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# Advanced Analysis of Alpha EEG Patterns for Identifying Meditative States in Alpha Power Activation Yoga (APAY)

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**Abstract:** Meditation, especially Alpha-Power Activation Yoga (APAY), is popular today for well-being. Apay promotes relaxation and focuses using yoga and attention. However, the inspiring settings app effectiveness evaluation made challenging. EEG can measure attentive brain activity. This work improves the Alfa EEG pattern analysis for the discovery of EFEM. EEG functions are classified through the moral analysis and machine learning of the time. This approach reflects the neurological attention process. Preliminary research found that alpha-EEG patterns change with training stages such as concentration, attentive absorption and relaxation. Deep concentration reduces hiking and increases frontal and lateral regions. Constant attention increases front and behind alpha, suggests brain treatment and sensory awareness. This shows that app-inspired attention requires more EEG study to understand neurophysiology. Strong EEG biomarker will track skill changes and its mental health benefits. Kaggle EEG Alpha Wave Dataset detects meditation (closes the eyes) with non-meditation (opening of the eyes) when relaxing the subject. In this dataset, the decisions identify accurately the trees in the decision, innocent bays and random forest phenomena. These findings will be repeated in a large population and investigated to see how the monkey practice affects psychological and neurological processes over time. Researchers can identify brainwave patterns and emotional welfare connections and explain these results. It can inspire new attention -based mental health treatments. Doctors can provide better mental and emotional care by adding these techniques to parting to the treatment. A full disposition goal is to improve the awareness of welfare and body. This can show how diet and exercise affect mental health.

**Keywords:** Alpha EEG, Meditation, Alpha Power Activation Yoga, APAY, Neural Correlates, Machine Learning, Well-being, Relaxation

## 1. Introduction

Permanent stress and fast life, many individuals seek inner peace and general welfare. This exploration has increased the popularity of a lot of focus function, Alpha Power Activation Yoga (APAY) appears as a unique merging of contemporary mindfulness practice with traditional yoga methods [1]. Apay uses a systematic combination to promote physical asana, breathing and intensive internal peace, increased awareness and deep relaxation. Despite individual experiences and empirical evidence, the evaluation of its efficiency is still challenging in motivating noticeable conditions, indicating the therapeutic benefits of the app. Traditional subjective evaluation techniques, such as self -report survey and qualitative observation, provide valuable insights, but lack the accuracy and justice required for scientific examination [2]. To address this limit, researchers have used neuroimaging techniques such as Elektro -Objective (EEG) to examine carefully associated brain systems. EEG technology clearly shows to change the interaction between brain activities that help with cognitive functions, such as focus, relaxation and self-insight, all things that are when meditating. Researchers can investigate real -time changes in the brain states during meditation using EEG [3], which captures the electrical signals generated by neuronal activity. The study of meditation highlights the alpha frequency range (8-12 Hz) which, due to introspection, calm vigilance and its collaboration with

expanded cognitive processing [4]. Recent progress in signal processing and EEG technologies has increased understanding of alpha swings and his role in noticeable states. Wavelet transformations and Hilbert-hung transformations are two-time frequency analysis methods that can be used to describe the spectral dynamics and temporary changes in alpha power under attention. In addition, machine learning techniques enable objective classification of reflective conditions by facilitating the extraction of specific functions from EEG data [5].

This study wants to examine the nervous correlations of conditions inspired by Ap by using progress in EEG analysis. Our goal is to clarify the complex patterns of Alfa EEG activity associated with different stages of APAY practice using advanced signal processing techniques, machine learning algorithms and high-class EEG recording [6]. In addition, to provide reliable matrix to assess personal differences mainly in attention capacity and to evaluate the effectiveness of treatment by identifying strong EEG biomarkers for noticeable conditions. We will give a comprehensive increase in the theoretical framework that emphasizes this study, investigating relevant research on meditation and EEG, prepared the planned research method and analysing the possible implications of our conclusions to continue our understanding of attention and promote mental health in contemporary society [7].

The purpose of our study is to fill the knowledge gap between modern neurological and traditional reflective practice through scientific examination, perhaps improves the medical efficiency of EFEM and other meditation methods. To begin with, consider the existing literature's body on EEG analysis techniques used in supplementary and alternative medical studies [8]. This review includes the preparation of EEG data, identifying relevant parameters and interpretation of brain correlates associated with treatment effects. This study will include techniques such as spectrum analysis, coordination analysis and capacity related to incident to provide a comprehensive observation of statistical methods available to investigate brain signals in terms of alternative agents [9]. By taking advantage of insights from scientific reviews, we will develop a systematic approach to complement the EEG signals in the brain and examine the effect of alternative medicines. This technique will include developing experimental protocols to assess the pre -medical sessions before and after the therapeutic sessions to assess cerebral activity. It will also entail putting in place suitable control conditions to distinguish between causes other than therapy-related effects. To detect therapy-related changes in brain dynamics, this comparison study will quantify changes in spectral power, coherence, and other EEG metrics [10].

## 2. Literature Review

Stress levels [11] may drop with emotional intelligence. The emotions muddle up life. Evaluate your feelings. NLP and ML have not been applied in suicide note sentiment analysis. SVM algorithms use psychological states and signals derived from EEG data to classify people as either under stress or not under stress. Yoga and relaxing music, according to Merged LSTM, lower stress. Ultimately, stress may be explained by emotions. The DEAP-synchronized brainwave dataset includes EEG signal levels and patient data. EEG and valence/arousal sense emotions. The spectral properties of alpha, gamma, theta, and beta EEG data are recovered using the discrete wavelet technique (DWT). Transforms that are same-dimensional isolate ICA characteristics. ANN categorizes feelings. 75% of anxious individuals feel relaxed by yoga and calming music, according to SVM's 92.86 percent accuracy and LSTM's 75.23 percent accuracy. Beta emotions are categorized using a cross-validated RBF kernel-based SVM with 90.3% arousal and 91.11% valence. The outcomes can be changed by the classifier, stressor type, length of the experiment, EEG processing, standardized technique, and brain area of interest. Utilize the right characteristics to identify stress-related feelings. In the research, stress is also identified and treated using yoga and music. Many biological domains, such as sleep and the brain-computer interface, use the non-invasive and sophisticated electroencephalography (EEG) signal [12].

In order to interpret EEG signals, researchers have developed a number of sophisticated feature extraction and preprocessing techniques due to their complexity. In this paper, we examine a thorough analysis of many EEG signal processing publications. We compiled the results of our search across the main scientific and technical databases. We covered every step of the EEG signal processing pipeline in our survey, from capture and pretreatment (denoising) to feature extraction, classification, and use. We provide a thorough analysis and comparison of many approaches and strategies for processing EEG signals [13].

Brain-computer interface technologies (BCI) [14] constitute one of the most promising fields in academia. By translating neural signals into orders that computer systems can understand, it establishes a connection between human brain waves. It creates a link between the outside physical environment and brain waves, or neural signals like EEG. This research suggests utilizing yoga, an appropriate therapy, to lower the stress level among the student fraternity. Electroencephalogram (EEG) signals are used to measure pupils' mental health and investigate brain waves. Three yoga techniques—Yoga Nidra, Nadi Shuddhi Pranayama, and Nine-Center Meditation—are employed to help pupils become more focused. The statistical characteristics of wave signals are retrieved

prior to doing yoga. Nowadays, people use meditation as a coping mechanism for stress brought on by their mechanized lifestyles or the health risks associated with the COVID-19 epidemic.

We are examining the electroencephalogram (EEG) [15] data of individuals who practice mindful meditation both with and without pranayama in our investigation. We used an eight-channel BCI (brain computer interface) device named Enibio-8 to collect EEG data. Subsequent time series analysis is used to quantify meditation by extracting parameters for different cognitive tasks, such as the Hjorth parameter, Kurtosis, and RMS (Root Mean Square) value. A vital, non-invasive analytical technique for diagnosing and characterizing mental health is electroencephalography (EEG). To overcome the aforementioned challenges, a computer-aided automatic decision-making model has been developed in this study to assess mental health states utilizing the alpha band (8–12 Hz) of the EEG data [16]. The suggested simulation model replicated the steps involved in signal denoising, splitting the EEG signal into several bands, extracting features from the alpha band of the EEG data, and classifying a person's mental state as either healthy or unwell. On datasets related to epileptic seizures and schizophrenia, the ensemble bagged tree classifier performs better than the other techniques, with classification accuracy of 99.5% and 98.68%, respectively.

The purpose of this research is to examine the effect of yoga and meditation on the waves of the brain related to mental and physical welfare. This article provides observations of ways to interpret strain signals from electroencephalograms (EEG) [17] recorded during yoga and meditation. These interpretations can uncover important patterns correlated with better emotional regulation, stress reduction and general cognitive function. In addition, understanding of these brain wave changes can increase medical practice and can promote mental health initiatives. In the interaction between these ancient practices and modern neurology, we expect to establish a clear relationship between mindfulness techniques and their physical effects. This understanding can lead to more effective interventions for people who want to improve their mental flexibility in today's fast book. Such intervention can not only promote individual development, but also contribute to widespread social change to preference to mental welfare. As we continue to detect these compounds, it becomes important to integrate mindfulness into educational and work environment, and ensure that individuals have important tools to navigate the challenges of life. Previous studies have demonstrated that yoga and meditation have major benefits for both the mind and body. A clinical and geriatric population may benefit from yoga practice as an additional therapy. More in-depth studies can look at how different styles of yoga affect a particular clinical group. Overall, healthy brain activity was enhanced by yoga and meditation.

The electroencephalogram (EEG) data [18] obtained from polysomnography recordings is an important resource for understanding the changes in behavior and physiology that occur during sleep. The purpose of this study is to distinguish between participants who practice yoga and those who do not. This study investigated frequency domain properties using power spectral density approaches. 1s and 0.5s were distinguished in the EEG recordings. Four windowing techniques (0%, 50%, 60%, and 75%) are used in EEG patterns to guarantee signal stationary behavior and examine the impact of the pre-processing step. The sensitivity and specificity of the non-linear KNN classifier were assessed in order to distinguish between the yoga and non-yoga groups during the N3 sleep stage.

Research [19] has been done on the differences in physiological parameters between yoga instructors and untrained participants when they execute specific poses, such as pranayama, dwipadapitham, apanasana, and jathara paritti. A simultaneous ECG and EMG are obtained before, during, and following the specifically designed yoga practice sequence. These signals are appropriately processed in order to quantify the properties in the time and frequency domains and examine how they changed over the recording period. MHR, LF/HF, and SD1/SD2 all vary with posture and diminish with rest, according to the HRV study. pNN50 exhibits an increase at rest and a reduction with posture.

## 3. Methodology

### 3.1. Electroencephalography (EEG)

Electroencephalography (EEG) is a non-invasive neuroimaging technology that analyses the electrical activity of the brain with electrodes positioned on the head. Brain wave patterns are generated by the coordinated firing of neurons in the brain, and this technique enables scientists and medical professionals to see and examine these patterns as shown in the figure 1. Real-time brain function research using EEG is beneficial since it provides information on neurological illnesses, emotional states, and cognitive functions [20]. Figure 2. denotes the neural oscillations, a substitute for brain waves, are regular electrical patterns that originate from the millions of neurons firing in networks across the brain. These oscillations, which are distinguished by their frequency, amplitude, and phase, are essential for aiding a variety of cognitive activities and coordinating communication across distinct brain areas.

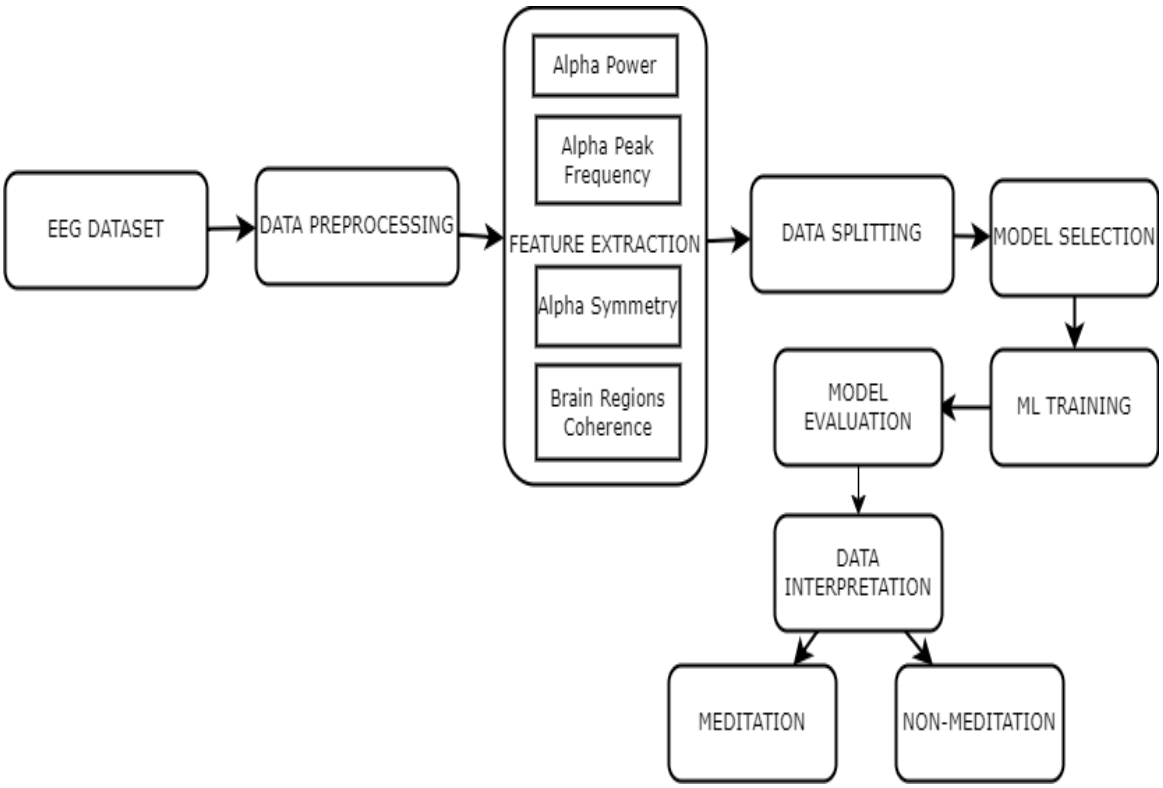


**Figure 1.** Proposed Architectural Diagram

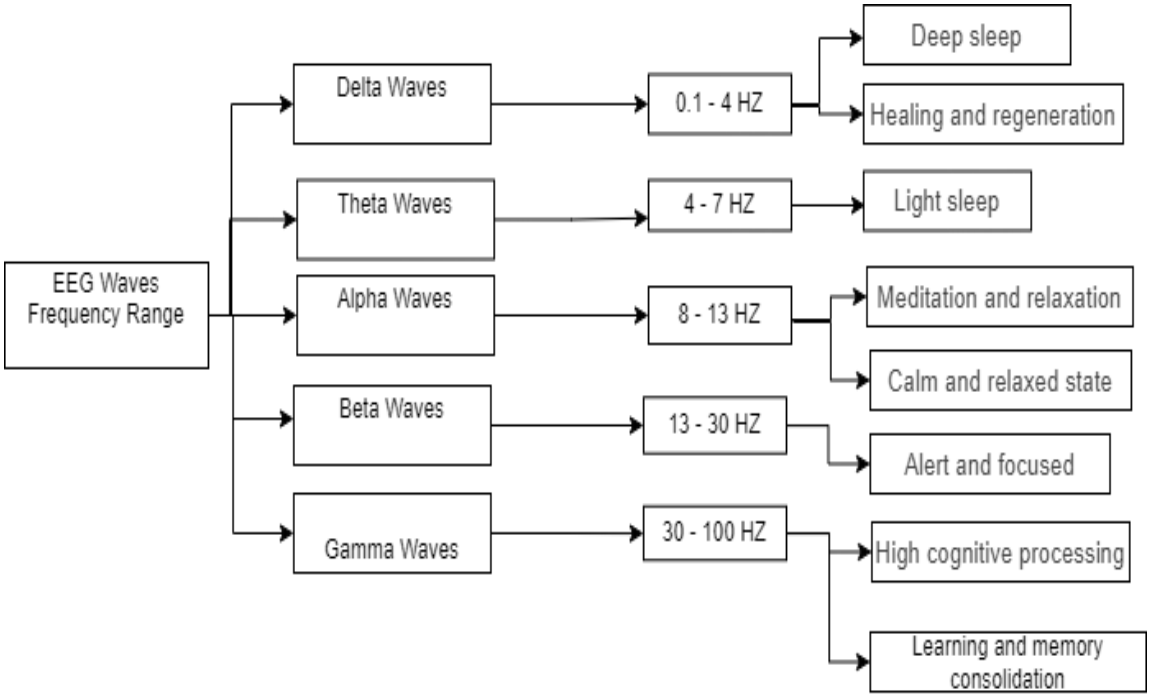


**Figure 2.** EEG Frequency Range.

### 3.2. Alpha Power Activation Yoga

Alpha Power Activation Yoga is a unique and effective method for achieving overall well-being. Through the advancement of a state of calm awareness and access to the subconscious, APAY assists people in realizing their full potential and creating a peaceful, balanced existence. APAY offers a route to significant personal transformation, whether the goal is spiritual development, improved creativity, or stress alleviation.

Individuals can achieve many benefits to this integrated yoga practice and use the effect of alpha waves through frequent engagement [21]. In the routable part of an apay session, doctors drive in deep breathing methods to calm the body and ideas. A series of mild asanas designed to promote relaxation and light

energy flies are as follows. A meditation session emphasizes imagination or confirmation that increases alpha wave activity. The contemplative component of Apay Foster is satisfied and satisfied with the help of the participants in their internal connection to themselves. Continuous practice of Apay can increase mental welfare. It promotes attention and emotional regulation, supports individuals in dealing with emotions and developing a positive attitude toward life. Apay is associated with better cognitive work and increased creativity [22]. Alpha waves provide a calm but gentle position that improves creativity and problem-solving abilities. Apaye's ability to reduce stress is one of the main benefits.

Figure 3 data exposes that data's from meditation performing subjects reduces cortisol levels and increases the alpha-brainavave activity, leading to a more balanced and produced mental state. The main purpose of Apay is to identify each person's internal powers. This involves using meditation and visual methods to link the subconscious, leading to an increase in self -insight and personal development. By promoting this deep relationship to themselves, individuals can unlock their ability and face challenges with fresh strength and insight. Finally, Apay acts as a powerful tool not only to change the mindset, but also a holistic approach to life and its countless complications.

| | Time | Fp1 | Fp2 | Fc5 | Fz | Fc6 | T7 | T8 | P7 | P3 | Pz | P4 | P8 | O1 | Oz | O2 | Meditation | Non-Meditation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 536 | 1.0469 | -16656 | 1032.30 | 7244.3 | 1517.7 | -4086.7 | 936.38 | -3859.9 | 1073.60 | -8869.0 | 1000.6 | -2098.1 | 8155.3 | -10002.0 | 13315 | -19746 | 1 | 0 |
| 571 | 1.1152 | -16686 | 1021.00 | 7258.1 | 1514.6 | -4080.3 | 899.89 | -3833.9 | 1058.00 | -8866.3 | 1000.5 | -2093.8 | 8148.8 | -10000.0 | 13297 | -19780 | 1 | 0 |
| 578 | 1.1289 | -16671 | 1011.90 | 7233.8 | 1512.1 | -4084.2 | 928.27 | -3839.5 | 1067.20 | -8860.7 | 1000.6 | -2109.4 | 8152.5 | -9974.8 | 13311 | -19766 | 1 | 0 |
| 609 | 1.1895 | -16677 | 1005.80 | 7234.6 | 1508.3 | -4089.9 | 945.70 | -3869.6 | 1031.00 | -8865.5 | 1000.7 | -2105.7 | 8154.0 | -9998.9 | 13291 | -19778 | 1 | 0 |
| 628 | 1.2266 | -16700 | 1014.20 | 7264.8 | 1512.4 | -4080.5 | 921.97 | -3835.9 | 1017.20 | -8873.5 | 1000.1 | -2110.3 | 8159.8 | -10016.0 | 13289 | -19776 | 1 | 0 |
| 655 | 1.2793 | -16702 | 1011.40 | 7213.5 | 1513.4 | -4077.1 | 941.18 | -3820.5 | 1044.60 | -8864.1 | 1000.2 | -2110.0 | 8170.4 | -9968.6 | 13317 | -19749 | 1 | 0 |
| 671 | 1.3105 | -16678 | 1006.60 | 7223.9 | 1513.2 | -4080.0 | 936.77 | -3892.6 | 1065.50 | -8869.3 | 1000.2 | -2118.5 | 8158.8 | -10006.0 | 13283 | -19791 | 1 | 0 |
| 687 | 1.3418 | -16670 | 1001.90 | 7224.3 | 1521.9 | -4065.7 | 918.13 | -3850.8 | 1079.30 | -8870.1 | 1000.6 | -2107.1 | 8167.7 | -10016.0 | 13274 | -19796 | 1 | 0 |
| 1104 | 2.1563 | -16692 | 958.58 | 7182.6 | 1484.0 | -4083.3 | 905.93 | -3857.4 | 899.74 | -8869.6 | 1000.1 | -2037.7 | 8225.0 | -10002.0 | 13283 | -19793 | 1 | 0 |
| 1751 | 3.4199 | -16654 | 957.19 | 7237.8 | 1501.3 | -4047.3 | 948.58 | -3827.5 | 902.55 | -8841.5 | 1000.6 | -2084.4 | 8293.7 | -9969.1 | 13302 | -19785 | 1 | 0 |

**Figure 3.** Meditation Data [23]

| | Time | Fp1 | Fp2 | Fc5 | Fz | Fc6 | T7 | T8 | P7 | P3 | Pz | P4 | P8 | O1 | Oz | O2 | Meditation | Non-Meditation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.000000 | -16640 | 1075.3 | 7197.5 | 1501.7 | -4080.5 | 872.67 | -3852.2 | 1030.8 | -8910.8 | 959.38 | -2181.5 | 8054.1 | -10051.0 | 13269 | -19776 | 0 | 1 |
| 1 | 0.001953 | -16635 | 1079.3 | 7204.3 | 1506.2 | -4079.5 | 877.05 | -3850.3 | 1030.4 | -8908.5 | 960.23 | -2170.2 | 8059.6 | -10066.0 | 13262 | -19779 | 0 | 1 |
| 2 | 0.003906 | -16637 | 1078.2 | 7205.8 | 1505.0 | -4078.3 | 884.08 | -3848.2 | 1034.6 | -8907.6 | 960.58 | -2172.2 | 8063.1 | -10064.0 | 13268 | -19773 | 0 | 1 |
| 3 | 0.005859 | -16640 | 1075.8 | 7200.0 | 1505.7 | -4082.1 | 883.72 | -3846.9 | 1029.3 | -8909.2 | 961.27 | -2172.0 | 8065.8 | -10062.0 | 13270 | -19771 | 0 | 1 |
| 4 | 0.007812 | -16641 | 1077.9 | 7203.8 | 1510.0 | -4076.7 | 880.42 | -3840.8 | 1039.5 | -8897.2 | 970.28 | -2159.3 | 8071.2 | -10049.0 | 13282 | -19760 | 0 | 1 |
| 5 | 0.009766 | -16642 | 1077.4 | 7200.6 | 1511.4 | -4078.4 | 878.31 | -3848.6 | 1032.8 | -8896.2 | 970.89 | -2162.7 | 8070.9 | -10044.0 | 13285 | -19757 | 0 | 1 |
| 6 | 0.011719 | -16638 | 1078.7 | 7194.0 | 1514.7 | -4079.5 | 886.00 | -3852.7 | 1035.1 | -8892.0 | 971.98 | -2159.1 | 8068.5 | -10039.0 | 13287 | -19767 | 0 | 1 |
| 7 | 0.013672 | -16635 | 1078.1 | 7193.7 | 1515.9 | -4078.4 | 885.37 | -3853.2 | 1032.7 | -8899.1 | 966.76 | -2164.5 | 8061.6 | -10053.0 | 13278 | -19771 | 0 | 1 |
| 8 | 0.015625 | -16625 | 1084.6 | 7195.6 | 1521.3 | -4076.4 | 892.99 | -3854.2 | 1035.2 | -8896.9 | 968.76 | -2160.4 | 8063.3 | -10057.0 | 13274 | -19770 | 0 | 1 |
| 9 | 0.017578 | -16621 | 1086.7 | 7195.9 | 1520.0 | -4080.5 | 892.88 | -3852.4 | 1034.0 | -8898.2 | 964.20 | -2165.3 | 8058.5 | -10058.0 | 13274 | -19769 | 0 | 1 |

**Figure 4.** Non-Meditation Data [23]

The word "alpha power" refers to the alpha brain waves that dominate under intensive relaxation and meditation stages. These brain waves are usually associated with 8 to 13 Hz, calm awareness, increased creativity and low stress levels. Apay suggests that we can gain an enlarged consciousness and inner strength by synchronizing our brain wave activity with alpha frequencies [24]. This exercise integrates traditional yoga asana, known as asana, referred to as pranayama, with breathing grass and meditation technique to facilitate the activation of the alpha brain waves. Studies indicate continuously enlarged alpha power in those who practice meditation, especially in frontal and lateral areas of the brain. The concern is expected to decrease while the rest level is expected to increase with this increase. Yoga meditation facilitates the achievement of a "flow" status, causing physical and mental activity harmoniously mixed.

The clear alpha rhythm in this situation indicates that yoga meditation increases cognitive clarity and optimal brain function. This better state of mental clarity not only benefits from emotionally good, but also increases meditation and creativity. When doctors continue to participate in meditation, they can discover that the general quality of life improved, promotes both individual and professional growth.

Alpha -power is seen frequent height in long - term yoga meditation doctors, indicating permanent modifications in brain function. These reforms are associated with general welfare, cognitive function and improvement of emotional regulation. Alpha waves usually appear under peace conditions when you wake up or during sleep with closed eyes. This condition contains moderate alpha activity and is often used as a base line in EEG research [25]. To reduce the cognitive activities required by high commitment, such as problem coordination and focus, alpha power, especially in the frontal cortex. It been proven by using the figure 4 non-meditation subject's data indicates an infection for one of the cognitive loads from the rest of the rest. Yoga meditation has a more obvious increase in alpha power than non-mediated relaxing relaxation. This outlines the effectiveness of systematic attention by promoting contrast deep discount and mental clarity [26]. Long - lasting neuroplastic changes are shown by continuous improvement in the alpha force seen during yoga meditation.

Use spectral analysis techniques such as Fast Fourier Transform (FFT) to detect Alfakraft from EEG data. The alpha frequency range can be collected to determine the power spectral density, including 8-13 Hz, alpha power [27]. Choose appropriate properties for classification. Along with the alpha effect -evaluation properties such as alpha -tea transfers, asymmetry indices and continuous calculations in different brain areas. Make a functional matrix that rows reflect samples (eg EEG recording) and reflect column properties. In addition, for each sample, build a target vector (Y) with binary label indicating attention (1) or non-meditation (0).

Figure 5 clearly shows the function matrix and the target vector Y are installed, continue using machine learning algorithms to classify the attention position. Support vector machines, decision trees or nervous networks can be used to see data and find patterns that clearly show the difference between attention and those who are not.

### 3.3. EEG Data Acquisition

Determine whether the system is compatible with active or passive electrodes based on the study requirements and participant comfort. Procurement of EEG (electroencephalography) data involves registering cerebral electrical activity. The person's skull is cleansed to reduce the resistance.

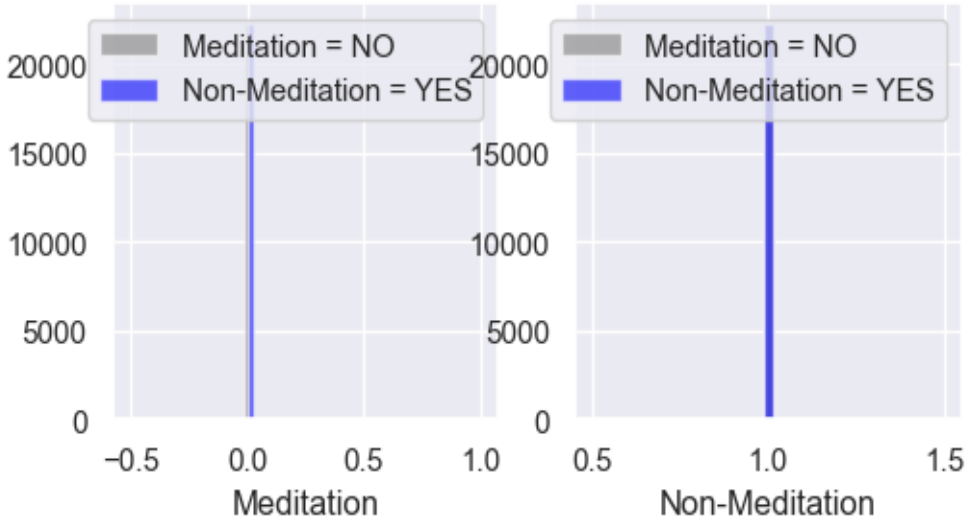


**Figure 5.** Meditation & Non-Meditation State [25]

Then the electrode is strategically located on the skull using international 10-20 systems or other electrode placement techniques. In order to provide sufficient electrical contact between the electrodes and the skull, they are often secured by means of conductive gel. Due to the minimum intensity of electrical impulses generated by the electrode, EEG amplifiers are necessary for their reinforcement [28]. In addition, these amplifiers excluded unwanted characters such as surrounding noise and muscle activity. To catch fast ups and downs of the brain, the reinforced signals are tested at high frequency, often from several hundred to several thousand times per second. This high sampling speed ensures that rapid changes in brain activity are also recorded correctly, which allows detailed analysis of nerve patterns. As a result, scientists and doctors can gain valuable insight into various neurological conditions and cognitive functions. This insight can inform the treatment strategies and increase our understanding of disorders such as epilepsy, depression and anxiety. By analyzing the data collected, scientifically targeted intervention is better equipped to develop and improve patient results.

## 4. Construction

### 4.1 Data Preprocessing

Retrieve EEG information from APAY session participants. Check that principles and adequate experimental design are taken into account. Preprocess the EEG data in order to get rid of baseline drift, artifacts, and noise. Filtering, baseline correction, and artifact removal are standard preprocessing procedures. Identify pertinent characteristics in the pre-processed EEG data. Features in the context of an alpha power analysis could include the following:

- Peak, mean, or median alpha power in a range of frequencies.
- Alpha band spectral power density.
- Alpha power ratios with relation to other frequency bands (beta, theta, etc.).

In order to capture temporal dynamics, take into consideration time-frequency analysis techniques as wavelet transformations. To identify alpha EEG patterns linked to meditative states during APAY, EEG data is studied. This entails cleaning the data to remove artifacts and noise before identifying characteristics associated with alpha power. The EEG Alpha Wave Recording dataset sourced from Kaggle comprises electrode readings aimed at distinguishing between states of meditation (with eyes closed) and non-meditation (with eyes opened) by analysing brainwave activity in resting state. Which is been proven in figure 6 correlation state mapping between meditation and non-meditation subject's data.

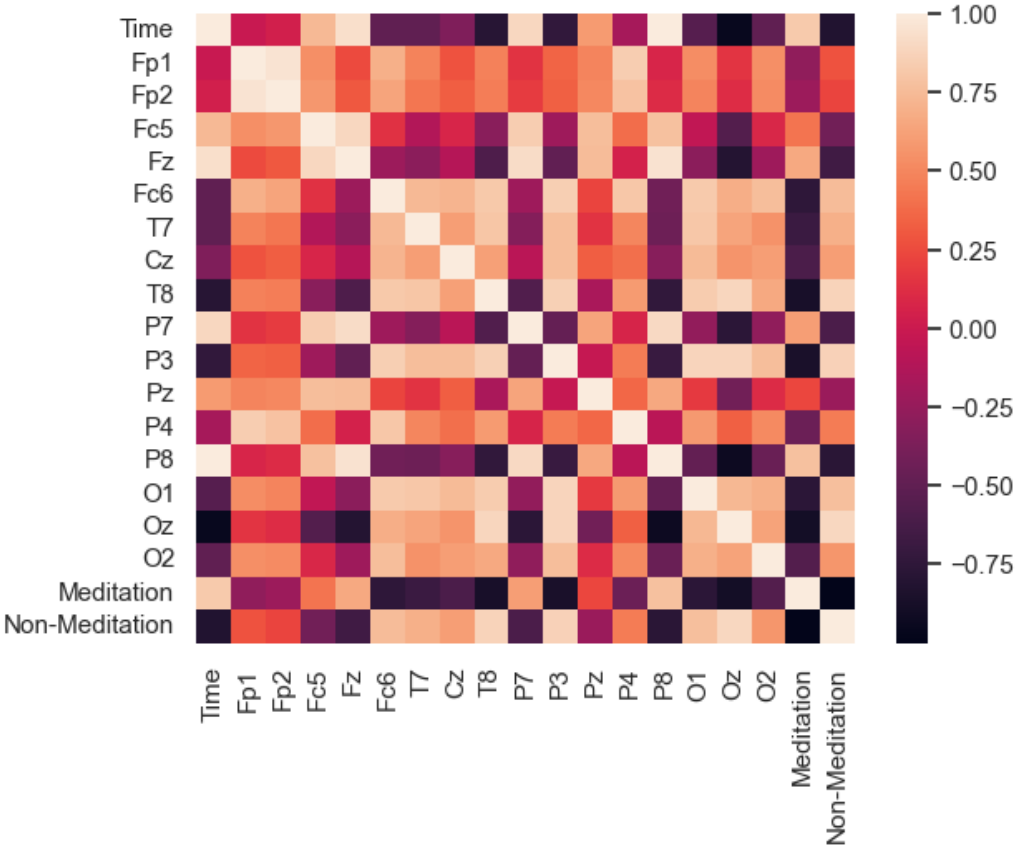


**Figure 6.** Correlation State

| | Time | Fp1 | Fp2 | Fc5 | Fz | Fc6 | T7 | Cz | T8 | P7 | P3 | Pz | P4 | P8 | O1 | Oz | O2 | Meditation | Non-Meditation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.000000 | -16640 | 1075.3 | 7197.5 | 1501.7 | -4080.5 | 872.67 | -7446.6 | -3852.2 | 1030.8 | -8910.8 | 959.38 | -2181.5 | 8054.1 | -10051.0 | 13269 | -19776 | 0 | 1 |
| 1 | 0.001953 | -16635 | 1079.3 | 7204.3 | 1506.2 | -4079.5 | 877.05 | -7445.6 | -3850.3 | 1030.4 | -8908.5 | 960.23 | -2170.2 | 8059.6 | -10066.0 | 13262 | -19779 | 0 | 1 |
| 2 | 0.003906 | -16637 | 1078.2 | 7205.8 | 1505.0 | -4078.3 | 884.08 | -7446.9 | -3848.2 | 1034.6 | -8907.6 | 960.58 | -2172.2 | 8063.1 | -10064.0 | 13268 | -19773 | 0 | 1 |
| 3 | 0.005859 | -16640 | 1075.8 | 7200.0 | 1505.7 | -4082.1 | 883.72 | -7445.1 | -3846.9 | 1029.3 | -8909.2 | 961.27 | -2172.0 | 8065.8 | -10062.0 | 13270 | -19771 | 0 | 1 |
| 4 | 0.007812 | -16641 | 1077.9 | 7203.8 | 1510.0 | -4076.7 | 880.42 | -7439.3 | -3840.8 | 1039.5 | -8897.2 | 970.28 | -2159.3 | 8071.2 | -10049.0 | 13282 | -19760 | 0 | 1 |

**Figure 7.** Dataset Description [29]

## 4.2 EEG Electrodes

During the APAY sessions, the electrical indications are generated by the brain recorded by the EEG electrode, which is properly placed on the skull. Because each electrode position corresponds to its own brain area, researchers and doctors can track and check the activity of different brain wave frequencies [30]. Gaining knowledge of how these brainwaves work in Apay can help to understand a better neurophysiological process that reduce the techniques and how they affect the mind-body connection. Figure 7 clearly describes the dataset which acquired for EEG registration, electrode placements are represented by FP1, FP2, FC5, FZ, FC6, T7, CZ, T8, P7, P3, PZ, P4, P8, O1, O1, O1, Oz and O2 letters, indicating the activity of each some short areas. These areas include frontal, central, parietal and parts of Occipital -Lobe, each of which has a different function in the treatment of emotions, ideas and senses. Knowing the functions of these brain areas makes it easy how the monkey methods can affect the brain waving activity and support the development of alpha power.

### *4.2.1 Frontal Electrodes*

Exercise features, attention and emotional control are associated with frontal electrodes (FP1, FP2). Increased alpha activity in these places may indicate a state of calm awareness, so that doctors can focus attention by maintaining mental clarity [31]. Two Develop This State and Improve Self-Awareness and Emotional Balance, Apay Physicians Can Use Methods Like Visualization, Mindful Breeding and Positive Confirmation.

### *4.2.2 Central Electrodes*

The sensor engine cortex, which is important in motor control and body awareness, is covered by the central electrode (CZ). An arbitrary relationship between breathing, movement and emotions is encouraged by exercises and attitudes performed throughout the monkey. By combining mental and physical awareness [32], it can improve alpha-wave synchronization in capitals and can promote a body-centric sense of appearance and stability.

### *4.2.3 Parietal Electrodes*

The functions of sensory processing, spatial awareness and attentive focus are associated with the parietal electrode (P7, P3, PZ, P4, P8). Yogic strategies that activate the lateral regions-like balance and spread-based attitude can help doctors maintain focus and attention [33]. The elevated alpha force in these places may indicate an increased level of sensory awareness and mental absorption, which promotes more intensive engagement at the present moment.

### *4.2.4 Occipital Electrodes*

The treatment and perception of images is mediated by the Occipital electrode (O1, Oz and O2). In Apay, internal vision and mental images develop using techniques such as imaging and visualization. Activating alpha swings in OCCPIL areas can help doctors reach the transformative power of the mind body by improving their ability to see and imagine.

### *4.2.5 Feature Extraction*

Relaxed meditative conditions are linked to alpha brainwaves (8–13 Hz). The brain's electrical activity is measured by the electroencephalogram, or EEG. During APAY sessions, participants' brainwave activity is recorded using EEG electrodes applied to their scalps. After that, the participants perform APAY while the EEG data is being captured. The EEG data is processed to identify features like amplitude, frequency, and coherence that are associated with alpha power [34].

The selection and extraction of features can be done using machine learning algorithms or statistical methods. Alpha EEG data patterns are seen in the data that match meditative states during APAY. This might entail comparing baseline data or EEG data collected at various points throughout the APAY session. Determine whether the characteristics of the EEG data are pertinent to alpha wave activity in both the meditative and non-meditative stages. Measures including alpha power, alpha peak frequency, and alpha asymmetry may fall within this category.

### *4.2.6 Data Validation*

The addiction and accuracy of the Alfa EEG pattern indicated by detecting noticeable conditions during APAY is established by verification. This may include re-studies the results with a large sample size or results of other methods with cross reference. Many procedures include many processes to validate data to ensure accuracy and addiction when using EEG alpha waves to distinguish between meditation and non-meditation states [35].

These participants may need to assign non-meditation tasks under others in fixed time and meditation methods (such as mindfulness meditation). This matrix provides insight into the model's ability to distinguish between meditation and non-meditation conditions. Install the correct verification measures to evaluate the efficiency of the classification model. The fields are the properties of the general matrix during the F1 score, accuracy, sensitivity, specificity, accuracy, recall and receiver that operates characteristic curve (AUC-Roc).

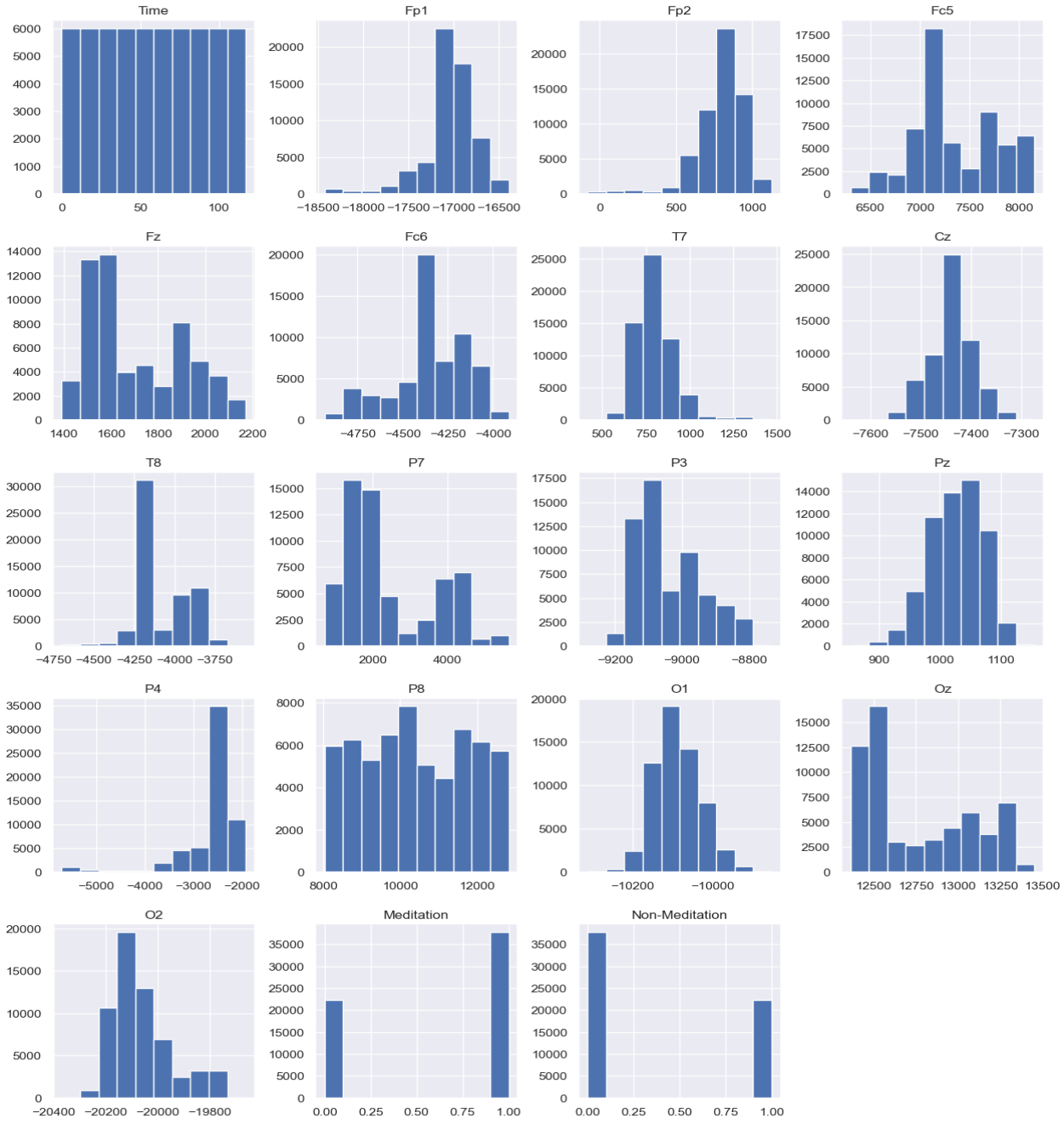


**Figure 8.** EEG Electrodes Analysis

Choose an effective classification algorithm, such as nerve networks, logistic regression, random forest or supporting Vektads (SVM). Install hyper parts and model parameters (eg the number of trees in a random forest, as the core of a SVM). Divide the dataset, use a holdout or cross-validation method in training and test sets. Using Training Data (X_TRAIN, Y_TRAIN), Train Machine Learning Models.

## 5. Result Analysis

Figure 8 represents the various experimental layouts is to check the properties and dynamics of the alpha brain waves the process of experimentally examining the Alfa EEG pattern. Install experimental parameters including activities and remedies (eg attention, cognitive function, sensory stimulation) that can affect the alpha activity [36]. To reduce variability, make sure electrode installation and data recording follow standard operating protocols. Preprocess the EEG data to get rid of noise and artifacts. Filtering (e.g., bandpass filtering to extract alpha frequencies), artifact rejection, and baseline correction are common preprocessing techniques. Acquire individual EEG data while adhering to the appropriate procedures and tools. While performing experimental activities and during baseline and resting periods, record EEG signals. Check that data recording and electrode installation meet normal operating practices. Extrapolate pertinent characteristics pertaining to alpha activity from the pre-processed EEG data.

Alpha power, peak frequency, asymmetry, and coherence are typical characteristics. Ensure that the features are appropriate to feed into algorithms for machine learning. Support vector machines (SVM), Naïve bayes, logistic regression, k-nearest neighbours, decision tree, random forests, convolutional neural networks (CNN) are the algorithms used for comparative analysis to predict whether the user is in meditation or non-meditation state which is been shown in figure 9. Using a subset of the dataset, train each machine learning algorithm on the characteristics that were retrieved. Optimize hyperparameters with methods like random or grid search. Utilizing a different test dataset, assess the performance of the trained models. Analyse performance measures such as the as the F1-score, area under the receiver operating characteristic curve (AUC-ROC), recall, sensitivity, specificity, accuracy, and precision. Based on the assessment measures, compare how well various machine learning algorithms perform [37]. Determine the optimal algorithms for the specific task of differentiating between alpha EEG rhythms in various experimental setups. If variations in performance are statistically significant, ascertain this using the relevant statistical tests.

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 17, 1)]           0

 conv1d_5 (Conv1D)           (None, 16, 16)            48

 max_pooling1d_5 (MaxPoolin  (None, 16, 16)            0
 g1D)

 conv1d_6 (Conv1D)           (None, 15, 32)            1056

 max_pooling1d_6 (MaxPoolin  (None, 15, 32)            0
 g1D)

 conv1d_7 (Conv1D)           (None, 14, 16)            1040

 max_pooling1d_7 (MaxPoolin  (None, 14, 16)            0
 g1D)

 flatten_2 (Flatten)         (None, 224)               0

 dense_3 (Dense)             (None, 1)                 225

=================================================================
Total params: 2369 (9.25 KB)
Trainable params: 2369 (9.25 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

**Figure 9.** CNN Model Architecture

**Table 1.** Comparative Analysis

| Algorithm | Classification | precision | recall | f1-score | support |
|---|---|---|---|---|---|
| **SVM** | 0 | 1 | 0.94 | 0.97 | 13669 |
| | 1 | 0.91 | 1 | 0.95 | 8231 |
| | accuracy | | | 0.96 | 21900 |
| | macro avg | 0.95 | 0.97 | 0.96 | 21900 |
| | weighted avg | 0.96 | 0.96 | 0.96 | 21900 |
| **Logistic Regression** | 0 | 0.99 | 0.97 | 0.98 | 13669 |
| | 1 | 0.96 | 0.99 | 0.97 | 8231 |
| | accuracy | | | 0.98 | 21900 |
| | macro avg | 0.98 | 0.98 | 0.98 | 21900 |
| | weighted avg | 0.98 | 0.98 | 0.98 | 21900 |
| **Naïve Bayes** | 0 | 1 | 1 | 1 | 13669 |
| | 1 | 1 | 1 | 1 | 8231 |
| | accuracy | | | 1 | 21900 |
| | macro avg | 1 | 1 | 1 | 21900 |
| | weighted avg | 1 | 1 | 1 | 21900 |
| **Random forest** | 0 | 1 | 1 | 1 | 13669 |
| | 1 | 1 | 1 | 1 | 8231 |
| | accuracy | | | 1 | 21900 |
| | macro avg | 1 | 1 | 1 | 21900 |
| | weighted avg | 1 | 1 | 1 | 21900 |
| **KNN** | 0 | 1 | 0.99 | 0.99 | 13669 |
| | 1 | 0.98 | 0.99 | 0.99 | 8231 |
| | accuracy | | | 0.99 | 21900 |
| | macro avg | 0.99 | 0.99 | 0.99 | 21900 |
| | weighted avg | 0.99 | 0.99 | 0.99 | 21900 |
| **Decision Tree** | 0 | 1 | 1 | 1 | 13669 |
| | 1 | 1 | 1 | 1 | 8231 |
| | accuracy | | | 1 | 21900 |
| | macro avg | 1 | 1 | 1 | 21900 |
| | weighted avg | 1 | 1 | 1 | 21900 |
| **CNN** | 0 | 0.98 | 0.99 | 0.99 | 13669 |
| | 1 | 0.99 | 0.99 | 0.99 | 8231 |
| | accuracy | | | 0.99 | 21900 |
| | macro avg | 0.99 | 0.99 | 0.99 | 21900 |
| | weighted avg | 0.99 | 0.99 | 0.99 | 21900 |

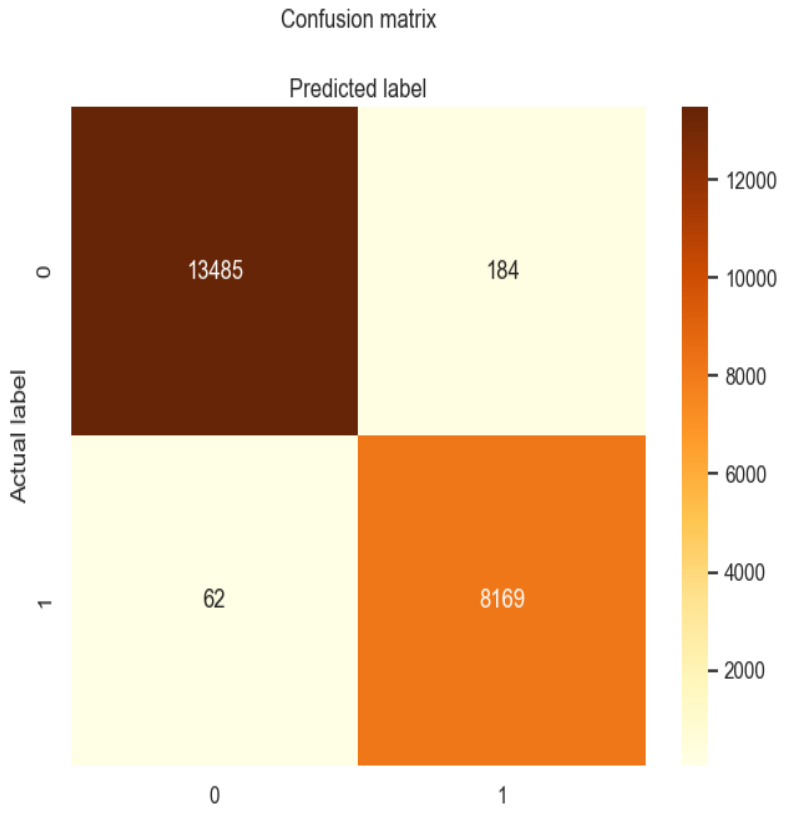


**Figure 10.** Overall Confusion Matrix

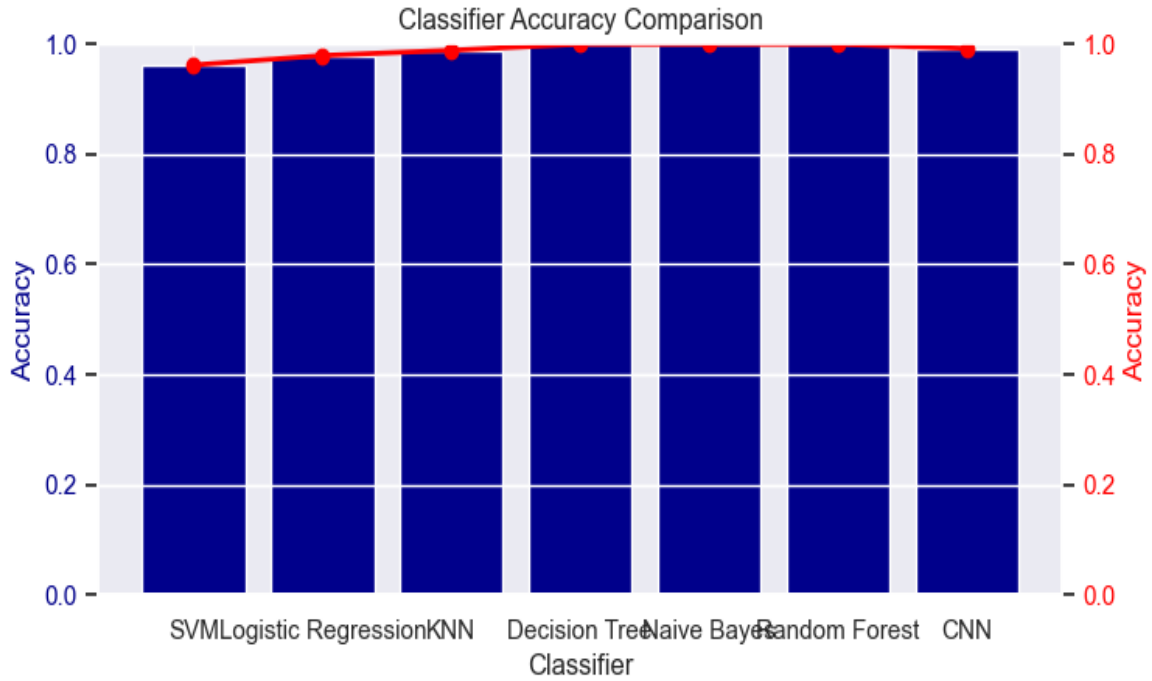


**Figure 11.** Comparative Analysis

Although this analysis demonstrates that Decision Tree, Naïve Bayes, and Random Forest are the most effective algorithms, it is important to recognize that other algorithms, like Support Vector Machine (SVM), Logistic Regression, K-Nearest Neighbors (KNN), and even Convolutional Neural Network (CNN), also engage in adversaries which was displayed in figure 10 mapping.

Several methods have been evaluated for accuracy when assessing EEG data to determine meditative vs. non-meditative states. The algorithms Decision Tree, Naïve Bayes, and Random Forests

distinguished themselves for their outstanding results in classification, almost reaching ideal accuracy. These algorithms demonstrated their dependability by effectively and consistently differentiating between the two states. In addition, K-Nearest Neighbors, Support Vector Machines, and Logistic Regression all performed effectively, predicting meditative states with a high degree of accuracy. By utilizing unique mathematical techniques, these algorithms proved to be adaptable and appropriate for EEG-based evaluations. Although CNN performed as well as traditional approaches, its use emphasizes improvements in neural network structures for handling complex EEG data [38]. CNN's projection in explaining noticeable conditions with EEG recording is shown by the ability to identify complex patterns in brain wave activity. Each algorithm has some advantages and disadvantages, with the ability to meet a wide range of applications and data. The classification report indicates extraordinary accuracy for all algorithms, scoring around the algorithms or around 1.0. This indicates that their forecasts were accurate. Bole Bayes, Random Forest and Decision Tree Classifier Resistance in the distinction between classes without spontaneous abortion, seen by their 100% accuracy.

## 6. Discussion

The results of this study provide significant insights based on the brain of alpha power activation yoga (APAY) and provide the ability to facilitate noticeable conditions. The study has found unique Alfa EEG patterns associated with different stages of exercise using sophisticated EEG analysis methods including time for time analysis and machine learning [39]. These patterns make it clear how meditation works in the brain and stress and how useful EEG is, a way of measuring how good attention works and how it can help mental health. The discovery of alpha power in the frontal and lateral regions during the stages of intensive attention is in line with research and how to control it. Hiking and increased concentration are often associated with increased alpha activity in these areas, suggesting that monkeys effectively promote intensive relaxation and high state of consciousness. Under continuous attention, there is more alpha stability in the frontal and fast regions [40].

This shows that the brain more processes information and that you are more aware of your surroundings. This discovery confirms the idea that APAY cultivates a peaceful balance between the welcoming concentration and the sensory belief, the characteristic of high meditation experiences. As practitioners delve deeper into their meditative states, they may find that this balance not only enhances their mental clarity but also fosters a profound sense of connection to their surroundings, allowing for a richer and more fulfilling experience of the present moment. The decision to classify EEG data reflects a remarkably functioning progression in the use of machine learning methods, including trees, naive bays, and random forests [41]. These algorithms demonstrated exceptional accuracy in distinguishing between reflective and non-meditation states, highlighting their effectiveness in explaining complex brain data. Using time ethics analysis made it easier to extract and group EEG functions, which led to a better understanding of how brain activity changes over time during epiphany practice. This method improves the accuracy of EEG-based evaluation and facilitates a personal difference in meditation skills [42].

Reliable EEG for reflective conditions is important for mental health and welfare in the development of biomarkers. These biomarkers provide an objective assessment of attention efficiency, enabling the evaluation of mental health benefits at Apay and other meditation techniques. It is particularly relevant in contemporary society, which is characterized by general welfare for mental health and increased attention to empirically supported methods. The ability to evaluate individual differences in meditation skills presents the ability to focus training programs, which can increase the mental health benefits of Apay for different people. By tailoring these programs to suit individual needs, practitioners can maximize the effectiveness of meditation practices, Under reflective conditions, reliably EEG is important in promoting mental health and promoting welfare in the development of biomarkers. These biomarkers provide an objective measure of vigilance, and provide facilities to assess the benefits of mental health associated with APAI and other attention techniques. It is particularly relevant in modern culture, which focuses on welfare for mental health and is emphasized scientifically valid views.

Meditation enables adaptation of training programs to assess individual variations in skills, so the mental health benefits of APAY for different individuals increase. By adapting these programs to meet personal needs, doctors can increase the effect of meditation practices, resulting in more sufficient progress in general welfare. This sewn approach not only improves the experience, but also provides a more intensive understanding of the relationship between mindfulness and mental welfare. In addition, it motivates doctors to join and are dedicated to their attention practices, as they can see specific results that match their conditions. This versatility can transform attention into an effective remedy for personal development and treatment in a universal practice. While the conclusions of this study are promising, many boundaries must be accepted as been proven in figure 11 analysis proof. These include the size of small samples and self -reported nature of data, which can introduce prejudice. Leading to more significant improvements in overall well-being. This personalized approach not only enhances the experience but also fosters a deeper understanding of

the relationship between mindfulness and mental health [43].

Moreover, it encourages practitioners to remain engaged and committed to their meditation journeys, as they can see tangible results that resonate with their unique circumstances. Ultimately, this adaptability can transform meditation from a universal practice into a potent tool for personal growth and healing. Although the results of this research are encouraging, some limitations should be recognized. The sample size of the EEG alpha wave recording data set, although it is enough for initial research, cannot represent the variation of individual responses to monkeys. Subsequent research should confirm these findings in larger and more strange groups to find out their generality. The long-term results of APAY practice in psychological and cerebral function have not yet been investigated. Over time, longitudinal studies are necessary to examine the effect of brain plasticity, cognitive function, and long-term training on mental health results [44].

These studies could provide valuable insights into how sustained engagement in APAY practice influences not only individual well-being but also the underlying neurological mechanisms at play. By examining these aspects, researchers may reveal significant correlations that might provide more effective treatments for improving mental health via customized cognitive training programs [45]. By examining these aspects, researchers can reveal important correlations that can provide more effective treatment to improve mental health through customized cognitive training programs.

## 7. Conclusion

The domain of alternative and supplementary agents increases the understanding of complex relationships between mind, body and treatment through EEG data examination. The study so many different ways to see EEG data and find useful information. These include teaching functional extraction techniques and algorithms. This progress not only helps to refine medical approaches, but also paves the way for innovative interventions to suit individual needs. Since researchers are deep in this field, mental health care is likely to reduce the conclusions rapidly. With each new discovery, the integration of technology and neurologically becomes clear and promotes collaboration in subjects. This synergy not only improves our understanding of brain function, but also paves the way of personal treatment strategies that can much better the patient's results. This progress not only helps to refine medical approaches, but also paves the way for innovative interventions to suit personal needs. Since researchers stay deep in this field, mental health care quickly becomes the chances of reducing findings. With each new discovery, the integration of technology and neurologically becomes clearer, and promotes collaboration in subjects. This synergy not only improves our understanding of brain function, but also paves the way for personal treatment strategies that can significantly improve the results of the patient. The treatment reaction by analysing subsequent therapy EEG registration mainly in brain dynamics and to find the biomarker for the treatment reaction. Through the intensive evaluation of the execution of the classification, our goal is to create a prediction model that can distinguish between medical respondents and non-efforts, which can enable analogue treatment strategies. Our proposed approach will be strengthened for its purpose, relapse and addiction in different types of public medicine methods. We expect to maximize medical treatment and use EEG technology ability to increase health results for people seeking different routes for improvement and welfare through collaboration between researchers, doctors and doctors. There is a lot of opportunity to improve our knowledge of mind-body and efficiency of general medical approaches through the control and analysis of EEG signals in alternative and complementary means. As knowledge increases, it can encourage active mental health and strength individuals to take responsibility for their emotional welfare through informed practice and self - care. This active strategy can benefit from mindfulness meditation, ironing and regular exercise. Better knowledge of thought buttons can increase the result and make society healthy.

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## Authors Contribution Statement

R. Kishore Kanna –Conceptualization, data collection, data anlysis, writing original manuscript, Pravin R. Kshirsagar -Writing –review & editing. R. Thiagarajan - Writing –review & editing, Tan Kuan Tak - Writing – review & editing. Sivaneasan - Writing –review & editing. All the author's read and approved the final version of the manuscript.

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## Competing Interests

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

## Data Availability

The data supporting the findings of this study can be obtained from the corresponding author upon reasonable request.

## Has this article screened for similarity?

Yes

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