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Percussion instruments in music therapy to combat mental health issues: A case study in Pune, India

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ABSTRACT
Mental health problems for billions of Indian people are of utmost importance since it is a human intensive world's fifth largest economy. In this paper we report music therapy treatment for different mental health issues using low frequency percussion instruments. Further we confirm the outcome with electroencephalography (EEG) measurements. EEG provides insights into changes in the Delta, Theta, Alpha and Beta wave patterns which are related with relaxation, focus and emotional regulations occurring due to neuronal oscillations. We conducted multiple experiments to understand the impact of rhythmic patterns on using the 10-20 electrode system with Bipolar Longitudinal montage with corresponding electrode placement configuration. The data acquisition machine RMS-MAXIMA was used for recording of EEGs on subjects. Our diagnostic analysis using relative power of different frequency band, Fast Fourier Transform (FFT), and power spectrum density show an increase in Theta (4−8 Hz) and Alpha (8−12 Hz) frequency bands as well as synchronisation between different regions of the brain also seen as enhancement of Beta (12 −30 Hz) waves alongside with a decrease in Delta waves(0.5-4Hz). We conclude that percussion instruments have a holistic effect on brain activity, and these should be used in music therapy treatments for different mental issues like depression, anxiety etc.
Keywords **-** Electroencephalography (EEG), Indian population, Mental health, Music therapy, Percussion instruments.

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I. Introduction

In recent years, there has been a significant rise in the prevalence of mental health disorders worldwide, including anxiety, depression, stress related disorders, Attention Deficit Hyperactive Disorder (ADHD) and other emotional imbalances. These conditions have impacted individuals across diverse age groups, socio-economic strata and different cultural backgrounds. These disorders not only influence the individual's psychological well-being, but it also affects in some way or the other on their physical health, relationships and also the overall quality of life [1]. These pose a great challenge to the global health systems and existing medical infrastructure. According to the World Health Organisation (WHO) around one billion people suffer from mental disorders every year [2]. The lockdown in Covid-19 pandemic exaggerated the emotional imbalances crisis leading to 53 million additional cases of depression and 76 million of anxiety and stress [3]. A recent study indicates that currently 50% of the global population is suffering from mental disorders [4]. In India ~15 % of the population is suffering from mental health issues including anxiety disorders, depression, bipolar disorder, schizophrenia, substance use disorders, and neurodevelopmental disorders [5][6]. The mental disorders in India have increased from 2·5% in 1990 to 4·7% in 2017[7]. These increasing mental health issues at an alarming rate cause suicide cases in this country [8]. This rising incidence emphasises the urgent need for improved mental health care access and intervention strategies for India.

To deal with these challenges traditional therapeutic approaches such as meditation and psychotherapy have proven effective to varying degrees, but there is a growing need for innovative techniques that are non-invasive, accessible and holistic as well as which are in the reach of common man. Recently, Music therapy has been identified as one of the non-invasive techniques to deal with such ailments [9][10]. Recent studies show clinical intervention that uses music to promote emotional and physical well- being, the use of percussion instruments has emerged as a promising intervention in addressing these mental health disorders [11]. The repetitive and structured nature of drumming or other percussion instruments offer unique advantages by engaging individuals in rhythmic activities that can improve mood, reduce stress, enhance cognitive skills and promote greater integration and

communication between the different brain networks [12]. By playing the percussion instruments with auditory stimulation one can activate neural pathways associated with relaxation and cognitive function [13].

Recent advancements in neuroscience have enabled the validation of music therapeutic interventions using Electroencephalography (EEG). By comparing brainwave activity with and without percussion instrument music, one can measure the effects of percussion instruments on mental health [11]. EEG provides insights into changes in the Delta, Theta, Alpha and Beta wave patterns which are often related with relaxation, creativity, focus and emotional regulations etc. [14]. Further, EEG analysis in music therapy gives us the opportunity for personalised treatments. By adjusting percussion-based exercises to an individual's specific brain wave patterns and mental health needs, therapists can design interventions which can maximize therapeutic outcomes. In this paper, we aim to investigate the potential of percussion-based music therapy as a therapeutic tool for mental health improvement in people in Pune, India. The study also aims to bridge the gap between classical and traditional therapeutic innovative techniques by using musical therapy [15] and evidence-based personalised treatments to help those suffering from mental health issues in this ever evolving and competitive world. The paper outlined as section 2 deliberates on experimental method, results are discussed in section 3 that shows how the different waveforms change after music and conclusions are made in section 4.

II. Methodology

In this study we collected different samples from 50 normal subjects in the age group of 20-30 years from different departments in Savitribai Phule Pune University in Maharashtra, India. This study was carried out after taking consent from the subjects and after obtaining approval from the department ethical committee. Electroencephalograms (EEG's) of these subjects were taken. After that the subjects were subjected to low frequency percussion instrument's music. Both these recordings were taken when the subject was in a relaxed state with eyes closed. Before recording the EEG of the subject, we cleaned the scalp and ensured proper contact with the electrodes and minimised the impedance. For recording and analysis of EEG signals, we have used the RMS MAXIMA 32 instrument. For the recordings we have used the scalp electrodes which have disc-like shapes made up of stainless-steel rods composed of silver chloride wires. These electrodes are connected to different regions of the brain using the 10-20 electrode system. The placement of electrodes is shown in Fig. 1 [16].

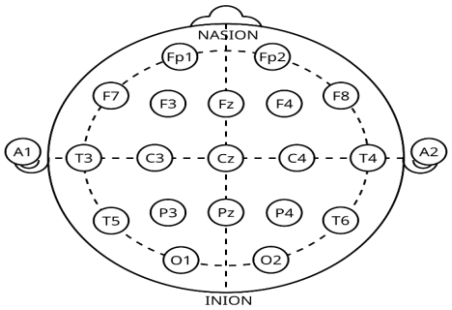


Figure 1: A schematic displaying the 10-20 electrode system. Here, F stands for frontal lobe, P for parietal lobe, T for temporal lobe, O for occipital lobe and C for central lobe. Odd numbers indicate electrode positions in the left hemisphere of the brain while even numbers show electrode position in right hemisphere of the brain while z indicates electrode placed on the midline of the brain.

For our study we have connected the electrodes to the following positions Fp_1, Fp_2 , Fp_z , C_z , O_z , F_7 , F_8, T_3, T_5 , T_4 and T_6 to record EEG in the Bipolar Longitudinal montage . In Bipolar Longitudinal montage a specific arrangement of electrode pairings is made where adjacent electrodes are connected from the front of the head to the back creating a chain like pattern along the midline of the scalp. When low frequency percussion instrument music is subjected changes in the EEG occur at the electrode positions in the Bipolar Longitudinal montage. Hence we are studying these positions to see the changes that occur in different frequency band regions of an EEG recording. After the placement of electrodes, the following filter values are adjusted to the desired values. The Low Frequency Filter (LFF) for attenuating the lower frequencies, High Frequency Filter (HFF) for attenuating the higher frequencies [17], NOTCH filter [18] is used for attenuating unwanted electrical interference that can distort or mask the brain signals. The most prominent source of interference is due to the machine itself generated due to the low voltage calibration signal. The last important filter is the MUSCLE filter [19]. The muscle filter is used to remove the unwanted electrical signals generated by muscle movements. The sensitivity and sweep rate of recording are adjusted. After the adjustments the acquisition and recording of EEG is done for about 60 seconds. After the recording of EEG signals without music the subject is made to listen to low frequency percussion instrument music for about 60 seconds. These recorded EEG signals are then analysed using different analysis tools that are present in the RMS MAXIMA acquisition application system present on a computer. We have used the frequency analysis tool to get the relative power of each frequency band for the corresponding electrode positions in the given

montage. Similarly, we have carried out a Fast Fourier Transform (FFT) to get a plot of the power spectrum density as a function of frequency. These different analysis techniques are carried out for both without music and with music EEG recordings of a subject. From these analysis techniques we can study the effect of low frequency percussion instruments on the EEG of a subject and how the electrical activity of the brain changes due to music. https://youtu.be/LznxZDX7fo4?si=HiPx6EhLVJ_vw6G0

III. Results

We explore the impact of music on 50 random subjects using EEG with Bipolar Longitudinal arrangement. In the Bipolar Longitudinal arrangement, the scalp leads are interconnected to each other. In this arrangement the potential difference between a pair of electrodes is amplified by the amplifiers. These signals were recorded and analysed in the Bipolar Longitudinal montage as shown in Fig. 2. As shown in Fig. 2 we have selected Fp_1, F_7, T_3, T_5 & Fp_2, F_8,T_4 ,T_6 & C_z ,O_z and Fp_z for our study.

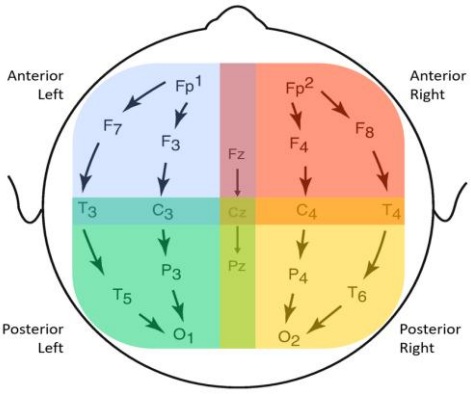
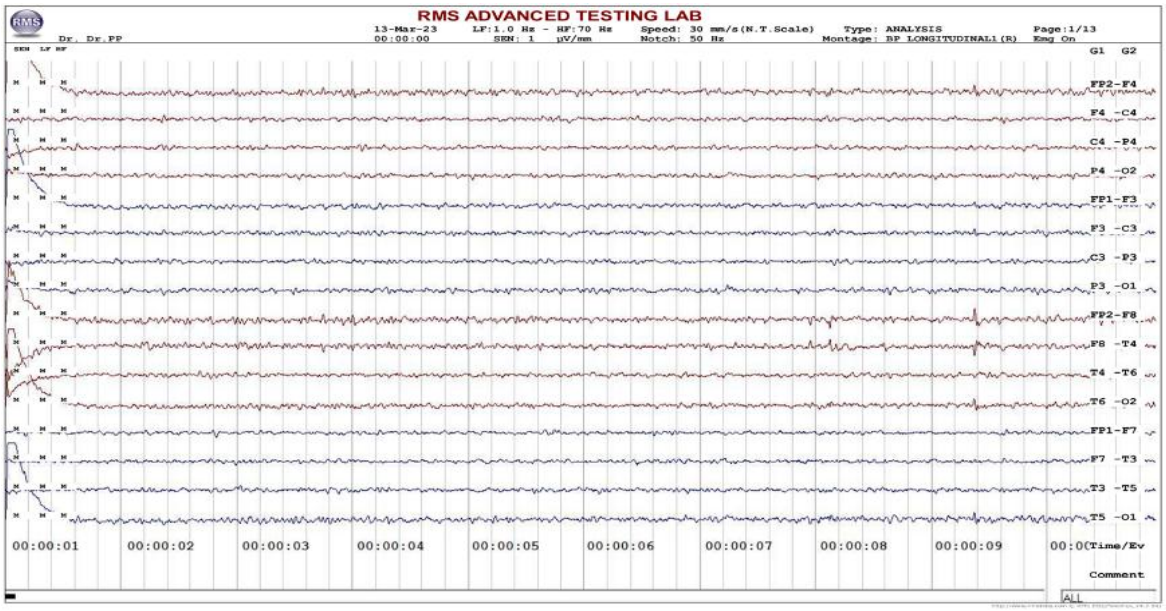


Figure 2: A Fig. depicting the Bipolar Longitudinal montage.

Further we show an EEG of one of the subjects out of 50 samples taken for without music in Figure 3a and with Music in Figure 3b. Here a section of total ten seconds out of the 60 seconds was taken. Electrode pairings of given montage are indicated on the right side in Figures 3a-b.



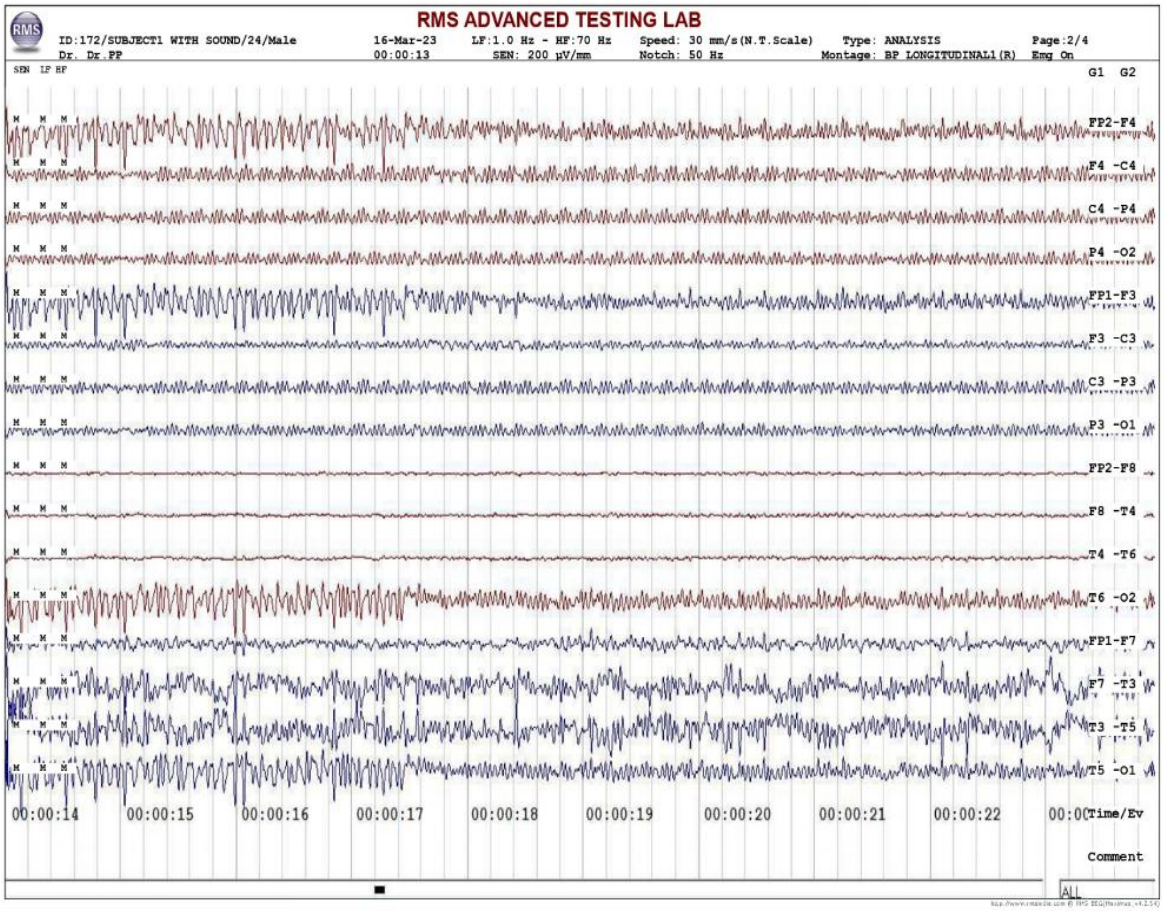


Figure 3: (a) EEG recording without music and (b) EEG recording with music. Electrode pairings of given montage are indicated on the right side in Fig. 3a-b.

When the same subject is subjected to low frequency percussion instrument music it shows changes in EEG signal as depicted in Fig. 3b. There is amplification in the signal in each of the waveforms of Electrode pairings for the given montage. Fig. 3b is also plotted as Fig-3a, i.e. it shows a section of total ten seconds out of the 60 seconds after application of music. The percentage changes or relative power in Fp_1, Fp_2, C_z, F_7, F_8, T_4, T_6, T_3, T_5 without music and with music on the same subject are shown in Fig. 4. Here the relative power of Delta, Beta, Alpha and Theta waves at each of the electrodes is shown for without music and with music. The Delta Waves (0.5 - 4 Hz) are typically associated with deep sleep and restorative states. These are present in higher amounts across most sites when there's no music. There is a slight decrease in the Delta waves with music (see Fig. 4). The Theta waves (4 - 8 Hz) are associated with light sleep, relaxation, or deep meditation. They are relatively higher with music as compared to without music. Thus, higher theta waves suggest reduced stress and anxiety. The Alpha waves (8 - 12 Hz) typically indicate relaxed, calm, and focused states which are often seen when someone is awake but relaxed. There seems to be a shift in Alpha wave activity between (1) without music and (2) with music states. It's more prominent with music, suggesting that music may be inducing more relaxation or calm states.

The Beta waves (12 - 30 Hz) indicate alertness, active thinking, or focus. It is higher with music at most sites, suggesting music may reduce the overall level of mental activity or increase relaxation.

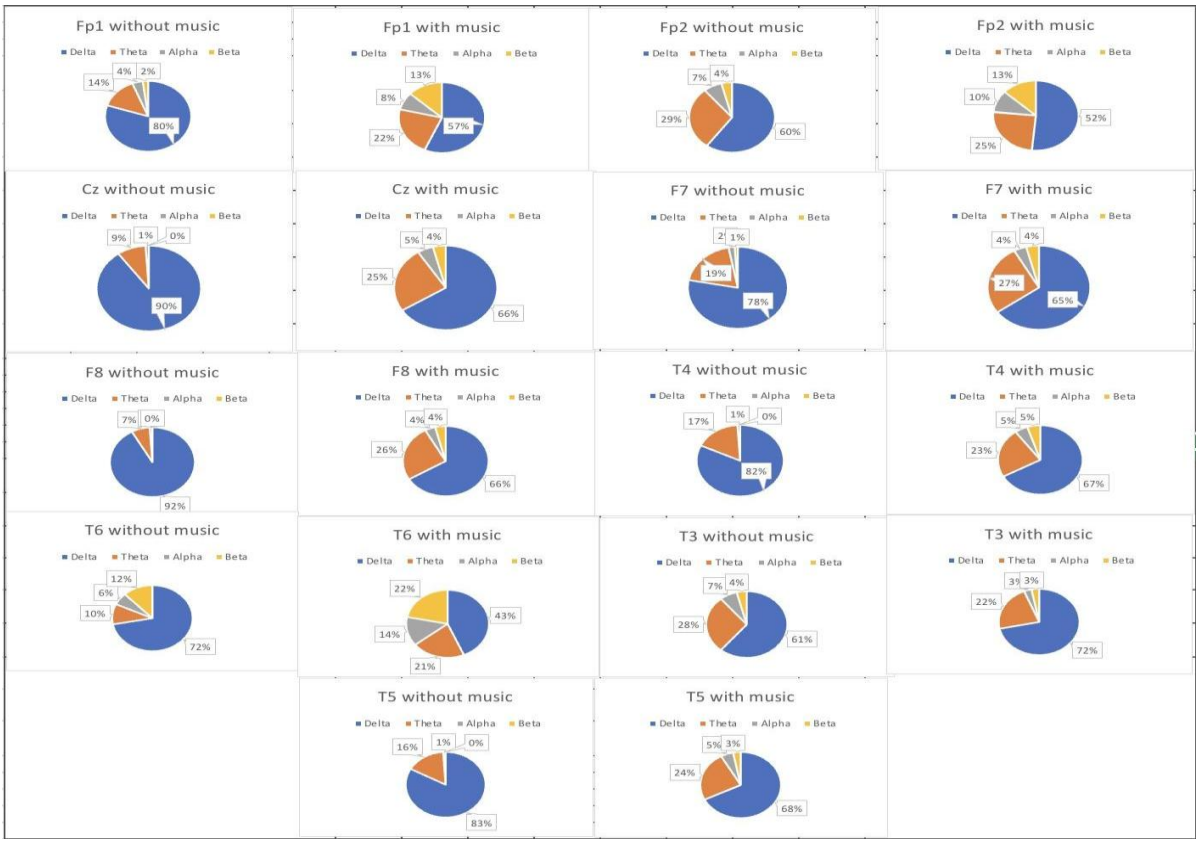


Figure 4: Pi chart of relative power of Delta, Theta , Alpha and Beta waves at Fp1, Fp2, Cz, F7, F8, T4, T6, T3,T5 without music and with music for one of the subjects.

IV. Conclusion

The subjects in Pune, India show an increase in Alpha waves, Beta waves and Theta waves and a decrease in Delta waves activity with music in comparison to without music. Indicating there is improvement in cognitive performance, creativity, focus, attentiveness and a decrease in stress, anxiety, depression, and other mental health issues. These results are comparable to the changes shown by [20]. In our study results are obtained from a limited sample of 50 subjects that includes 20 - 30 age groups. However, more concrete conclusions can be obtained with large numbers of samples. A specialized analysis on the subjects suffering from different mental health issues, for example Epilepsy, Schizophrenia should be conducted. These studies with different age groups will be useful to combat mental health related issues in Pune, India.

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