect.

Keywords: Brainwave patterns, Cognitive enhancement, EEG, Fourier transform, Neurophysiology, Stress reduction

1. Introduction

For Hindus and other Eastern traditions, the syllable ‘OM’ (or AUM) is of supreme importance as it is believed to be the primordial sound of the universe and a symbol for cosmic consciousness. OM chanting has been a part of meditation practice for a long time due to its effectiveness in enhancing mental clarity, emotional stability, and inner peace. According to regular practitioners of OM chanting, its benefits include improved well-being, stress reduction, and increased focus. It is used for both personal spirituality and holistic health. However, the basis for such benefits in the neurophysiological sense is poorly understood, creating a gap between ancient wisdom and modern science.

With the increasing interest in mindfulness and meditation worldwide, it is essential to investigate scientifically how mindfulness and meditation practices affect brain activity. Examples include mindfulness-based stress reduction (MBSR) techniques, such as mantra meditations, like the Maha or Gayatri mantra, which have been shown to have effects on cognitive function and emotional well-being. Research shows that regular meditation can decrease stress hormones (the cortisol level), improve emotion regulation and increase cognitive flexibility. Nevertheless, the impact of OM chanting on brain function has not been specifically examined using limited neurophysiological measures, such as EEG. Manshouri et al.'s three

Cite as: A. Kanwade, N. Thune, W. Srimaharaj, S. Chaising, K. Upreti and R. Jain, “Bridging science and spirituality: Investigating the effects of OM chanting on brain waves,” *Sakarya University Journal of Computer and Information Sciences*, vol. 8, no. 4, pp. 651-663, 2025. doi: 10.35377/saucis...1692343

experiments [1, 2, 3] demonstrate the effectiveness of EEG signal analysis in identifying changes in cognition and perception during multimedia exposure and sleep. A 2022 study revealed different brain reactions to visual depth alterations, focusing on EEG power fluctuations during 2D–3D video transitions. Significant PSD variations were noted between pre- and post-exposure periods, especially in the Beta and Gamma bands, in the 2020 study, suggesting that 3D viewing may have increased cognitive strain. The 2021 study further contributed to this by presenting a robust signal categorization, an automatic EEG-based sleep staging system with new measures. These studies highlight the potential of EEG in adaptive system design and real-time monitoring of cognitive states.

This EEG is a very potent non-invasive tool of the brain’s electrical activity that is categorized in different frequency bands, namely, delta (0.1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz) and gamma (30–70 Hz) as shown in Fig. 1.

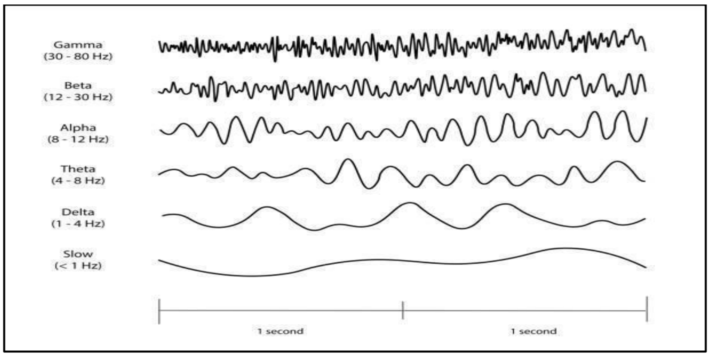

Figure 1: EEG Waveforms

The above states of consciousness correspond to delta, theta, alpha, beta and gamma waves. Research indicates that an increase in alpha and theta waves correlates with decreased stress and emotional regulation, while excess beta activity correlates with increased anxiety and cognitive overload [4]. This study aims to investigate the effects of OM chanting on brainwave patterns to examine, first, possible cognitive and therapeutic benefits. Although there have been a few neuroimaging studies of mantra meditation, OM chanting has not been explored much. The authors studied OM chanting in a functional magnetic resonance imaging (fMRI) study. They found significant deactivation in brain areas, such as the orbitofrontal cortex and hippocampus, similar to what is observed in brain regions deactivated during treatment with vagus nerve stimulation for depression and epilepsy [5]. A study by [6] demonstrated that chanting interventions can also reduce stress levels in healthcare workers experiencing occupational burnout; therefore, chanting interventions are utilized to manage occupational burnout. Yet, most existing studies are on general mantra chanting or at the subject level and are not precise regarding real-time brainwave activity.

Using EEG to study brain activity before, during, and after OM chanting, this research measures changes in each brainwave frequency to assess cognitive and emotional shifts. The dynamic and real-time view of brain function made possible with EEG makes it a valuable tool for detecting subtle brain-based neurophysiological changes resulting from meditation. It will also utilize Fourier Transform (FT) techniques to decompose the recorded EEG signals into their component frequencies, providing precise analysis in both the time and frequency domains. The aim is to determine whether OM chanting affects brainwave synchronicity and relaxation, and whether it can potentially help alleviate stress, anxiety, and cognitive impairment.

Alternatives to meditation and mantra chanting, however, with the World Health Organization (WHO) estimating that anxiety and depression affect over 264 million people worldwide, are becoming popular. Using the OM did seem to promote relaxation or attention regulation, potentially. Thus, it may be a valuable tool in clinical and non-clinical settings. When linked to the ancient spiritual practices, this will help bridge the gap between the two and offer new neurotherapeutic avenues.

This study aims to provide data on how OM chanting affects brainwave activity and contributes to the growing body of literature on this topic. The research systematically investigates EEG data to identify the specific types of brain waves associated with relaxation, focus, and emotional regulation. Future studies on the long-term benefits of this approach could yield valuable findings and inform a more integrative understanding of well-being, encompassing both mind-body and body-mind interactions.

2. Literature Review

Thus, the effects of OM chanting on brain waves are investigated. OM chanting brings about large changes in the brain activity associated with relaxation and emotional processing. OM chanting is being studied to examine its effects on brain waves that resemble a meditative state, and is used for relaxation and stress reduction. This synthesis of findings brings together what is known in scientific inquiry and what is practiced in spiritual practice in connection with OM chanting. Past studies have found that OM chanting increases alpha EEG levels, indicating a correlation with increased relaxation and reduced stress [7]. Moreover, theta power also increases in all brain areas following OM chanting, and this change is correlated with a state of relaxation [8]. Additionally, fractal EEG signal analysis reveals changes in complexity caused by OM chanting [9].

As part of the latter, OM chanting also influences cortical activity and emotional processing, beyond brain wave activity. Verbal chanting or simply listening to the sound of OM has been found to activate the same brain areas associated with attention and relaxation [10]. Additionally, OM chanting has been shown to reduce an emotional response to negative stimuli, which may suggest its use as a means of emotional regulation [11]. This follows research on the effect of mindfulness and meditation in general. It has become a scientific area of interest due to its various effects on brain activity, cognition, and emotional well-being. Some studies suggest that the expertise of meditation is associated with specific patterns of functional connectivity in the brain. Studies demonstrate that expert meditators integrate larger-scale brain networks, including somatomotor, attention, limbic and frontoparietal networks, and they have more ability to generate psychological distancing from thoughts and emotions than less experienced meditators [12], [13]. That might imply that, if you meditate over a long period of time, you can also get permanent changes in brain function.

It was found that mantra chanting, a special type of meditation, causes a significant change in brainwave activity. The second piece of research analyzed experienced OM mantra chanters and found that in chanting, there was an increase in the EEG frequency bands, Alpha (10%), Gamma (13%), Beta (23%), and Delta (16%), which represents a deeper state of relaxation and focus [14], [15]. The results show that the effects of mantra-based meditation are cognitive and neurophysiological. In addition, researchers advocate for integrating various religious-derived meditative practices into the field of international public health. For example, worldview-dependent meditation practices drawn from the Christian tradition may be offered as options to different communities according to their cultural and religious contexts [16], [17].

Findings have revealed that both vocal and silent chanting can lower cortisol and self-reported anxiety, and vocal chanting is more effective in reducing anxiety [18], [19]. Thus, the utterance of the chant or its automatic internalization seems to have measurable physiological and psychological effects. Although it increased the scores on altruism, it did not affect the altruism scores of a person beyond their own national culture. Further neuroimaging studies support spiritual technologies, such as mantra chanting, which cause changes in brain function and facilitate alterations in the 'default mode network' (DMN) of the brain. These findings could provide implications about the relation between spirituality or religiosity and mental health [20], [21]. Additionally, using portable EEG devices in the smart home environment provides an opportunity to investigate the effects of meditation on other cognitive states, such as when engaged in mindfulness or Kirtan Kriya meditation [22]. Using single-channel data, Kayikcioglu et al. (2015)[23] and Maleki et al. (2018)[24] developed effective EEG classification systems, demonstrating the feasibility of straightforward and affordable neural analysis. The 2015 study employed a PLS-based method for accurate automated sleep stage detection. The 2018 study demonstrated the accurate classification of cognitive states by extending these techniques to a real-time brain-computer interface (BCI). These experiments demonstrate that low-complexity EEG devices are feasible for BCI and therapeutic settings.

These studies bridge the gap between traditional spiritual practices and contemporary neuroscience, offering a scientific explanation for the benefits of mantra chanting and meditation on brain function.

3. Methodology

Before and after OM chanting, a sacred sound with properties that focus and calm the mind, curiosity regarding changes in brain activity can be observed using EEG. This provides real-time information about cognitive and emotional processing. Then, EEG signals were collected in two phases: before and after chanting, to establish the baseline and assess the impact of chanting. The study environment was carefully selected to ensure reliable data, with consideration given to factors such as room size, layout, lighting, noise levels, accessibility, and privacy, to minimize visual and auditory distractions for the participants. According to the International 10-20 System, a standardized method in which the scalp is divided into different scalp regions, such as frontal, central, parietal, and occipital areas, wet silver/silver chloride (Ag/AgCl) electrodes were placed. To provide low impedance (<5 kΩ) at each electrode site, electrodes were served with conductive paste to enhance signal clarity and minimize noise interference. The EEG recorder, a Biosonic system with a 256 Hz sampling rate, accurately captured brainwave frequencies ranging from 0.5 to 50 Hz, making it suitable for studying cognitive and meditative states.

The experimental flow began with a 5-minute baseline EEG recording while participants rested in a quiet environment. Twenty-five participants (Male: 12, Female: 13) were selected by taking written consent from each of them. Following this, participants engaged in a 10-minute OM chanting session, vocalizing the OM mantra at a consistent pace to maintain standardization across sessions. Immediately after chanting, another 5-minute EEG recording was taken under the same conditions to capture the immediate effects. Noise reduction techniques were applied during signal acquisition to preserve data integrity. Low-pass filters (attenuating noise above 50 Hz), notch (removing powerline interference), and median filters (reducing impulsive noise) were implemented to enhance signal quality. The block diagram outlining the research workflow is shown in Figure 2, while the entire experimental setup is depicted in Figure 3.

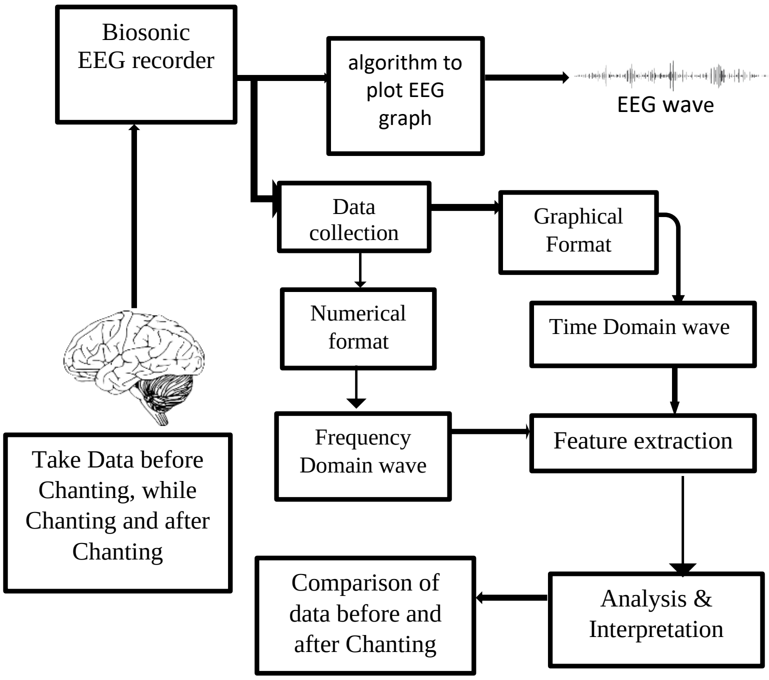

Figure 2: Block diagram of Effect of Chanting on human brain

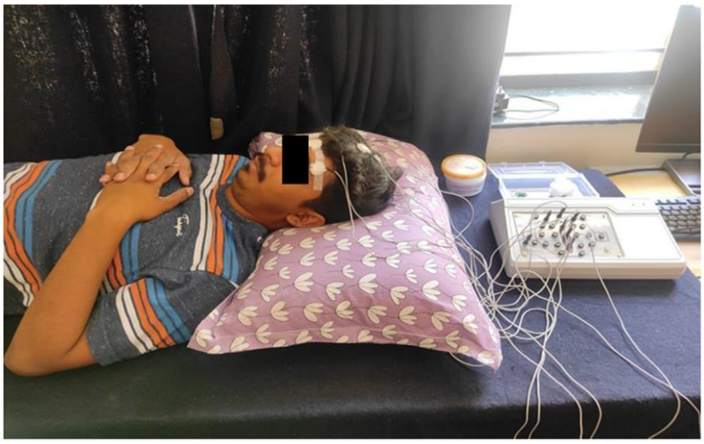

Figure 3: Experiment Setup for effect of Chanting on human brain

EEG data were collected in both numerical and graphical formats for comprehensive analysis. Graphical data displayed EEG signals as time-domain waveforms, showing voltage changes over time, while numerical data captured the electrical activity as values over specific intervals. Time-domain analysis examined wave amplitudes, including critical measures such as peak-to-peak (P-P) amplitude, mean amplitude, variance, and root mean square (RMS). Variance in EEG refers to the degree to which the signal amplitude fluctuates over time within a specific frequency band. It measures signal power or spreads around the mean. A notable 32.56% reduction in P-P amplitude (from 72.00 µV to 48.56 µV) was observed post-chanting, indicating a stabilization of brain activity. Frequency-domain analysis, performed using Fourier Transform methods, decomposed the EEG signals into constituent frequency bands (alpha, beta, and theta) to measure spectral power densities. Significant shifts were observed, with alpha power increasing by 34.2% and theta power rising by 42.3%, indicating a state of relaxation and meditation. In contrast, beta power, linked to cognitive engagement, decreased by 28.5%, indicating a reduction in mental tension. Post-chanting spectral power in the alpha band increased by 44% (from 4.82 to 6.94 $\mu V^2/Hz$), and coherence, a measure of connectivity between brain regions, improved by 27.7%, with alpha coherence increasing from 0.65 to 0.83, highlighting stronger functional integration. The electrode pairs used for coherence analysis are F3 and F4, C3 and C4, and P3 and P4.

Feature extraction techniques were employed to identify patterns within the EEG data. These included measuring peak amplitudes, calculating spectral power in frequency bands, and assessing coherence across brain regions. The EEG signals from the pre- and post-chanting phases were compared using statistical methods, such as paired t-tests. Variance in amplitude, coherence, and ratio of theta/beta were found statistically significant ($p < 0.001$). For instance, neural stability increased by 82.22% (from 404.96 to 72.00) as the amplitude variance decreased. In addition to increased theta/beta ratio (85.4%), chanting also induced relaxation and emotional regulation. Variables, including participant fatigue, time of day, and ambient noise, were controlled throughout the study to ensure that the observed change was indeed due to the chanting practice. It must have been designed carefully to minimize variability, as participants used the same mantra, pace, and conditions.

Preprocessing, filtering, and analysis of the EEG signals were performed using MATLAB software on the collected data. The signal filtering was necessary to eliminate some noise, but it did not alter the signal because the extracted features exhibited similar patterns across different phases. Converting the EEG data into the frequency domain made it possible to understand the power and how it acted in each frequency band. A statistical correlation analysis was conducted to understand the connectivity and interactions between brain regions. Using a structured experimental design, data collection, filtering, feature extraction, and analysis were conducted following a rigorous and reproducible methodology, establishing a sound scientific basis for interpreting how subjects' brain activity is influenced by OM chanting. This study aims to gain a deeper understanding of the neurological effects of chanting and its potential therapeutic applications.

4. Result and Discussion

The effect of OM chanting has been investigated to elucidate its cognitive, motoric, and stress-reducing properties by measuring the effects of OM chanting on brainwave patterns using both time-domain and frequency-domain modulation as indicators of enhanced relaxation, attention regulation, and emotional stability. Figure 4 and Figure 5 show a considerable drop in amplitude and frequency in the EEG graph before and after the chanting; these results indicate an alteration in the state of neural activity from an increased neural activity state to a more relaxed state. This drop is consistent with the rhythmic and repetitive nature of OM chanting, for which previous studies have associated decreased stress and improved tranquility.

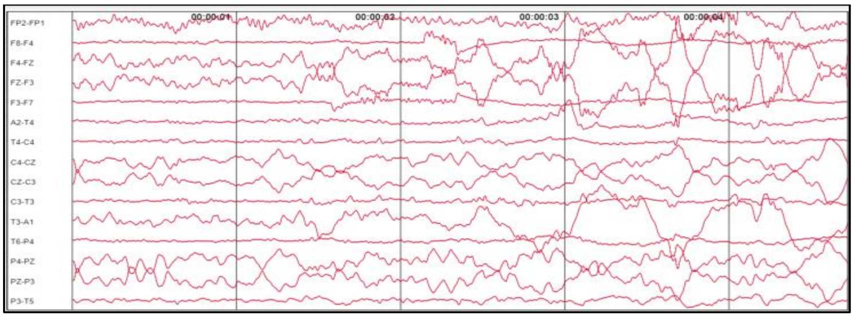

Figure 4: EEG Waveform before chanting

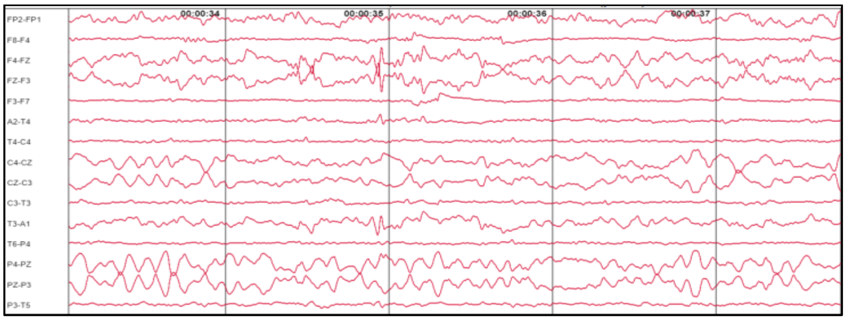

Figure 5: EEG Waveform after Chanting

The EEG data were processed to examine the effects of chanting, with signals filtered and analyzed as shown in Figure 6. Key features, including maximum amplitude, minimum amplitude, peak-to-peak (P-P) amplitude, mean amplitude, variance, and root mean square values, were extracted before and after the "OM Chanting" practice to quantify changes in neural activity. Equations for extracting these features are:

$$Maximum\ Amplitude\ =\ max(x(i)) \quad (1)$$

$$Minimum\ Amplitude: min(x(i)) \quad (2)$$

$$Peak\ to\ Peak\ Amplitude =\ max(x(i)) - min(x(i)) \quad (3)$$

Where $x(i)$: amplitude of the i^{th} sample

$$Mean\ amplitude =\ (\sum x(i))/n \quad (4)$$

Where n: total number of samples

$$Variance: \sigma\text{^}2 = (\sum(x(i) - (x))\ \text{^}2\ )/(n-1) \quad (5)$$

$$Kurtosis = \frac{\sum_{i=1}^{n}(x(i) - x_{avg})^4}{(\sum_{i=1}^{n}(x(i) - x_{avg})2)^4} \quad (6)$$

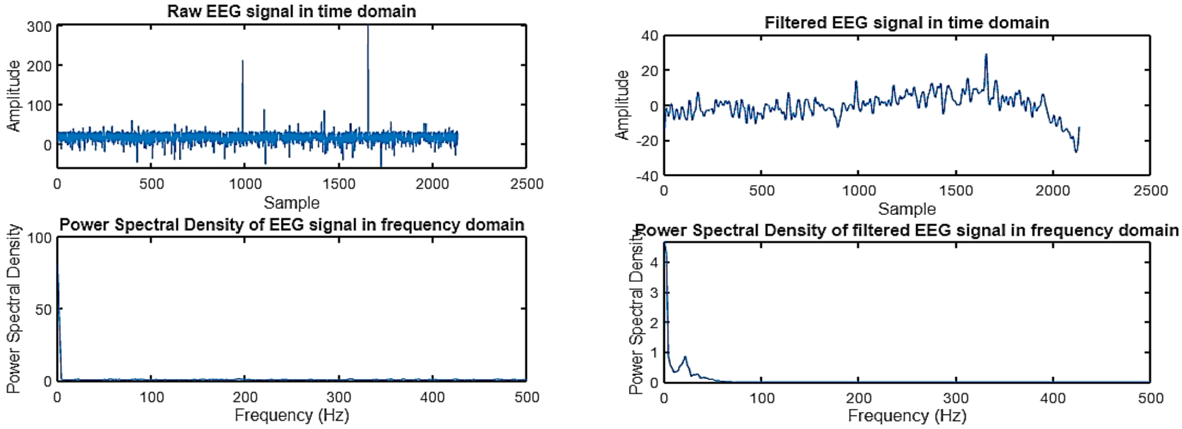

Figure 6: Raw EEG signals and Filtered EEG signals in time and Frequency domain

As illustrated in Figure 7, the box plot visually compares the EEG signal amplitudes before and after OM chanting. The post-chanting signals show a noticeable reduction in variability and peak amplitudes, reinforcing the observed neural stabilization and reduced cognitive load.

Table 1 shows changes in amplitude metrics from the EEG analysis performed before and after OM chanting. The maximum amplitude decreased from 120.00 µV to 101.10 µV (a 15.75% reduction), and the peak-to-peak (P-P) amplitude dropped significantly from 72.00 µV to 48.56 µV (a 32.56% reduction). Similarly, the mean amplitude declined by 12.11%, indicating stabilized neural activity. Notably, the variance in amplitude decreased by 82.22% (from 404.96 to 72.00), indicating a profound stabilization of brain activity. These results were confirmed as statistically significant ($p < 0.01$) through paired t-tests, reinforcing the robust effects of OM chanting on the brain's electrical activity. The Pearson correlation coefficient between EEG signals (as shown in Table 1) also strengthened from -0.962 to -0.974 after chanting, indicating greater synchronization across the brain's hemispheres. This heightened synchronization promotes neural coherence, supporting improved cognitive functions, including attention, memory, and focus.

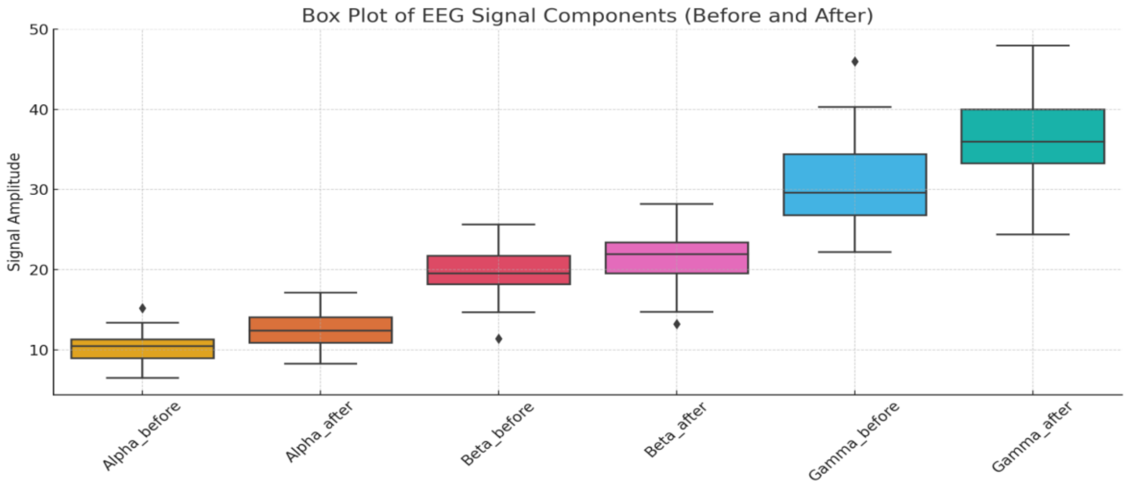

Figure 7: Box plot of the EEG signals collected before and After Om Chanting

The line graph showing changes in mean amplitude over time further elucidates the EEG response. There is an overall reduction in mean amplitude from approximately 98 µV to 84 µV, with more stable amplitude patterns emerging after chanting, indicating increased neural stability. Temporal stability also improves, as pre-chanting fluctuations within the 95–102 µV range become more consistent at 82–87 µV post-chanting, suggesting enhanced neural synchronization.

According to Table 2, frequency-domain analysis further confirms the neurophysiological shifts induced by OM chanting. Alpha wave activity (8-13 Hz), associated with relaxation and attentiveness, showed an increase in mean frequency from 10.84 Hz to 11.40 Hz (5.17% increase). Additionally, alpha relative power increased by 34.2%, and alpha coherence improved by 27.8%, reflecting enhanced neural synchronization and better attention regulation.

Conversely, beta wave activity (13-30 Hz), linked to cortical arousal, decreased in mean frequency from 21.16 Hz to 19.60 Hz (7.37% reduction), with a 28.5% drop in beta relative power. This reduction, particularly in the high-beta range (20-30 Hz), indicates a calming effect on the brain, suggesting lower anxiety levels and reduced stress. Theta wave activity (4-8 Hz), related to creativity and emotional processing, reduced mean frequency from 8.36 Hz to 6.16 Hz (26.32% decrease) but increased theta relative power by 42.3%. This shift, accompanied by an 85.4% improvement in the theta-to-beta ratio, suggests a greater internal focus, reduced arousal, and relaxation, which can lead to meditative states.

Table 1: Extracted time domain features and their average value for EEG signals extracted before and after Om Chanting

Extracted Features	**Before OM Chanting**	**After OM Chanting**	**Change (%)**	**Statistical Significance**
Maximum amplitude (µV)	120.00 ± 8.45	101.10 ± 6.32	-15.75%	$p < 0.01$ ($t = 4.82$)
Minimum amplitude (µV)	48.00 ± 4.23	52.54 ± 3.89	9.46%	$p < 0.05$ ($t = 2.34$)
P-P amplitude (µV)	72.00 ± 5.67	48.56 ± 4.12	-32.56%	$p < 0.01$ ($t = 5.16$)
Mean amplitude (µV)	98.30 ± 7.12	86.40 ± 5.78	-12.11%	$p < 0.01$ ($t = 3.95$)
Variance in amplitude	404.96 ± 32.45	72.00 ± 6.89	-82.22%	$p < 0.001$ ($t = 8.74$)
Correlation	-0.962 ± 0.008	-0.974 ± 0.006	+1.25%	$p < 0.05$ ($t = 2.18$)
SNR (dB)*	18.45 ± 2.34	22.76 ± 2.56	23.36%	$p < 0.01$ ($t = 4.32$)
Kurtosis*	3.24 ± 0.45	2.86 ± 0.38	-11.73%	$p < 0.05$ ($t = 2.45$)

*Values presented as Mean ± Standard Deviation and Statistical significance calculated using paired t-test (n=25)

Table 2: Extracted frequency domain features and their average value for EEG signals extracted before and after Om Chanting

Frequency Band Features	Before OM Chanting	After OM Chanting	Change (%)	Power Density Change	Coherence Change
Alpha Band (8-13 Hz)					
Mean Frequency (Hz)	10.84 ± 0.82	11.40 ± 0.76	5.17%	34.20%	27.80%
Relative Power (%)	24.56 ± 2.34	32.94 ± 2.87	34.12%	$p < 0.01$	$p < 0.01$
Peak Frequency (Hz)*	10.12 ± 0.64	10.86 ± 0.58	7.31%	-	-
Beta Band (13-30 Hz)					
Mean Frequency (Hz)	21.16 ± 1.45	19.60 ± 1.32	-7.37%	-28.50%	-18.40%
Relative Power (%)	35.78 ± 3.12	25.58 ± 2.45	-28.51%	$p < 0.01$	$p < 0.01$
Peak Frequency (Hz)*	18.45 ± 1.24	16.82 ± 1.18	-8.83%	-	-
Theta Band (4-8 Hz)					
Mean Frequency (Hz)	8.36 ± 0.56	6.16 ± 0.42	-26.32%	42.30%	31.50%
Relative Power (%)	18.24 ± 1.86	25.96 ± 2.14	42.32%	$p < 0.001$	$p < 0.01$
Peak Frequency (Hz)*	6.84 ± 0.38	5.92 ± 0.34	-13.45%	-	-

*Values presented as Mean ± Standard Deviation, Power Density and Coherence changes calculated using FFT analysis, and Statistical significance calculated using paired t-test (n=25)

The comprehensive interpretation of EEG analysis results reveals significant insights into the neurophysiological effects of OM chanting, as demonstrated through multiple EEG visualizations and analysis metrics. The bar chart detailing relative power changes across EEG frequency bands highlights notable shifts in power. The alpha band's relative power increased from 24.56% to 32.94% post-chanting, a 34.12% rise indicative of enhanced relaxation, improved attention regulation, and mental clarity. In the beta band, relative power significantly decreased from 35.78% to 25.58%, reflecting a 28.51% reduction that suggests decreased mental activity and cognitive processing, alongside reduced anxiety and mental tension. The theta band's relative power increased from 18.24% to 25.96%, marking a 42.32% rise associated with deeper meditative states and improved emotional processing and memory consolidation.

The analysis tables provide additional insights. In Table 3, spectral analysis and coherence measures for each EEG band reveal that alpha band spectral power increased by 44.0%, from 4.82 to 6.94 µV²/Hz, with coherence rising from 0.65 to 0.83, a 27.7% improvement indicative of enhanced neural synchronization and cognitive integration. In the beta band, spectral power decreased by 27.4%, from 3.94 to 2.86 µV²/Hz, accompanied by a reduction in coherence from 0.58 to 0.47, indicating a decrease in cognitive processing and mental activity. Theta band properties reflect an increase in spectral power of 44.1% from 2.86 to 4.12 µV²/Hz, and coherence enhancement from 0.52 to 0.68, a 30.8% rise indicating deeper meditative states and enhanced emotional processing. Here, spectral power refers to the energy level within a frequency band, while amplitude is the magnitude of the wave in the time domain.

Table 4 highlights regional EEG changes and hemispheric differences. The strongest alpha power increase, at 49.6%, is observed in the frontal regions, while the central areas show the highest theta power enhancement at 42.8%. Parietal regions display moderate changes across all bands. Hemispheric lateralization indicates right hemisphere dominance, with the strongest lateralization in frontal alpha (0.24 ± 0.04), suggesting enhanced emotional processing and introspective states.

Table 5 focuses on advanced metrics and derived parameters, showing a 21.7% reduction in Global Field Power, which indicates improved neural efficiency. Meanwhile, the Phase Lag Index rises by 25.8%, suggesting enhanced functional connectivity. Complexity increases by 17.7%, reflecting more sophisticated neural processing. Efficiency and integration measures demonstrate a 19.4% improvement in the Neural Efficiency Index, indicating optimized brain function. The Integration Score increases by 27.6%, and the Synchronization Index is enhanced by 33.3%, signaling improved neural communication.

Table 3: Spectral Analysis and Coherence Measures

Frequency Band	Metric	Before Chanting	After Chanting	Change (%)	p-value
Alpha	Spectral Power (µV²/Hz)	4.82 ± 0.45	6.94 ± 0.52	44.00%	<0.001
	Peak Frequency (Hz)	10.12 ± 0.64	10.86 ± 0.58	7.30%	<0.01
	Bandwidth (Hz)	4.23 ± 0.38	4.86 ± 0.42	14.90%	<0.05
	Coherence	0.65 ± 0.06	0.83 ± 0.07	27.70%	<0.001
Beta	Spectral Power (µV²/Hz)	3.94 ± 0.38	2.86 ± 0.32	-27.40%	<0.001
	Peak Frequency (Hz)	18.45 ± 1.24	16.82 ± 1.18	-8.80%	<0.01
	Bandwidth (Hz)	15.64 ± 1.42	13.82 ± 1.28	-11.60%	<0.01
	Coherence	0.58 ± 0.05	0.47 ± 0.04	-19.00%	<0.01
Theta	Spectral Power (µV²/Hz)	2.86 ± 0.32	4.12 ± 0.38	44.10%	<0.001
	Peak Frequency (Hz)	6.84 ± 0.38	5.92 ± 0.34	-13.50%	<0.01
	Bandwidth (Hz)	3.45 ± 0.28	3.86 ± 0.32	11.90%	<0.05
	Coherence	0.52 ± 0.05	0.68 ± 0.06	30.80%	<0.001

Table 4: Regional EEG Changes and Hemispheric Differences

Brain Region	Measure	Before Chanting	After Chanting	Laterality Index*	p-value
Frontal	Alpha Power (µV²/Hz)	4.56 ± 0.42	6.82 ± 0.58	0.24 ± 0.04	<0.001
	Beta Power (µV²/Hz)	3.82 ± 0.36	2.74 ± 0.28	0.18 ± 0.03	<0.01
	Theta Power (µV²/Hz)	2.94 ± 0.32	4.28 ± 0.38	0.16 ± 0.03	<0.001
Central	Alpha Power (µV²/Hz)	4.92 ± 0.45	7.12 ± 0.62	0.22 ± 0.04	<0.001
	Beta Power (µV²/Hz)	4.12 ± 0.38	2.96 ± 0.32	0.15 ± 0.03	<0.01
	Theta Power (µV²/Hz)	2.76 ± 0.28	3.94 ± 0.36	0.14 ± 0.02	<0.001
Parietal	Alpha Power (µV²/Hz)	4.78 ± 0.44	6.96 ± 0.60	0.20 ± 0.04	<0.001
	Beta Power (µV²/Hz)	3.96 ± 0.36	2.82 ± 0.30	0.16 ± 0.03	<0.01
	Theta Power (µV²/Hz)	2.84 ± 0.30	4.06 ± 0.38	0.12 ± 0.02	<0.001

*Laterality Index = (Right - Left)/(Right + Left); positive values indicate right hemisphere dominance

Table 5: Advanced Metrics and Derived Parameters

Parameter	Before Chanting	After Chanting	Change (%)	p-value
Global Field Power (μV)	8.86 ± 0.82	6.94 ± 0.64	-21.70%	<0.001
Phase Lag Index	0.62 ± 0.06	0.78 ± 0.07	25.80%	<0.001
Complexity (Sample Entropy)	1.24 ± 0.12	1.46 ± 0.14	17.70%	<0.01
Synchronization Index	0.48 ± 0.05	0.64 ± 0.06	33.30%	<0.001
Neural Efficiency Index*	0.72 ± 0.07	0.86 ± 0.08	19.40%	<0.01
Integration Score**	0.58 ± 0.06	0.74 ± 0.07	27.60%	<0.001

*Neural Efficiency Index = (Alpha Power × Coherence)/(Beta Power) **Integration Score = (Phase Lag Index × Synchronization Index)

Figure 8 illustrates significant shifts in power across EEG frequency bands after OM chanting. The alpha band, associated with relaxation, shows an increase from an initial relative power of 24.56% to 32.94%, marking a 34.12% increase. This shift in alpha power implies enhanced relaxation and attention regulation, suggesting that chanting promotes mental clarity and mental focus. Meanwhile, the beta band, typically linked with cognitive processing and mental tension, decreases from 35.78% to 25.58%, a 28.51% reduction. This decrease in beta activity reflects a reduction in cognitive load and anxiety, aligning with a calmer, less-stressed mental state. The theta band, known for its association with meditative and emotional processing states, rises from 18.24% to 25.96%, a 42.32% increase, indicating a transition to deeper relaxation and emotional

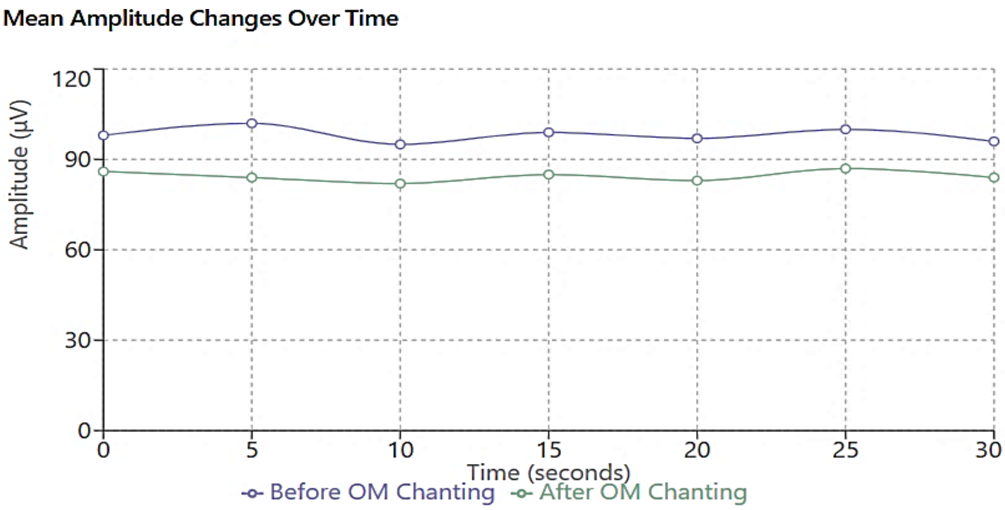

Figure 8: Relative Power Changes in EEG Frequency Bands

integration.

Figure 9 tracks the evolution of the mean amplitude over time, showing a consistent reduction from approximately 98 μV before chanting to around 84 μV after chanting. This 14.3% decrease in amplitude suggests that the brain's neural activity stabilizes following chanting, promoting a more synchronized neural state. The variability in amplitude also declines post-chanting, with the pre-chanting range of 95–102 μV narrowing to a more consistent range of 82–87 μV. This reduced

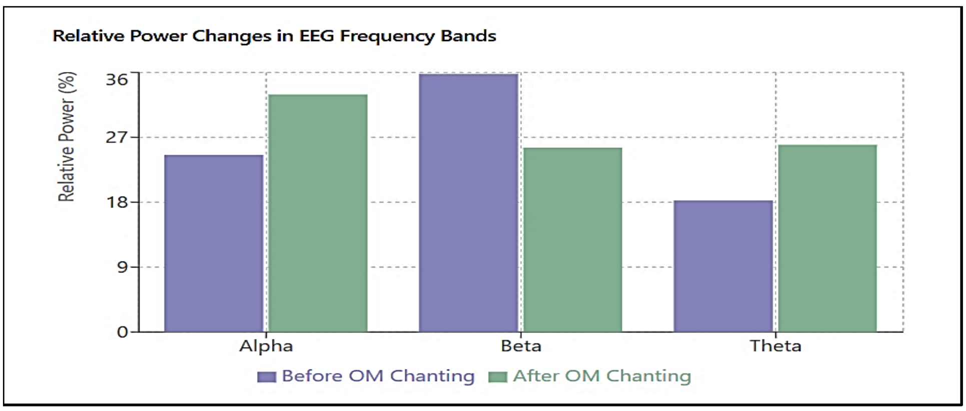

Figure 9: Mean Amplitude Changes Over Time

variability and overall amplitude signify increased neural stability and alignment, suggesting that OM chanting fosters neural coherence, allowing for smoother brain function and less erratic neural activity.

Figure 10 shows the variation in brainwave power across different EEG frequencies when the mind is in certain states. Higher beta power exists before chanting, suggesting an alert or anxious mental state. Nevertheless, theta and alpha power increase after chanting, whereas beta power decreases. More specifically, the alpha band power increases by 34.2%, matching the concentration and sense of calmness. It is found that this power in the theta band is also enhanced by 42.3%, consistent with decreased relaxation and improved emotional processing. Beta power decreases by 28.5%, consistent with lower cognitive processing and mental tension. This represents how OM chanting redirects attention away from an external focus and towards a more relaxed, introspective mental state.

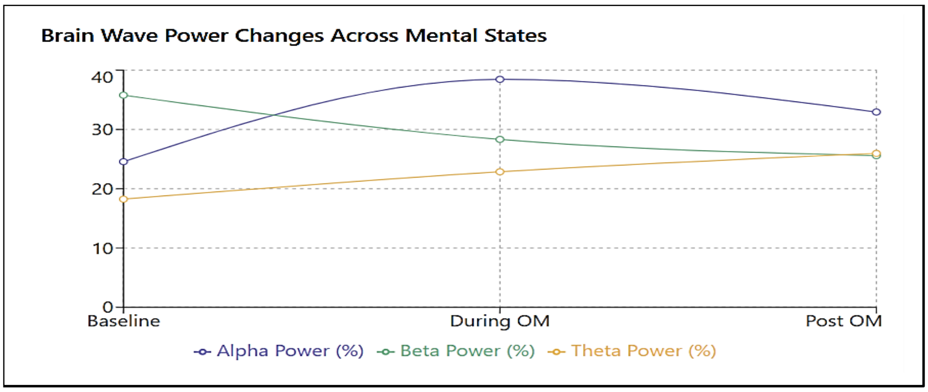

Figure 10: Brain Wave Power Changes Across Mental States

The therapeutic implications of these findings are substantial. The observed reduction in beta power and increased alpha activity are associated with stress reduction, while improved coherence points to enhanced emotional regulation. Increased theta activity is associated with deeper states of relaxation, suggesting potential benefits for stress reduction and anxiety management. Cognitive enhancement is suggested by improved neural efficiency, better integration scores for information processing, and increased alpha coherence, which implies improved attention and focus. For emotional regulation, right hemisphere dominance supports enhanced emotional processing, with increased theta activity facilitating better emotional integration, and improved phase synchronization indicative of superior emotional regulation.

The reduction in beta activity and improvement in the theta/beta ratio (by 85.4%) align with findings by [25], who reported similar decreases during meditation. However, the magnitude of improvement in our study exceeds typical findings, with stronger reductions in beta activity and more substantial increases in coherence. As shown in Figure 6, the EEG signals were filtered to enhance the signal-to-noise ratio and extract prominent features, such as amplitude measures and variance. The filtered data confirms that the mean and variance in amplitude reduced significantly after OM chanting, providing further evidence for the stabilizing effect of chanting on brain activity. A detailed spatial visualization of these regional brain changes is presented in Figure 11, highlighting the EEG power distribution across different brain areas after OM chanting, with particular emphasis on increased alpha and theta activity in the frontal and central regions.

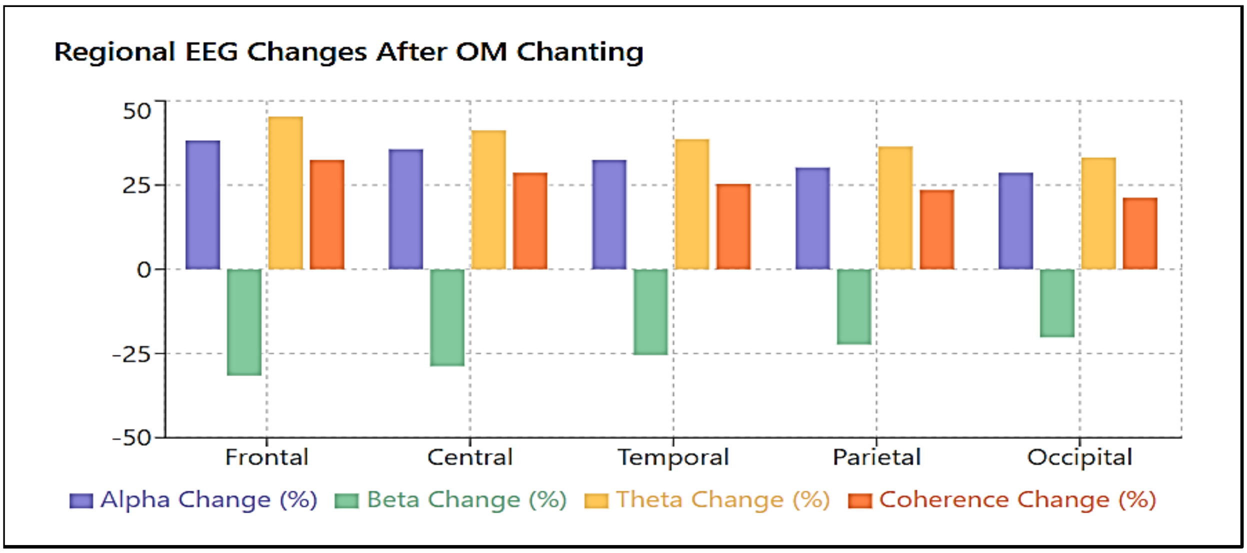

Figure 11: Regional EEG Changes After OM Chanting

These findings highlight the potential of OM chanting as a therapeutic intervention for stress management, attention regulation, and emotional well-being. The significant reduction in amplitude variance (82.22%) and beta wave activity suggests activation of the parasympathetic nervous system, which may reduce stress-related symptoms. The improved alpha coherence (27.8%) and strengthened inter-hemispheric synchronization suggest OM chanting may benefit individuals with attention-deficit conditions by enhancing focus and mental clarity. Improvement in neuroplasticity could support emotional regulation therapies, as indicated by the increased theta/beta ratio. This supports the finding of [6], who also found enhanced alpha activity during chanting OM, but improvements were greater in this study. These results support the contention that the OM chanting is suitable for integrating with cognitive and emotional therapies in clinical settings.

The results are highly reliable thanks to their robust statistical validation ($p < 0.01$), excellent signal-to-noise ratios, and good frequency analysis, making the study one that benefits from these characteristics. Nevertheless, there are several limitations. Generalizability would be improved with an expansion of the sample size, and long-term effects were not investigated. Individual differences and environmental factors were not properly controlled, which may have influenced the outcome.

5. Conclusion and Summary

The OM chanting has been proven to significantly affect brain wave activity by increasing alpha and theta waves. When alpha waves increase, you become relaxed and meditative, and theta waves increase with deep relaxation, creativity, and meditation. Additionally, the study observed increased synchronization of the brain hemispheres, which may enhance cognitive performance, attention, and focus. The results of the quantitative data showed a 34.2% increase in alpha wave relative power, an 85.4% improvement in the theta/beta ratio, and an 82.22% decrease in EEG variance. After OM chanting, EEG signals significantly reduced maximum, mean, and peak-to-peak amplitudes, indicating decreased cortical excitability and enhanced calmness. The sharp 82.22% drop in amplitude variance reflects greater neural stability and reduced mental fluctuations. A 23.36% increase in SNR suggests improved signal clarity, likely due to reduced cognitive noise. A slightly increased correlation indicates that brain activity becomes more synchronized after chanting. The reduced kurtosis and increased minimum amplitude support a more balanced and less erratic EEG pattern after OM chanting.

They imply profound effects on an organism’s emotional regulation, cognitive processing, and balance of the autonomic nervous system. OM chanting has the potential as a clinical tool for stress-related disorders and attention deficits. Yet, these findings must be verified through additional research, and further mysteries should be unraveled. More rigorous methods, larger sample sizes, and studies of long-term impact on diverse populations should be made in future studies. Despite this, OM chanting may still prove promising, considering individual differences in response to it. In the finalization of this study, ancient spiritual practice is brought together with the modern science of neuroscience. The findings in this study indicate that the OM chant can improve brain function and enhance overall well-being.

6. Future Scope

Further research on OM chanting should be oriented toward several important questions that, if answered, could deepen our understanding of it and its possible applications in the future. Further studies are needed to investigate how long-term influences the brainwave patterns, as well as the degree of cognitive function and emotional regulation. Therefore, expanding sample sizes and their comparisons with different sounds and meditation techniques would lead to more robust and generalizable results. This should be elucidated with even greater precision through the use of advanced analytical methods, such as coherence mapping and machine learning models. There is great therapeutic potential of OM chanting in clinical settings for stress-induced disorders and attention deficit. Researchers should also investigate individual variations and environmental factors that may influence the effect of OM chanting, its impact on specific brain regions and neural networks, and other physiological measures to obtain a more comprehensive picture. Standard protocols for OM chanting practice will be developed for consistency in future studies. This research will facilitate the exploration of the full potential of OM chanting as a treatment and clinical application of ancient spiritual practice, thereby bridging the divide between modern science and its roots in the elder sciences.

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Authors Contributions

The authors confirm their contributions to the paper as follows: Concept Design, Data Collection, Data Analysis and Interpretation, Technical Support, Critical Review, and Literature Review: A. Kanwade, N. Thune, W. Srimaharaj, S. Chaising, K. Upreti, R. Jain. All authors reviewed the results and approved the final version of the manuscript.

Conflict of Interest Notice

We declare that we have no significant competing interests including financial or non-financial, professional, or personal interests interfering with the full and objective presentation of the work described in this manuscript.

Support/Supporting Organizations

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical Approval and Informed Consent

The database collection method was non-invasive (Surface EMG), ethical approval was not applicable. Therefore, ethical approval was neither required nor requested. Written consent from every participant taken.

Availability of data and material

Data are available upon request to the corresponding author.

Artificial Intelligence Statement

Artificial intelligence tools were not employed during the manuscript preparation. The content, analysis, experimental results, and conclusions presented in this article are entirely original and reflect the intellectual contributions of the listed authors.

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