A Cognitive Task based EEG analysis of Meditation using ENOBIO-8 BCI Device

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***Abstract*—Meditation has become a "tool" to overcome the stress related to mechanical life style of human beings or the health hazard created by Covid-19 pandemic. In our work, we are analyzing the EEG(Electroencephalogram) data of a person who attempts mindful meditation without pranayama and with pranayama. We have extracted EEG data using a BCI (Brain Computer interface) device called Enibio-8, an 8 channel device. Later time series analysis such as RMS(Root Mean Square) value, Kurtosis and Hjorth parameter are extracted for differenent cognitive task to measure the meditation.**

Keywords—EEG,BCI,ENOBIO-8,Stress,Meditation;

I. INTRODUCTION

Meditation which is an ancient practice for maintaining mental harmony, which is now become part of life for all the individuals. It may be due to stressful work or due to recent covid-19 pandemics. Different meditation[2] is practiced across the world which itself is the proof of concept where meditation[3] acts as "tool" which strengthens the mental health [4] and their by benefits human society. Different cognitive activities during meditation changes the brainwaves or mindwaves called EEG [5].A statistical measure and analysis of this acquired EEG data using BCI [6] will provide us effectiveness of mediation.

II. EEG DATA AQUSITION

A. Human Brain And its EEG data

The human brain consists of millions of neurons which generates minute electrical signals for each cognitive task as shown in below Figure 1.

Collective measurement of these electrical signals can be done using electrodes. Function of each brain parts is well defined and it's available in numerous resources.

Fig 1: Overview of Brain

[Courtesy https://nncionline.org/course/basic-neuroscience-3-d-brain/]

These brain waves has different frequency ranges like Delta (0.5–4 Hz), Theta(4–8 Hz, Alpha (8–12 Hz) Beta (12–35 Hz) and Gamma (Above 35Hz).The frequency domain features are used to remove artifacts like external electrical signal noise of 50Hz.

B. EEG data collection

In our work, human subjects perform different cognitive tasks related to meditation and for each task EEG data is collected using BCI device called Enobio-8 device.Enobio-8 is an 8-channel device which is very flexible to wear and used for research related activities. Following figure 2 shows the Enobio-8 device used for collecting the EEG data on the scalp non-invasively [1] and transferring to the computer for further analysis.

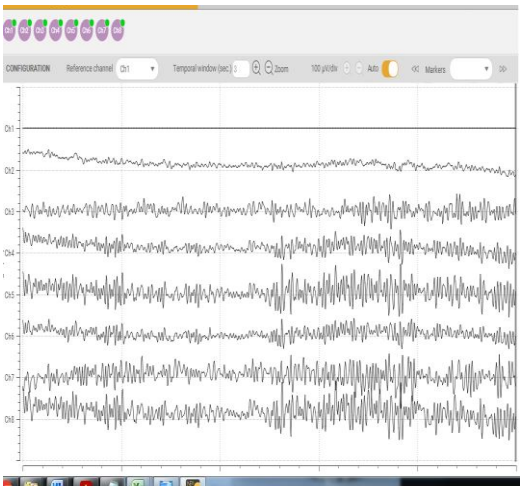

Fig 2: Enobio-8 BCI device from NeuroElectrics

III. METHODOLOGY

Before acquiring the EEG data from subjects a training on meditation is required for the subjects to get better data. After acquiring the EEG data it will be preprocessed and features are extracted for the analysis purpose.

A. Mind-Body Awarness training-MBAT

In our work, those who are not aware of meditation, a session has been arranged to demonstrate meditation and pranayama. The process of data acquisition using BCI device has been explained. For the subjects such as meditators or non-meditator's following 2 cognitive tasks has been given for collecting the data.

(1)Performing meditation for 10 minutes.

(2)Performing Pranayama for 10 minutes and followed by meditation for 10 minutes.

B. *NIC- Software tool*

NeuroElectric Interface Controller (NIC) is the tool used for collecting data from the scalp noninvasively and interfacing with computer. Below figure 3 shows the sample display of EEG data acquired for analysis.

Fig 3: EEG data acquired for analysis

Electrodes are placed at 8 locations on the scalp for measuring EEG data. The locations of electrode is provided in the below table 1 and corresponding Electrode setup is shown in figure 4.

TABLE 1 : ELECTRODE POSITION

Channel Number	Electrode Location
Channel 1	T7
Channel 2	C3
Channel 3	F3
Channel 4	Fz
Channel 5	Cz
Channel 6	F4
Channel 7	C4
Channel 8	T8

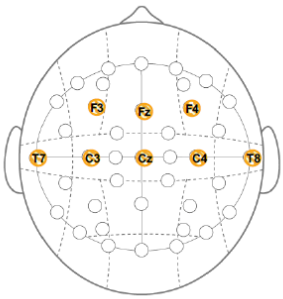

Fig 4: Electrode setup

C. *Data aqusition protocol*

In the NIC software tool, protocol has been setup which is used for acquiring the data in a timely well defined manner. In our work, following protocols are performed.

Protocol-1: EEG acquisition is done for 3 minutes before mediation and also acquisition is done for 3 minutes after subject performing mediation.

Protocol-2: EEG acquisition is done for 3 minutes before mediation & pranayama and also acquisition is done for 3 minutes after subject performing mediation and pranayama.

The following figure 5 depicts the protocol used in NIC tool.

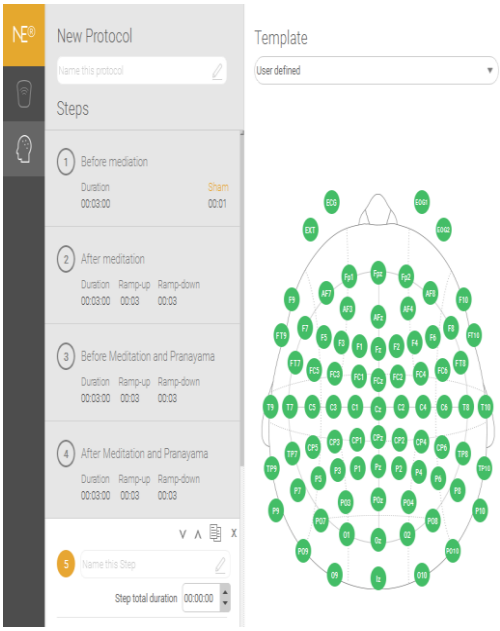

Fig 5: Protocol for EEG data acquisition

D. *Preprocessing of raw EEG data*

The acquired raw EEG data needs to be free from artifacts and hence preprocessing is done using MATLAB. The EEG data received is in the .easy file format as shown in below figure 6.

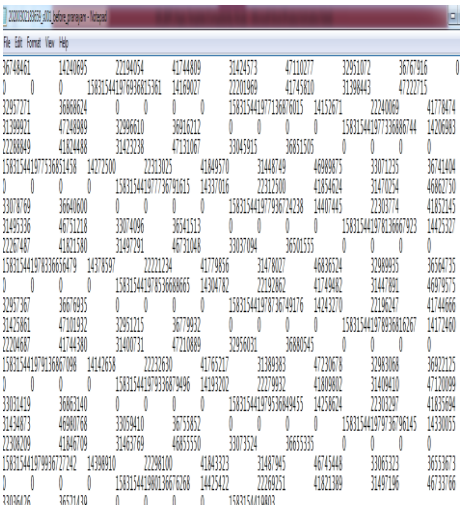

Fig 6: Raw EEG data in .easy file

This data has been filtered with 50Hz notch filter to remove electrical interference, detrend and any other unwanted signal using MATLAB R2019a tool. EEG data has been then used to extract different five brain wave frequency bands such as alpha,beta,gamma,delta and theta waves using DB4 wavelet extractor.

E. *Feature Extraction from preprocessed data*

The EEG data which is free from artifacts can be used to extract time domain and frequency domain features. In our work rms values, kurtosis and Hjorth parameters(Complexity and Mobility) for all the 5 bands are extracted for the analysis of meditation effect before and after with and without pranayama.

IV. RESULTS AND DISCUSSION

Below figure 7 shows the FFT spectral response analysis of channel 1- T7 location data.

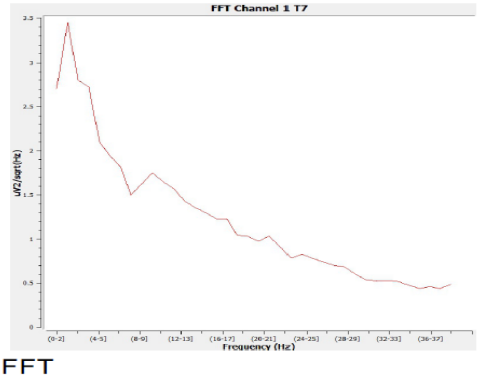

Fig 7: FFT Spectral response analysis of channel 1-T7

Below figure 8 shows the PSD spectral response analysis of channel 1- T7 location data.

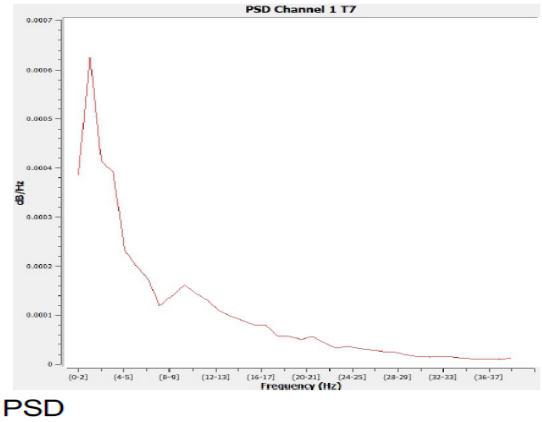

Figure 8: PSD Spectral response analysis of channel 1-T7

Similarly for channel 2 to channel 8 as been shown in below figure 9.

Below figure 10 shows the band power analysis of brain waves in all 5 different bands.

Below Table 2 depicts the rms values of channel 1 before mediation, after meditation ,before meditation and Pranayama and after meditation and Pranayama.

Below Table 3 depicts the kurtosis values of channel 1 before mediation, after meditation ,before meditation and Pranayama and after meditation and Pranayama.

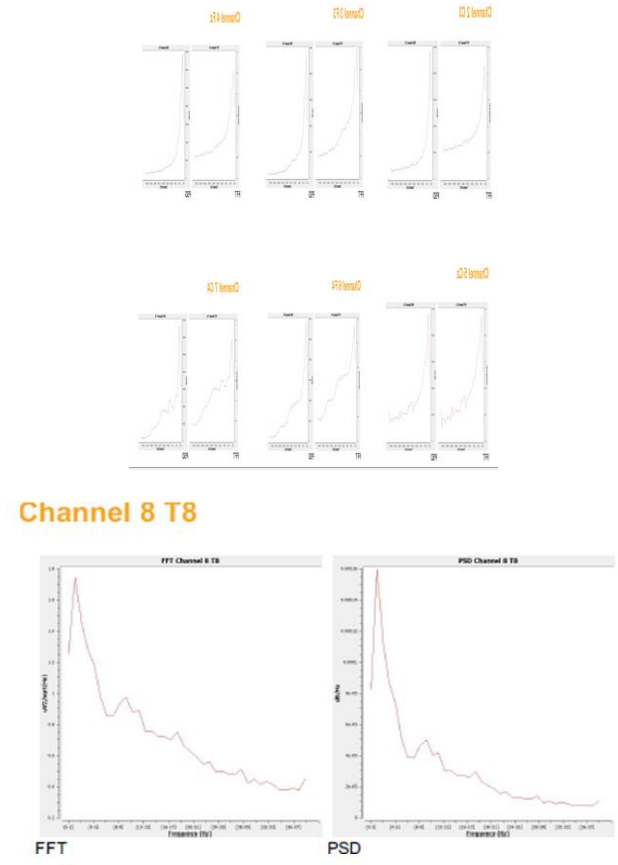

Fig 9: FFT and PSD Spectral response analysis of channel 2 to channel 8

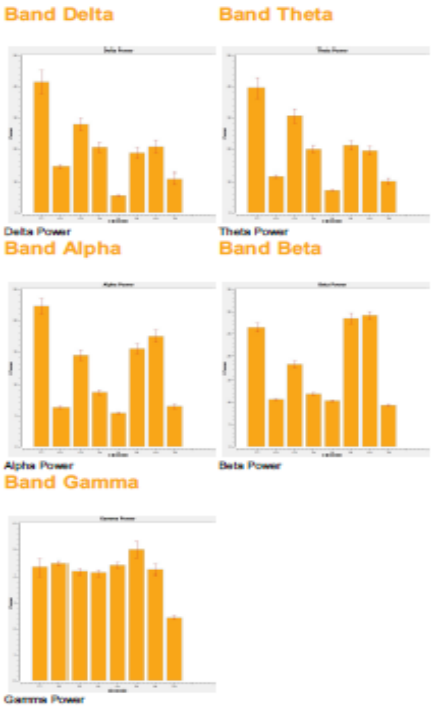

Fig 10: Band power analysis of EEG data

TABLE.2: RMS VALUES OF CHANNEL 1

COGNITIVE TASK	DELTA	THETA	ALPHA	BETA	GAMMA
BEFORE MED	7912.848	2523.662	1198.673	264.5378	60.66419
AFTER MED	5075.112	2215.35	1029.993	205.1497	22.79285
BEFORE MED AND PRANAYAMA	3734.529	1432.774	698.3876	150.914	17.70018
AFTTER MED AND PRANAYAMA	2584.912	1215.92	684.676	126.476	16.04044

TABLE.3: KURTOSIS VALUES OF CHANNEL 1

COGNITIVE TASK	DELTA	THETA	ALPHA	BETA	GAMMA
BEFORE MED	3.940963	5.689389	5.418424	4.405094	5574.863
AFTER MED	8.842547	5.090438	4.827963	3.144727	4.908049
BEFORE MED AND PRANAYAMA	28.66945	10.33846	4.479437	3.553357	7.70838
AFTTER MED AND PRANAYAMA	9.436149	5.235464	9.625249	5.956668	544.1134

Below Table 4 depicts the Complexity and Mobility Hjorth parameters of channel 1 before mediation, after meditation, before meditation and Pranayama and after meditation and Pranayama.

TABLE.4: COMPLEXITY AND MOBILITY HJORTH PARAMETERS OF CHANNEL 1

COGNITIVE TASK	COMPLEXITY	MOBILITY
BEFORE MED	0.595924853	0.1367924
AFTER MED	0.543539195	0.1719062
BEFORE MED AND PRANAYAMA	0.555288305	0.161218
AFTTER MED AND PRANAYAMA	0.568007341	0.1915289

By the above analysis we can effectively analyze that time domain and frequency domain parameters are different for different cognitive tasks of mediation

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