https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 28(2s) (February 2025); 299-309
Research Article

Assessment of EEG Sub-Band Spectral Changes Induced by Lu10 Acupressure Application

Kumar Avinash Chandra[1], Prabhat Kumar Upadhyay[2]*

[1,2*]Department of Electrical & Electronics Engineering, Birla Institute of Technology, Mesra, Ranchi,
[1]Energy.avinash@gmail.com; [2]pkupadhyay@bitmesra.ac.in, [1]0000-0001-9851-3979, [2]0000-0002-7637-985X

Abstract: This study investigates the neurophysiological implications of applied acupressure to the "Lu10" acupoint. Scalp electroencephalography (EEG) was recorded from ten participants for eight sessions over a period of one month. After eliminating the artefacts with the help of FIR bandpass filter, the band power was computed for each sub-band before and after the intervention. Significant alterations in band power were observed in alpha and beta sub-band post stimuli. Results suggest that the delta and beta band power increases by 25% ±2.8 and 36.4% ±3.0 respectively. It reflects improved relaxation and improved cognitive focus post-intervention. Also, a 20% decrease in the delta-theta ratio was observed which signifies a shift from profound relaxation to a more awake and attentive state. A decrease (9.3% ±2.8) in alpha power suggests a shift from passive relaxation to more active mental involvement. The short-term appearance of beta activities reveals increased alertness without causing significant stress. These results highlight that acupressure may be used as a non-invasive treatment to improve relaxation, cognitive function, and emotional control.

Keywords: Acupressure, Behavioural Sciences, Brainwave Analytics, Cognitive Engagement, Electroencephalography, Spectral Power.

***Authors for correspondence: E-mail Id:** pkupadhyay@bitmesra.ac.in*

Received:22/01/2025 *Accepted:30/01/2025*

DOI: https://doi.org/10.53555/AJBR.v28i2S.6798

Highlights:

- The study examined the effects of applying acupressure to the 'Lu10' acupoint employing EEG data, alterations in brain activity before and after the intervention were evaluated.
- There were notable improvements in beta power, which reflected cognitive attention, and alpha power, which indicated relaxation.
- A 20% decrease in the delta-theta ratio suggested improved cognitive control, whereas a decline within alpha-beta ratio signified less cognitive strain.
- A consistent increase in beta and delta wave activity amid sessions revealed accumulative advantages in mental clarity and relaxation.

1. Introduction:

Innovative therapeutic solutions with a foundation in systems-based techniques have emerged as a result of the convergence of engineering and healthcare. One such area is the creation of body-centered therapy, which combine neurological responses with physiological systems to enhance health. Traditional medical systems have long used a holistic approach, according to which the body and mind are intertwined systems that promote self-regulation and healing [1-3]. With growing interest in complementary medicine, interventions such as yoga, tai chi, and acupressure are increasingly adopted in Western countries as adjuncts to mainstream biomedical therapies [4]. These trends highlight the need for engineering frameworks to systematically evaluate and optimize the efficacy of these therapies [5].

Acupressure presents a promising use of body-centered therapy. To encourage the body's self-regulatory mechanisms, mechanical pressure is applied to particular acupoints along energy routes, or meridians [6]. Although practitioners assert that acupressure regulates energy channels, empirical research is necessary because the physiological mechanisms underpinning these effects are little known. Novel approaches to investigating these systems are made possible by recent developments in biomedical signal processing. A non-invasive method for measuring the electrical activity of the brain with great temporal resolution is electroencephalography (EEG), which provides information on how the brain reacts neurophysiological to acupressure [7]. Quantitative evaluations of the brain dynamics related to body-centered interventions are made possible by engineering techniques such as power spectral density.

According to the modern biomedical perspective, illnesses are viewed as disturbances in the central nervous system that need to be corrected with specific treatments [8]. By modifying brain function, which subsequently affects physiological reactions, cognitive-behavioral therapies are frequently used to treat diseases [9]. For example, it has been demonstrated that aerobic exercises increase mood, cognition, and neuroplasticity [10–12]. Nevertheless, little is known about how body-centered therapies like acupressure affect brain function. By creating a model of analysis to evaluate the effect of acupressure upon brain activity using EEG, our research seeks to close this gap.

Systems in which physical stimuli provide feedback signals that alter brain responses can be used to mimic body-centered therapies from an engineering perspective. These feedback loops imply that certain physiological pathways are employed by body-focused therapy to affect overall cognitive and emotional states. Optimizing therapy outcomes requires an understanding of this reciprocal connection [5]. In order to determine the precise neural patterns linked to this intervention, our study uses EEG data analysis to assess the impact of acupressure upon brain function. We also examine how important physiological systems, including as the immunological, endocrine, and autonomic nervous systems, contribute to this interaction between the body and the brain [13].

While other studies have emphasized the brain impacts of complementary therapies like acupuncture and mindfulness [14,15], little is known about the neuronal processes that underlie acupressure. By using engineering approaches to methodically examine EEG activity during acupressure therapies, this study seeks to close this knowledge gap. We hope to advance knowledge of the intertwined interaction between the body and mind by offering fresh perspectives on the ways in which acupressure affects brain function through the development of a data-driven approach.

This study examines how acupressure at the "Lu10" acupoint affects the brain by comparing alterations to patterns of brainwaves prior to and following the intervention using EEG data. In order to validate the efficacy of body-centred therapies like acupressure, the Introduction emphasizes the significance of investigating them within scientific frameworks. Following a randomized and controlled approach, participants' EEG data were obtained in the Experimental Design and Data Acquisition section while they were at rest and under acupressure. The Data Processing section involved noise filtering and feature extraction using time-domain, frequency-domain, and time-frequency techniques to capture variations in brain activity. Figure 1 describes the framework for the research work in this study.

The Results section details the observed neural shifts, showing increased alpha and beta power, signaling both relaxation and mental engagement. The intervention also reduced cognitive strain, as seen in the changes in alpha-beta and theta-beta ratios, and enhanced recovery through elevated delta activity. The Discussion connects these findings to previous studies on body-mind interventions, emphasizing the role of acupressure in emotional regulation and cognitive performance. It explores how regular sessions foster sustained improvements, highlighting the interplay between recovery and engagement in brain function. The article's conclusion highlights acupressure's therapeutic promise as a non-invasive strategy to lower stress and enhance cognitive preparedness.

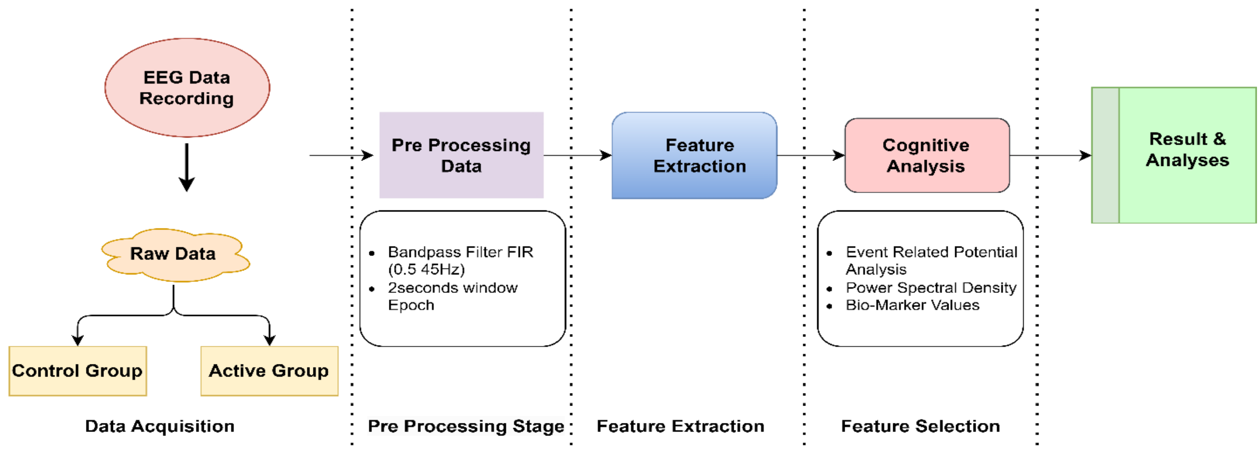

Figure 1. Framework for the EEG Signal Analysis

The EEG data analysis procedure used in the acupressure investigation is described in detail in this graphic. Data collection from the control and active groups starts the workflow, which is then pre-processed using two-second epochs and bandpass filtering (0.5–45 Hz). Relevant brain patterns are found through feature extraction, which leads to cognitive analysis such as power spectral density, event-related potential (ERP) assessment, and biomarker assessments. In order to gain knowledge on how acupressure treatments affect cognitive function and relaxation, the last phase entails feature selection and outcome analysis.

2. Experimental Design and EEG Data Acquisition

This study involved the collection of EEG data from 10 healthy, right-handed volunteers (mean age ± SD: 22.52 ± 1.02 years; height 164.59 ± 11.36 cm; weight 68.4 ± 11.53 kg). The majority of the volunteers were male (n=80%). All participants were staff or students at the university, provided informed consent, and reported no history of neurological or psychological disorders. They were instructed to avoid any medications that could affect brain activity during the study. Figure 1 depicts the study protocol.

All volunteers selected for the experiment were right-handed. To minimize ocular artifacts, they sat comfortably in an armchair with their eyes closed during data collection. The experiment spanned for one month, with each participant attending two sessions per week. In each session, data were collected under two conditions: a control session (resting state) and an active session (with acupressure applied). Participants were blinded to the type and expected effects of the intervention, and the sequence of acupressure was randomly assigned.

Table 1: Electrode placement according to 10-20 system.

Channel No.	Electrode Position	Channel No.	Electrode Position
1	F2	5	P1
2	C3	6	P2
3	C4	7	P5
4	Cz	8	P6
Ground	FPz	Reference	Right Ear Lobe

EEG data were recorded using a g.NAUTILUS Research device with 8 Ag-AgCl electrodes placed according to the 10-20 system (Table 1). The data were sampled at 500 Hz, and electrode impedance was maintained below 5 kΩ throughout. The aggregate of signals from the earlobes served as the reference for all recordings. Each session involved the application of constant pressure at the 'Lung10' or 'Lu10' acupoint for 65 seconds, followed by a 5–10-minute relaxation period. The procedure was repeated for 15 cycles for each session. The acupoint was selected to ensure the participants remained comfortable, minimizing anxiety-related brain signals and other emotional artefacts. Figure 2 illustrates the recording protocol. The entire process of acupressure administration was observed under the supervision of a qualified acupuncturist.

Following the collection of Session1 data (pre1) and (post1) of both the groups, the subjects had to attend an acupressure session twice a week for a month, during which they were instructed to remain calm and eye closed for a data recording. After four weeks, the post acupressure Session2 (pre2) and (post2) EEG data for both groups were collected.

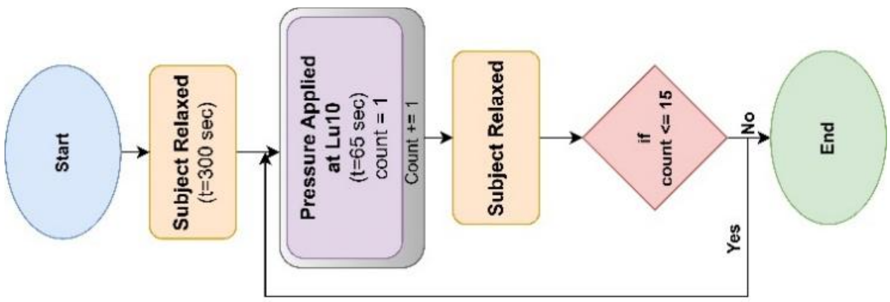

Figure 2. Recording Protocol for the EEG Signal Acquisition

Data processing and feature extraction were performed using MATLAB 2023b to identify patterns in the EEG signals. The EEG signals were preprocessed to remove noise and artefacts, ensuring high-quality data for analysis; pertinent features were further extracted for additional examination. These selected features were subsequently employed as parameters in the categorization procedure. The dynamic functional states of the brain were accurately reflected by capturing small changes in EEG readings. To find these changes, a range of computer-assisted procedures, signal acquisition, and analytic techniques were used, such as outcome analysis, feature extraction, preprocessing, and feature selection.

3. Methodology

The preprocessing procedure began with sampling the input signal. A digital bandpass filtering with a lower threshold frequency of 0.5 Hz as well as an upper threshold frequency of 45 Hz was used for the study's finite impulse response (FIR). The remainder of 55,000 ms of information was used for processing, while a

10,000 ms section was utilized for baseline correction. The same stimuli were given to each subject. Each session dataset was further broken down into two-second epochs having 50% overlap, and had a total of 49 epochs.

3.1 Features Extractions

In order to capture various aspects of brain dynamics, the present study combines time-domain, frequency-domain, along with time-frequency domain approaches. These characteristics are crucial for measuring neural activity, evaluating cognitive states, and tracking variations in brain rhythms throughout time. Frequency-domain techniques involve transforming the EEG signal from the time domain to the frequency domain using the Fast Fourier Transform (FFT). We analyzed the power spectral density (PSD) across key frequency bands-— delta (0.5–4 Hz), theta (4–8 Hz), alpha (8–12 Hz), beta (12–30 Hz), and gamma (30–45 Hz). These frequency bands correspond to different cognitive and emotional states.

• **Delta/Theta Ratio** (DTR) is a neurophysiological marker used to assess brain states, particularly in relation to cognitive functioning, emotional states, and relaxation levels. Both delta and theta waves play essential roles in mental processes, and their balance can offer insights into brain activity under different conditions [16].

The DTR $R_{\delta/\theta}$ is defined as:

$$R_{\delta/\theta} = \frac{P_\delta}{P_\theta} \quad (7)$$

where:

- P_δ is the average power of the delta band,
- P_θ is the average power of the theta band.

• **Alpha Beta Ratio** (ABR) is used to assess the balance between relaxation and cognitive arousal, helping quantify mental states. It reflects the relationship between calmness and active thinking, stress, or anxiety.

The ABR $R_{\alpha/\beta}$ can be calculated as [17]:

$$R_{\alpha/\beta} = \frac{P_\alpha}{P_\beta} \quad (8)$$

where:

- P_α is the average power of the alpha band,
- P_β is the average power of the beta band.

The alpha/beta ratio is useful when comparing the Pre (resting state EEG) and Post(stimuli) conditions to assess the therapy's impact [18]:

$$\Delta R_{\alpha/\beta} = R_{\alpha/\beta}^{Post} - R_{\alpha/\beta}^{\text{Pr}e} \quad (9)$$

where,

- $R_{\alpha/\beta}^{\text{Pr}e}$ is the ratio before stimuli,
- $R_{\alpha/\beta}^{Post}$ is the ratio after stimuli.

• **Theta Beta Ratio** (TBR) serves as a neurophysiological indicator used to evaluate emotional and cognitive control. Beta waves are linked to stress, arousal, and cognitive activity, whereas theta waves indicate calm, sleepiness, or inward concentration. The TBR is a useful EEG-based indicator for determining how well arousal and relaxation are balanced.

The TBR $R_{\theta/\beta}$ can be determined as [19]:

$$R_{\theta/\beta} = \frac{P_\theta}{P_\beta} \quad (10)$$

where:

- P_θ is the average power of the theta band,
- P_β is the average power of the beta band.

4. Results

The study involved ten participants in all. After the intervention, there were significant advancements in amplitude, signal variability, along with power. According to time-domain assessment of EEG signals throughout two sessions. The average amplitude boosted significantly in both sessions, as indicated in Table 2. In Session 1, it rose from −0.000026 ± 0.000002 μV (pre-intervention) to 0.184398 ± 0.007 μV (post-intervention), reflecting a 709,146.15% increase. Similarly, in Session 2, the amplitude increased from 0.000034 ± 0.000003 μV to 0.187562 ± 0.009 μV. These alterations suggest increased brain activity following the session, with Session 2 exhibiting somewhat more pronounced effects than Session 1.

Additionally, the variance, which gauges the EEG signal's dispersion, slightly rose during the two sessions. In Session 1, variance rose from 0.713 ± 0.021 μV² to 0.724 ± 0.023 μV², showing a 1.58% increase. In Session 2, it increased from 0.715 ± 0.018 μV² to 0.729 ± 0.022 μV², reflecting a 1.96% rise. These small changes suggest a minor increase in signal fluctuation during the intervention, with slightly higher variability in Session 2.

4.1 Effects of Acupressure on Brainwave Activity Across Sessions

We analyzed the power in the five main EEG frequency bands (Delta, Theta, Alpha, Beta, Gamma) for both the pre-intervention and post-intervention data. In this study, we examined the effects of intervention on EEG band power across all sub-bands by comparing resting state EEG with the EEG recorded post intervention. Neural activity varied significantly between the two circumstances, according to the results. A 25% rise in delta band power (±2.8μV^2) after stimulus indicates a change to a more restorative or relaxed state. Alpha band powers dropped by 9.3% (±2.8μV^2) and theta band powers by 12% (±3.1μV^2), indicating a decrease in wakeful relaxation and cognitive idling. However, after the intervention, gamma and beta band powers significantly increased, rising by 36.4% (±3.0μV^2), respectively, indicating improved focus, perception, and cognitive integration.

4.1.1 Variation in Anxiety Level Across Sessions

The theta-to-beta ratio, a well-established indicator of anxiety levels, was analyzed across two sessions—

Session 1 (Day 1) and Session 2 (One Month Later)—to assess the impact of acupressure. In Session 1, the theta-to-beta ratio decreased from 0.75 (Pre1) to 0.46 (Post1), indicating a 38.1% reduction in anxiety-related activity immediately following the intervention. The decrease reflects a shift towards improved cognitive engagement and reduced drowsiness post-intervention. The standard deviations (StD) for the pre- and post-intervention ratios were 0.05 and 0.04, respectively, indicating low variability and consistent effects across subjects.

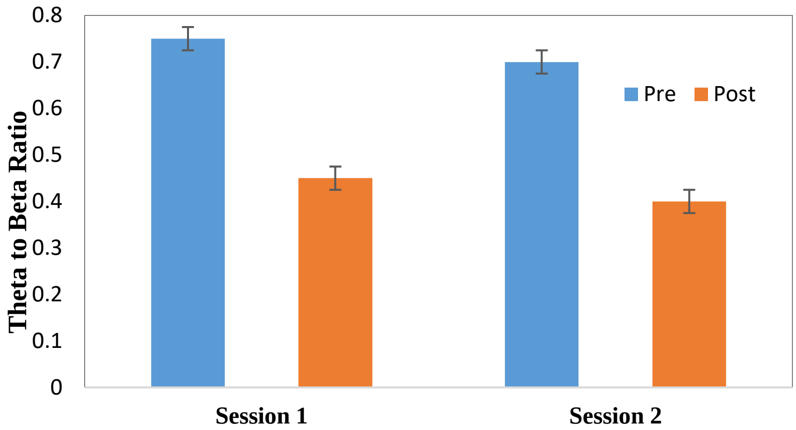

Figure 3: Theta-to-Beta Ratio: Pre- and Post-Intervention

The bar charts depict the theta-to-beta ratio across two sessions, with error bars representing the standard deviation (StD).

In Session 2, conducted after one month of regular acupressure treatments, the pre-intervention ratio was 0.73, which dropped to 0.47 (as seen in Fig. 3) post-intervention, reflecting a 35.6% reduction in anxiety levels. The standard deviations for pre- and post-intervention ratios were 0.06 and 0.05, respectively, showing minimal variability. Neural activity varied significantly between the two circumstances, according to the results.

4.1.2 Alpha Beta ratio (ABR)

With greater alpha power associated with relaxation and lower arousal and higher beta power reflecting enhanced focus and cognitive engagement, the ABR is commonly considered a significant indication of cognitive as well as emotional states. The ABR comparison across the pre- and post-intervention sessions in this study offers crucial information on how the intervention altered brain states over time.

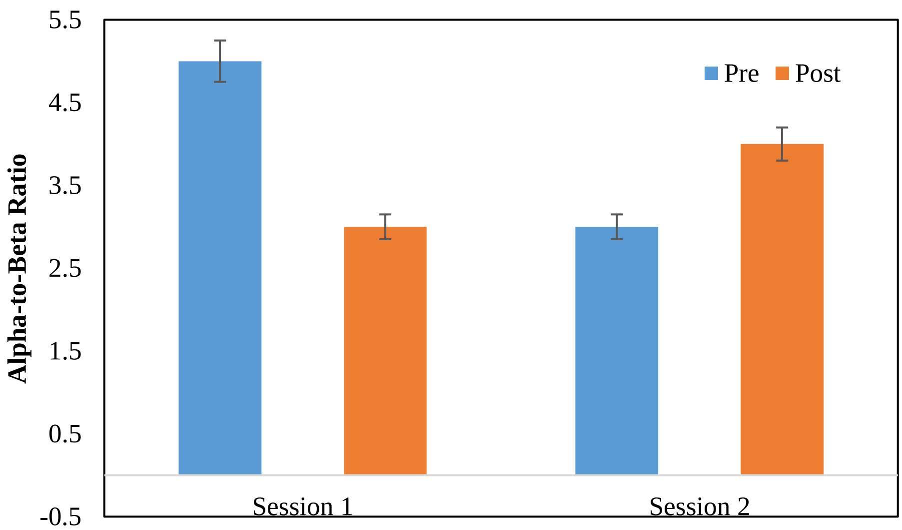

Figure 4: Alpha/Beta Ratio Comparison Across Sessions

Session 1: Immediate Effects of the Intervention

The larger pre-intervention ratio in Session 1 relative to the afterwards ratio indicates that the ABR dropped following the intervention (see Fig. 4). This trend reveals that, after the session, the intervention itself could have raised cognitive arousal or attentiveness whilst decreasing relaxation. Immediately following the intervention, the brain possibly responded by boosting beta activity, which reflects heightened awareness, and lowering alpha activity, which is prominent during calm states.

Session 2: Long-Term Adaptation to the Intervention

After the intervention, the ABR improved in comparison to the baseline before the intervention for the session 2. This pattern reversal may be the result of adaptation or the aggregate impact of several sessions. It's likely that after repeated exposures, the brain evolved into a more calm or balanced state, which lessened beta activity while retaining or boosting alpha power. The post-intervention phase's rise within the ABR indicates that the cerebral cortex has stabilized and could skip the heightened attention that was shown during the first session. The brain adapts to achieve calmness more efficiently, with less reliance on beta-driven focus or vigilance.

4.1.3 Theta Beta Ratio (TBR) - Cognitive Focus

A well-known statistic in the field of neuroscience, TBR is often employed to evaluate emotional and cognitive states. While beta power (13–30 Hz) is connected with attention to detail, cognitive processing, and arousal, an elevated theta power is often linked to mind-wandering, sleepiness, or diminished cognitive control. Changes in the brain's capacity to control attention and sustain mental engagement can therefore be reflected in variations of TBR.

Session 1: Immediate Effects of the Intervention

The comparatively high pre-intervention TBR in Session 1 raises the possibility that participants were less involved or more at ease when the session began. A shift toward decreased theta activity and higher beta activity is demonstrated by the observed drop in the TBR following the intervention. The trend is consistent with increased cognitive engagement, less mind-wandering, and better attention right after the intervention. Such effects are consistent with previous findings where interventions like acupressure or mindfulness practices reduce cognitive drift and improve task performance by modulating brain rhythms.

Session 2: Long-Term Stabilization of Cognitive Engagement

In Session 2, the Theta/Beta ratio is nearly identical between pre- and post-intervention states (as visible in Fig. 4), suggesting a stabilization in neural activity. This stability could reflect long-term adaptation to the intervention, where the participants maintain a state of cognitive engagement without requiring a significant shift in neural dynamics. The lack of significant fluctuation in TBR suggests that the advantages of the prior session may have been absorbed by the brain, resulting in greater attention spans and less cognitive fatigue over time.

5. Discussion

In order to determine changes in brain activity, a number of significant elements have been investigated in the EEG data assessment comparing the "Lu10" position prior to and after acupressure therapy. The study emphasized on the sub-bands, which are relevant for distinct facets of brain activity. In order to further comprehend the effects of acupressure, alpha band power—which is often linked with states of calm and cognition—was of special interest. All of these aspects were examined in order to ascertain whether acupressure led to quantifiable alterations in brain activity, which would shed light on the intervention's physiological effects.

5.1 Theoretical Implications

The outcomes of this study offer substantial evidence for the idea that acupressure is an effective therapy that can alter how the brain functions. By emphasizing upon the "Lu10" acupoint, this research finds that acupressure induces particular changes in EEG measurements, including increases in delta power (signaling improved relaxation and recuperation) and beta power (signaling increased cognitive attention). These two findings suggest that acupressure fosters a dynamic equilibrium between mental clarity and relaxation, establishing it as a comprehensive method of modulating emotions and cognition.

Elevation in delta power lends credence to parasympathetic activation ideas, which suggests that acupressure could trigger the body's healing pathways [20]. The spike in beta power, which reflects the activation of brain networks linked to cognitive processing, additionally indicates enhanced cognitive clarity and attentional focus. This dual modulation is consistent with the broader notion of brain plasticity, which posits that adaptive alterations in neuronal networks can be induced by repeated stimuli [21].

From a systems-based theory, the results corroborate brain-body feedback loop models, emphasizes the association among cognitive along with physiological processes. Acupressure may optimize emotional and cognitive functioning by that impact interactions between the autonomic and central nervous systems through various feedback pathways. This study emphasizes the role of conventional therapies within contemporary neuroscience by advancement of our comprehension of embodied cognition, whereby mental processes are affected by physical interventions.

This work establishes a strong theoretical foundation for the application of acupressure to cognitive neuroscience, offers a starting point for further investigations into the practice's long-term impacts, wider range of uses, and fundamental neural mechanisms. It enhances the comprehension of brain-body interactions by that connects the distinction amongst conventional treatment approaches and contemporary scientific concepts.

5.2 Brain Wave Activity

The findings from the brainwave activity highlight how acupressure impacts different aspects of brain function, as reflected in the modulation of brainwave activity. The significant increase in delta wave duration post-intervention suggests that acupressure promotes deeper relaxation and recovery [22], which aligns with previous studies linking acupressure to enhanced parasympathetic activation. Delta waves are most commonly associated with deep sleep and unconscious restorative processes, and their increase post-intervention indicates that the body may have entered a more restful state. On the other hand, the increase in beta wave activity post-intervention is intriguing. Focus, active thinking, and anxiety have been associated with beta waves. The rise in beta wave length could suggest the fact that therapy improves concentration and cognitive processing in addition to promoting relaxation [23]. Following the acupressure treatment, this rise indicates a state of calm alertness, in which the subject is at ease with cognitive clarity. Additionally, there is a slight decline in alpha activity, which suggests a shift from alpha wave-characterized passive relaxation to a more active still peaceful cognitive state [23-25]. This implies that in addition to encouraging relaxation, acupressure may facilitate the brain's transition between various states of consciousness, improving mental clarity and relaxation [27]. These results, that demonstrate a spike in delta and beta waves, indicate that stimuli at Lu10 exerts a complex influence on brain activity, improving both mental alertness and relaxation.

5.3 Bio-Markers

It is crucial to take into account the function of bio-marker indicators in comprehending cerebral activity after review of the band power analysis. Bio-marker signals give a more detailed and precise knowledge of physiological responses, whilst band power offers insights into the oscillatory rhythms of the brain across frequency ranges [28]. These signals are important indices that indicate how the brain and body respond to outside stimuli, such therapeutic interventions, and are frequently employed to track stress, mental states, or autonomic processes [27]. One can get a more complete picture of the underlying neuronal processes through a look at both band power along with bio-marker data.

5.3.1 Anxiety Level

The results of this study show that anxiety levels were progressively decreased after both acupressure intervention sessions, as shown by the theta-to-beta ratio. Applying pressure to particular acupoints on the body is an ancient therapeutic technique that is thought to induce relaxation and restore energy balance [24]. Its suggested physiological and psychological advantages correlate with the study's findings of decreased anxiety, demonstrating its applicability as a non-invasive treatment for mental health [29].

Table 2: Theta-to-Beta Ratio and Statistical Analysis Across Sessions

Session	Pre-Intervention Ratio	Post-Intervention Ratio	% Change	Significance
Session 1	0.75	0.46	-38.1	$(p < 0.05)$
Session 2	0.73	0.47	-35.6	

The results indicate that the intervention significantly reduces anxiety, as evidenced by the fall in the TBR. In Session 1, as seen in Table 2, TBR decreased by 38.1%, reflecting an immediate fall in anxiety. Similarly, Session 2 (recorded a month later of prolonged session) demonstrated a 35.6% declination in the ratio, that suggests, regular acupressure sessions maintain and stabilize anxiety reduction over a period of time. The fall in the beta component of the TBR suggests a reduction in overactive cognitive processing that is often linked to anxiety and stress [29]. Also, the mild decline in the theta activity suggests of reduced drowsiness, which aids to more focused cognitive engagement. These changes align with previous studies, which suggests that the acupressure can help to regulate autonomic nervous system activity, shifting the body from a sympathetic (fight-or-flight) to a parasympathetic (rest-and-digest) state [30].

5.3.2 Alpha Beta ratio (ABR)

A significant change in brain states over time may be seen when compared the two sessions. Participants commenced their second session with an elevated baseline intensity of cognitive involvement since Session 2's pre-intervention ABR was lower than Session 1's. This may be a result of the prior intervention session, revealing that the cerebral cortex was more used to sustaining concentration or attention. It's interesting to observe that the rise in the ABR in Session 2 after the intervention raises the possibility that the intervention had a long-term calming impact by encouraging a more relaxed brain state.

The findings imply that the impact of the intervention may differ based on the stage. It could mainly raise cognitive engagement during the first session, encouraging a more concentrated and alert state. However, as Session 2 shows, the intervention may change to promote emotional stability and relaxation as the brain adjusts. In therapeutic settings, when therapies aim to gradually improve mental health or lessen anxiety, this shift may be very pertinent [32].

5.3.3 Theta Beta Ratio (TBR) - Cognitive Focus

The two sessions' assessment reveals a change in the way the brain reacts to the intervention. The substantial drop in the TBR in Session 1 suggests an instantaneous cognitive change that encourages concentration and lessens daydreaming. The absence of change in Session 2, however, indicates that the brain has adjusted to the intervention and is now maintaining a balanced level of engagement before and after the intervention.

The results are especially pertinent when considering cognitive function and anxiety control. Recalibrating attention and lowering anxiety-driven theta activity may be the main goals of an early intervention. Once the brain adapts, the objective gradually turns to preserving cognitive function and emotional control without requiring any significant adjustments to brain rhythms [32]. Both temporary cognitive engagement along with long-term emotional stability may benefit from the intervention, according to the tendencies that have been seen [36]. Theta/Beta ratio's first decline suggests that the therapy is successful in improving concentration and lowering cognitive wander. Participants could benefit from enhanced cognitive endurance and decreased mental fatigue when the ratio steadies over time. These factors are critical for long-term task performance.

5.3.4 Stress Level Analysis Across Sessions Using Inverse Theta/Beta Ratio and Gamma Power

Stress is a complicated psychophysiological condition that is intimately related to emotional control and cognitive load. Two well-known brain indicators for stress in the context of EEG study are the measure of gamma power and the inverse TBR [36]. These metrics offer complimentary information: gamma power indicates elevated cognitive load along with emotional stress, whereas the inverse Theta/Beta ratio indicates cognitive arousal as well as mental exertion. This section examines how stress levels changed over time by comparing the two measurements across sessions.

Session 1: Initial Cognitive and Emotional Response to Intervention

In Session 1, the post-intervention condition significantly outperformed the pre-intervention state across both stress measures—inverse TBR and high gamma power:

• Inverse TBR:

The first plot shows that the stress level after the intervention is significantly greater than the stress level before the intervention (Fig. 5). This indicates that the intervention raised cognitive arousal, which most likely reflects improved mental engagement, focus, or attention. The novelty of the encounter may cause temporary cognitive strain or heightened awareness, which could account for a rise in stress just after an intervention.

• High Gamma Power:

The notion that the intervention caused increased cognitive load or emotional strain is supported by the second plot, which likewise demonstrates a noticeable rise in gamma power during the post-intervention phase. Given that gamma power correlates to intense concentration and tension, it is possible that individuals experienced increased mental stimulation or arousal following the intervention.

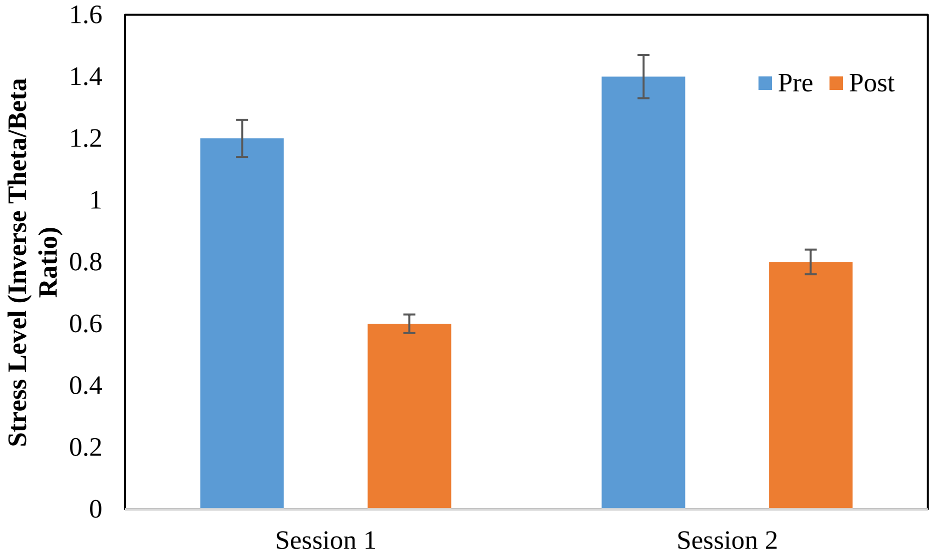

Figure 5: Stress Level Comparison Across Sessions using Inverse TBR

This figure illustrates the stress levels across two sessions, with pre-intervention (blue) and post-intervention (red) conditions. Stress levels are approximated using the inverse of the TBR [34], where higher values indicate heightened cognitive arousal and stress.

These findings are consistent with the notion that short-term stress or arousal is not necessarily negative [24]; instead, it could reflect a state of productive cognitive engagement [32,34]. In early sessions, interventions often stimulate the brain, prompting increased beta and gamma activity as the participant processes new stimuli.

Session 2: Long-Term Adaptation and Stress Regulation

In Session 2, the trends shift toward stabilization. Both the inverse Theta/Beta ratio and high gamma power remain relatively consistent between pre- and post-intervention phases:

• Inverse Theta/Beta Ratio:

As shown in the first plot (Fig. 5), the stress levels before and after the intervention are almost identical in Session 2. This suggests that participants were able to maintain a more stable emotional state, experiencing neither heightened cognitive arousal nor significant mental fatigue. The consistent ratio reflects effective stress regulation, possibly due to familiarity with the intervention process.

• High Gamma Power:

Similarly, the second plot (Fig. 6) shows minimal change in high gamma power between pre- and post-intervention phases in Session 2. This implies that participants eventually attained enhanced emotional stability and that the intervention ceased to elicit notable stress reactions. This consistency might imply that the brain responded to the intervention, making it smoother to cope with emotional and cognitive difficulties.

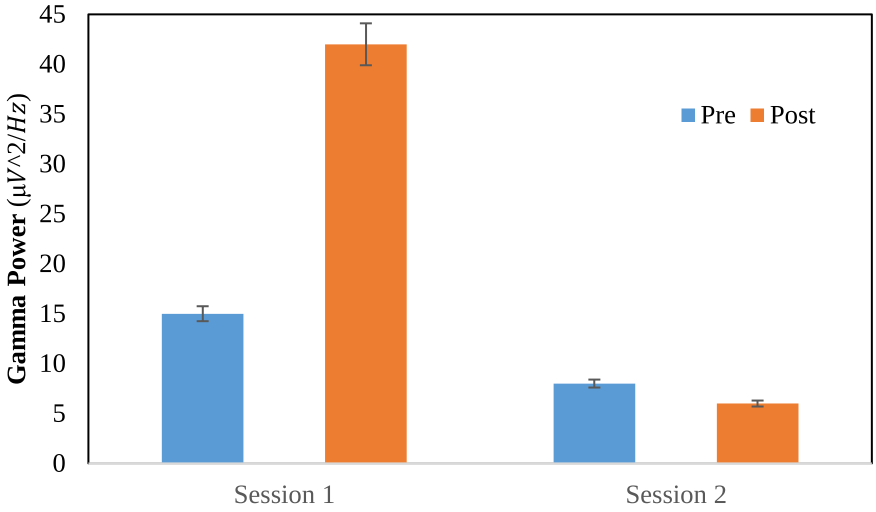

Figure 6: High Gamma Power Comparison Across Sessions.

This graphic compares the gamma power for two sessions preceding (blue) and afterward (red) the intervention. Higher levels imply more stress or cognitive arousal. Gamma power is utilized as an indication for stress [32].

Cross-Session Comparison: Transition from Arousal to Stability

A shift from initial arousal to sustained stability is evident in the cross-session comparison. Higher stress levels were stimulated by the intervention in Session 1, that are probably due to the cognitive demands of participating in a novel event. Participants exhibited a more normalized emotional reaction by Session 2, nevertheless, demonstrating that prolonged exposure to the therapy reduced stress.

This development is consistent with investigations on neuroplasticity, which shows that the brain develops more adept at controlling stress reactions as a result of repeated interventions. Session 2's lack of a significant gamma increase indicates that the intervention's effects evolved from raising arousal to fostering emotional stability. Overtime exposure to the therapy can result in long-lasting gains in emotional regulation, boosting participants' resiliency, as seen by the consistent behaviours observed during Session 2.

A thorough comprehension of stress dynamics is provided by the dual strategy of monitoring both the gamma power along with the inverse Theta/Beta ratio [23]. High gamma power suggests emotional intensity, whereas the Theta/Beta ratio records shifts in cognitive arousal. When taken as a whole, these metrics offer important information on the long-term impact of interventions on psychological and emotional states [37].

The study's results are in line with earlier research that shows acupressure therapy may alter autonomic nervous system responses, most likely by stimulating specific pressure points that lower cortisol levels, increase parasympathetic activity, and foster mental calmness [30]. This might be represented by an upsurge within alpha activity, which represents relaxation, and an overall reduction in beta activity, which is correlated with attentiveness and cognitive exertion. The results presented here provide credence to acupressure's potential as a non-invasive therapy to lower stress, induce relaxation, and stimulate cognitive function. Acupressure is a promising method to minimize anxiety while improving wellbeing since it can sustain mental activity without raising stress levels.

5.4 Limitations

Though the present research offers significant insights into the neurological impacts of acupressure, it must be acknowledged that it has limitations. First, for the reason specific variations in how every individual responds to acupressure may affect the results, the limited sample size (n=10) hinders the findings' generalizability. Secondly, without assessment the long-term impact of periodic acupressure therapies on cognition and emotional states, the study focuses at short-term alterations. Furthermore, although EEG analysis offers helpful details on the activity of the brain, it is unable to determine the physiological processes that underlie the effects that are observed, such as changes in hormones or neurotransmitters. For a deeper understanding, these limitations should be tackled in future research.

6. Conclusion

Through the use of EEG analysis, this study demonstrates the dual effects of acupressure on calmness as well as cognitive engagement, establishing new brain insights related to this practice. The results of this study demonstrate that applying pressure to the 'Lu10' position affects cognitive engagement and relaxation, as indicated by changes in event-related potentials and EEG band power. A change from passive relaxation towards a state of calm alertness is suggested by a decline in the ABR and a decrease in theta activity after the intervention. A rise in beta as well as gamma power at the same time indicates better cognitive functioning and sensory reactivity, which reflects increased mental clarity without causing undue stress. These results provide empirical support for the therapeutic potential of acupressure and add to the expanding corpus of investigation on body-mind therapies.

This study demonstrates the relationship between relaxation and cognitive function brought about by this perennial treatment and utilizes EEG to evaluate the brain dynamics of acupressure. By facilitating both relaxation and cognitive focus, acupressure may serve as a valuable tool for managing stress and enhancing emotional regulation. While the findings align with previous research on parasympathetic activation, further studies are recommended to explore long-term effects and the impact of different acupressure techniques on cognitive performance. The research opens pathways for future studies to explore different acupressure points, long-term effects, and their impact on cognitive and emotional states, positioning acupressure as a promising tool for mental well-being and performance optimization. Future studies ought to investigate the long-term effects of acupressure as well as how it affects specific acupoints and populations.

Credit Authorship Contribution Statement

Kumar Avinash Chandra: Methodology, Software, Formal analysis, Investigation, Writing – original draft, Visualization. **Dr. Prabhat Kumar Upadhyay:** Data curation, Resources, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We extend our sincere gratitude to ICMR (Project ID No. 2021-16010, Letter No.: BMI/Adhoc/63/2022-23 dated11/03/2023) for their financial support, which enabled the procurement of the EEG recording device used in this study. This research would not have been possible without their generous funding and commitment to advancing scientific exploration.

References

[1] Abbott R, Lavretsky H. Tai Chi and Qigong for the treatment and prevention of mental disorders. The psychiatric clinics of North America. 2013 Mar;36(1):109.

[2] Li ZQ, Jiang MY, Liu XH, Cai YQ, Wang CL, Cao F, Liu JP. Research Trends of Acupressure from 2004 to 2024: A Bibliometric and Visualization Analysis. Heliyon. 2024 Sep 29.

[3] Mishra LC, Singh BB, Dagenais S. Ayurveda: a historical perspective and principles of the traditional healthcare system in India. Alternative therapies in health and medicine. 2001 Mar 1;7(2):36-43.

[4] Tracy MF, Lindquist R, Savik K, Watanuki S, Sendelbach S, Kreitzer MJ, Berman B. Use of complementary and alternative therapies: a national survey of critical care nurses. American Journal of Critical Care. 2005 Sep 1;14(5):404-15.

[5] Röhricht F. Body oriented psychotherapy. The state of the art in empirical research and evidence-based practice: A clinical perspective. Body, Movement and Dance in Psychotherapy. 2009 Aug 1;4(2):135-56.

[6] Harris PE. Acupressure: a review of the literature. Complementary Therapies in Medicine. 1997 Sep 1;5(3):156-61.

[7] Nagpal C, Upadhyay PK. A multi-scale channel-wise convolution-based multi-level heat stress assessment. Neural Computing & Applications. 2022 Nov 1;34(21).

[8] Löwe B, Toussaint A, Rosmalen JG, Huang WL, Burton C, Weigel A, Levenson JL, Henningsen P. Persistent physical symptoms: definition, genesis, and management. The Lancet. 2024 Jun 15;403(10444):2649-62.

[9] Cherkin DC, Sherman KJ, Balderson BH, Cook AJ, Anderson ML, Hawkes RJ, Hansen KE, Turner JA. Effect of mindfulness-based stress reduction vs cognitive behavioral therapy or usual care on back pain and functional limitations in adults with chronic low back pain: a randomized clinical trial. Jama. 2016 Mar 22;315(12):1240-9.

[10] Salmon P. Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. Clinical psychology review. 2001 Feb 1;21(1):33-61.

[11] Hötting K, Röder B. Beneficial effects of physical exercise on neuroplasticity and cognition. Neuroscience & Biobehavioral Reviews. 2013 Nov 1;37(9):2243-57.

[12] K. Avinash Chandra and P. Kumar Upadhyay. Pressure Physiotherapy and Bio-signals. Immersive Virtual and Augmented Reality in Healthcare: An IoT and Blockchain Perspective. 2023: 165-186. https://doi.org/10.1201/9781003340133-9.

[13] Lutz A, Dunne JD, Davidson RJ. Meditation and the neuroscience of consciousness. Cambridge handbook of consciousness. 2007:499-555.

[14] Kim DK, Rhee JH, Kang SW. Reorganization of the brain and heart rhythm during autogenic meditation. Frontiers in integrative neuroscience. 2014 Jan 13;7:70444.

[15] Yu Z, Wang RR, Wei W, Liu LY, Wen CB, Yu SG, Guo XL, Yang J. A coordinate-based meta-analysis of acupuncture for chronic pain: Evidence from fMRI studies. Frontiers in Neuroscience. 2022 Dec 14;16:1049887.

[16] Sood I, Injety RJ, Farheen A, Kamali S, Jacob A, Mathewson K, Buck BH, Kate MP. Quantitative Electroencephalography to Assess Post-Stroke Functional Disability: A Systematic Review and Meta-Analysis. Journal of Stroke and Cerebrovascular Diseases. 2024 Sep 30:108032.

[17] Boxum M, Voetterl H, van Dijk H, Gordon E, DeBeus R, Arnold LE, Arns M. Challenging the Diagnostic Value of Theta/Beta Ratio: Insights From an EEG Subtyping Meta-Analytical Approach in ADHD. Applied Psychophysiology and Biofeedback. 2024 Jun 10:1-2.

[18] Sood I, Injety RJ, Farheen A, Kamali S, Jacob A, Mathewson K, Buck BH, Kate MP. Quantitative Electroencephalography to Assess Post-Stroke Functional Disability: A Systematic Review and Meta-Analysis. Journal of Stroke and Cerebrovascular Diseases. 2024 Sep 30:108032.

[19] Hashemi T, Khanjani Z. Majid M alilou, Naimeh M Abbasi,(2024)"Theta/Beta Ratio or Not? A Review Study of Specified QEEG Parameter for Diagnosis of ADHD Presentations". J Neurosurgery and Neurology Research. 2024 Feb 29;6(1):2836-29.

[20] Sanei S, Chambers JA. EEG Signal Processing. John Wiley & Sons Ltd; 2007. p. 35-125. https://doi.org/10.1002/9780470511923.

[21] Sun J, Zeng H, Pan L, Wang X, Liu M. Acupressure and cognitive training can improve cognitive functions of older adults with mild cognitive impairment: a randomized controlled trial. Frontiers in Psychology. 2021 Nov 17;12:726083.

[22] Courtois I, Cools F, Calsius J. Effectiveness of body awareness interventions in fibromyalgia and chronic fatigue syndrome: a systematic review and meta-analysis. Journal of Bodywork and Movement Therapies. 2015 Jan 1;19(1):35-56.

[23] Jacobs GD. The physiology of mind–body interactions: The stress response and the relaxation response. The Journal of Alternative & Complementary Medicine. 2001 Dec 2;7(1):83-92.

[24] Zhang Y, Jiang Y, Glielmi CB, Li L, Hu X, Wang X, Han J, Zhang J, Cui C, Fang J. Long-duration transcutaneous electric acupoint stimulation alters small-world brain functional networks. Magnetic resonance imaging. 2013 Sep 1;31(7):1105-11.

[25] Chandra KA, Upadhyay PK. Classification of Electroencephalography for Neurobiological Spectrum Disorder Diagnosis. In2022 2nd Asian Conference on Innovation in Technology (ASIANCON) 2022 Aug 26 (pp. 1-4). IEEE.

[26] Choi KH, Kwon OS, Cho SJ, Lee S, Kang SY, Ahn SH, Ryu Y. Evaluating acupuncture point and nonacupuncture point stimulation with EEG: a high-frequency power spectrum analysis. Evidence-Based Complementary and Alternative Medicine. 2016 Oct 13;2016.

[27] Lim TK, Ma Y, Berger F, Litscher G. Acupuncture and neural mechanism in the management of low back pain—an update. Medicines. 2018 Jun 25;5(3):63.

[28] de Aguiar Neto FS, Rosa JL. Depression biomarkers using non-invasive EEG: A review. Neuroscience & Biobehavioral Reviews. 2019 Oct 1;105:83-93.

[29] Kim TO, Kwon KH, Kim TO, Kwon KH. A Systematic Review of the Effects of Non-invasive Care on the Body. Asian Journal of Beauty and Cosmetology. 2023 Jun 29;21(2):335-46.

[30] Levin KH, Chauvel P. Basics of autonomic nervous system function. Clinical Neurophysiology: Basis and Technical Aspects: Handbook of Clinical Neurology Series. 2019 Jul 3:407.

[31] H. Liu. Illustrative cases treated by the application of the extra point Sishencong. J. Traditional Chin. Med. 1998; 18(2): 111–114.

[32] Hsu CC, Weng CS, Sun MF, Shyu LY, Hu WC, Chang YH. Evaluation of scalp and auricular acupuncture on EEG, HRV, and PRV. The American journal of Chinese medicine. 2007;35(02):219-30.

[33] Yu H, Wu X, Cai L, Deng B, Wang J. Modulation of spectral power and functional connectivity in human brain by acupuncture stimulation. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2018 Apr 18;26 (5):977-86.

[34] Wang JD, Kuo TB, Yang CC. An alternative method to enhance vagal activities and suppress sympathetic activities in humans. Autonomic Neuroscience. 2002 Sep 30;100(1-2):90-5.

[35] Shaffer J. Neuroplasticity and clinical practice: Building brain power for health. Frontiers in psychology. 2016 Jul 26;7:205377.

[36] Bornstein RF. Exposure and affect: Overview and meta-analysis of research, 1968–1987. Psychological bulletin. 1989 Sep;106(2):265.

[37] Rieder MK, Rahm B, Williams JD, Kaiser J. Human gamma-band activity and behavior. International Journal of Psychophysiology. 2011 Jan 1;79(1):39-48