



A novel approach for Reducing Attention Deficit Disorder in children using Brainwave Entrainment

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Abstract

A new technology of brainwave entrainment is coming up recently for reducing attentional disorders. Some of the modern researches appeared in the past few years show that binaural beats entrainment actually produces changes that can be measured. Children with Autism & Attention Deficit Disorder (ADD) have difficulty in paying attention during cognitive tasks specifically reading and understanding. Particular brain-waves can be improved by listening to audio signals entrenched with tones that construct frequency-specific binaural beats. High levels of external stimulations have been shown to improve attention. Recent studies have shown that beta waves binaural beats entrainment can cause changes in power and connectivity of the brain.

Keywords: Binaural beats, electroencephalographic signal, auditory impulses, frequency following response, Cortical Evoked Response.

1. Introduction

The human brain is extremely sophisticated and remains the least understood organ in the human body. Even as we evolve with great advances in fields such as aerospace science, neuroscientists still do not fully understand the human brain. Across a few thousand years of human civilization, ancient great philosophers and current scientists shared a general view that music therapy can help the human brain to attain desired states of relaxation, happiness and enhance brain functions. This project aims at using music therapy to entrain the human brain to produce the desired frequencies.

The emergence of binaural beats entrainment as a field of study in the nineteenth century opened a new frontier of research into EEG (electroencephalography) and the use of rhythmic brain entrainment with low frequencies comparable to brain waves to influence and elevate the function of human brains. Traditional music therapy,

binaural waves and TMS are mainstream techniques used in the mental wellness industry today.

Attention Deficit Disorder (ADD) is exceptional intentional disorder which mainly involves slow frontal brain wave action and hypo-perfusion of cerebral blood flow in the frontal regions, particularly in tasks such as reading. A variety of problems, such as uneasiness and gloominess are often combined with ADD, therefore creating an increase in complications in treatment methods. The Autistic people or persons diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) have learning disabilities and more hyperactivity issues. This is the reason that such children cannot be treated like normal children. The first-line treatment for this disorder is through the use of psychostimulant drugs, but some may experience negative side-effects.

Audio-Visual Entrainment can produce intense increases in cerebral blood flow. Several studies using the use of AVE in the treatment of attention deficit disorders and its related disorders like slow learners and moderate learners have been undertaken by various Special educators and counsellors. This treatment process has obtained wide-spread results including improvements in IQ, performance, concentration, recklessness, hyperactivity, nervousness, depression and reading level.

This paper aims at using binaural beats or AVE technology in the treatment of ADD/ADHD sufferers. Audio Visual Entrainment can be an operational and affordable treatment of special-needs children. The objective of this research project is to establish Brain Wave Entrainment as a remedial curing method for ADHD/ autistic children in society. Measures of brain activity with the help of brainwaves or EEG signal suggest that people with autism concern retaining the excessive ranges of cortical arousal related with sustained alertness and targeted attention.

Specifically, they exhibit an inadequate quantity of coordinated hemispheric brain-wave patterns, in particular inside the alpha and beta frequency range indicate that individuals with ADHD have difficulty maintaining the high levels of cortical arousal associated with sustained alertness and focused attention. Specifically, they show an insufficient amount of coordinated hemispheric brain-wave patterns, especially within the alpha and beta frequency range.

In this project a trial has been done for a group of children suffering with Autism and ADHD by exposing them to beta and alpha binaural beats, specifically designed on the basis of their scalp EEG signal. It is expected that as their brain starts to produce the desired brainwaves automatically and naturally using Brainwave Entrainment Technology, they will eventually become more focused and attentional disorder will reduce to a measurable extent.

2. Literature Survey & Problem Identification

From the study of several papers on EEG signals recorded from the scalp of ADHD and Autistic children and normal children it was determined that Alpha-Beta activity and

Theta activity in human brain can be used as a diagnostic tool to differentiate between mentally disabled and normal children. It was concluded that Electroencephalogram recorded in clinical settings can aid adult attention deficit hyperactivity disorder diagnosis. It was also concluded from these papers that the elevation of Theta/Beta Ratio (TBR) is a specific phenomenon in case of ADHD and Autistic children.

A commercial product called Neuropsychiatric Electroencephalograph-Based ADHD Assessment Aid (NEBA) system was developed in year 2013, which received FDA approval (Food and Drug Administration) for diagnosis of mental disability among childhood populations. Targeting individuals between the ages of 6 and 17, the NEBA system interprets the theta/beta ratio of the EEG, as this ratio was found to be higher in children and adolescents with ADHD. It was accepted that the NEBA system should not be used as a stand-alone diagnostic tool and is recommended to be combined with a clinician's clinical evaluation by psycho-therapists and experts.



Figure 1 shows NEBA system

Thus, it can be hypothesized that elevation of TBR ratio is a characteristic of ADHD and Autism Spectrum Disorder in children. The treatment methods for mentally disabled children suffering with autism or ADHD included listening to music to improve concentration. When it was explored further, it was concluded that Brainwave Entrainment Technology using binaural beats of desired frequencies can be a novel treatment method for cure of various ailments like sleep disorders, hypertension, anxiety and even autism. In some of the papers, EEG was analyzed and it improved the desired brainwave. But this result was not established specifically for ADHD group. In this project, we have undertaken a group of Autistic children and tried

to prove that the Theta-Beta Ratio improved by listening to binaural beats.

3. METHODOLOGY

After the problem identification on the basis of literature survey, the final design and layout of the project was established as shown in figure 1.

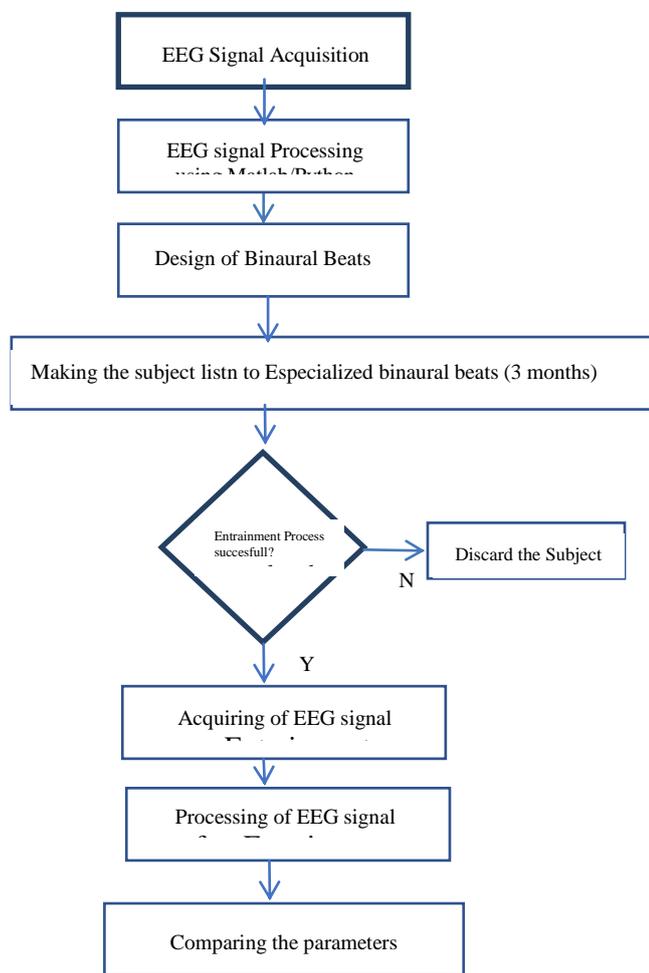


Figure 2 shows Layout of Project

3.1 Electroencephalography Signal Acquisition

Electroencephalography is the recording of electrical activity or rhythmical potentials which originate in the individual neurons of the brain. It is indicative of Different states of mind. However, it is not possible to get certain information from brainwave signals simply in the time domain just by observing them. They are essentially non-linear and non-stationary in nature. Significant features can be extracted for the analysis using advanced signal processing techniques.

EEG is the most used signal acquisition method for inspecting brainwaves because of the high temporal

resolution, safety, and easy usage. Many software tools are available to analyze these signals in different formats. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 10-15 minutes, as recorded from various electrodes positioned on the scalp.



Figure 3 shows Typical EEG signal

The EEG reveals not what is thought, but indicates the context in which thinking occurs---state of arousal, state of vigilance and alertness, etc. A predominant feature of the EEG is rhythmic activity, or periodicity. These rhythms are very complex in nature generated by various cortical, sub-cortical, and cortico-subcortical dynamics.

In relation with the eeg signals, a number of studies and reports have been executed to locate the vast changes in brainwaves by way of the use of extraordinary superior processing algorithms.

A normal eeg tracing is a rapidly converting composite or combination of different frequencies---waves moving up and down at extraordinary quotes---a few sluggish, a few fast.

At some point, EEG patterns are complicated, scattered and disorderly. After acting filtering operations using matlab, wave extraction from the EEG signal may be achieved at the special frequency stages.

Alpha waves (α), are in the frequency range of five hz to twelve hz. Those kinds of waves originate from occipital lobe and lower back facet of the pinnacle. Alpha waves dominate in cozy and calm mental states whilst being wide awake. They have higher amplitude compared with other waves.

Beta waves (β), ranging from 13 to 30 hz, are associated to deep wondering, excessive attention degree and anxious nation. They have huge frequency band as compared with others. Beta waves originate from significant area of the

brain and front facet of head.

Theta waves (θ), are in the frequency range from 3 to 7 hz. They originate from significant, temporal and parietal elements of head. Excessive level of theta waves usually occur in unusual adults, normally one with adhd.

Gamma waves (γ), are the waves which lies within the frequency variety of 30 hz and above. Motor capabilities, simultaneous paintings and different multi-tasking occur on this range of frequency.

Delta waves, are inthe frequency variety from 0.5 to 3 hz. They're the slowest waves compared to others. Delta waves typically arise in deep sleep.

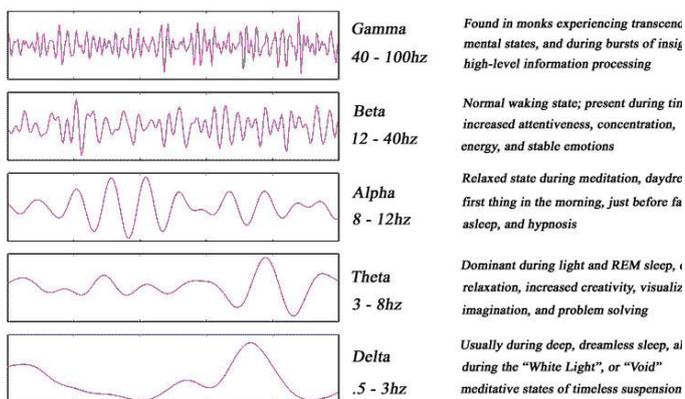


Figure 4 shows Brainwaves in different frequency ranges after filtering

In the first step the physio-psychotherapist and counsellors selected around 35 children which included some slow learners, Autistic and ADHD children. Finally 20 children with Attentional Disorders, with the consent of their guardians, agreed for being a part of this project and the EEG signals were recorded from their scalp.

Out of the total number of 20, 6 were slow learners, 9 were Autistic and 5 suffered with ADHD down syndrome. All of them had learning disabilities which is diagnosed by elevated values of Theta to Beta ratio. Out of them only 17 were able to record the EEG signal successfully. Other subjects reacted very badly and their signal could not be recorded at the diagnostic centre. Finally 15 subjects were able to complete the entrainment process. The special Councillor also handled the children while listening to the binaural beats sound.

The location of EEG electrode was matched with the international 10/20 system and the mind activities were recorded in various regions of brain. The recordings sets so obtained were utilized for evaluating the potential of the

proposed method. Due to less noise and artifact of EEG alerts in closed eye states compared to open eyes and cognitive work, the participants were asked to close their eyes for achieving more accuracy in the calculations and the prognosis. Similarly, inside the EC mode, the mind dynamics of adhd affected person were recorded with no outside stimulus. The pictures of EEG signal recording procedure for two cases are illustrated in Figure 5.

Recording of EEG signals of final 15 subjects from Muskan School of Mentally Challenged Children and Shristi Child Guidance clinic at Images Diagnostic Center, Nehru Nagar Bhilai was conducted at Images Diagnostic Center, Nehru Nagar Bhilai.

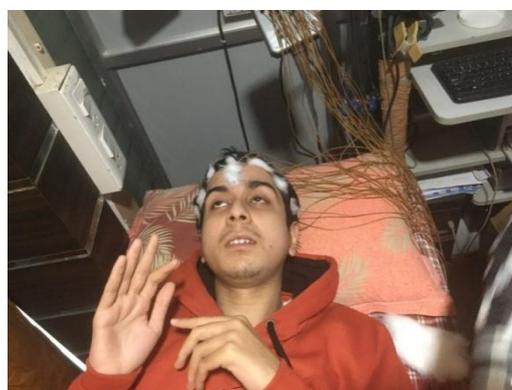


Figure 5 shows Picture of a subject during recoring of EEG signal

The recordings of EEG signals are saved in edf format to be processed in matlab software. The processing of EEG signal of the subjects in eeglab using Matlab Software is being done and power is computed. After processing the data the plot of data is obtained.

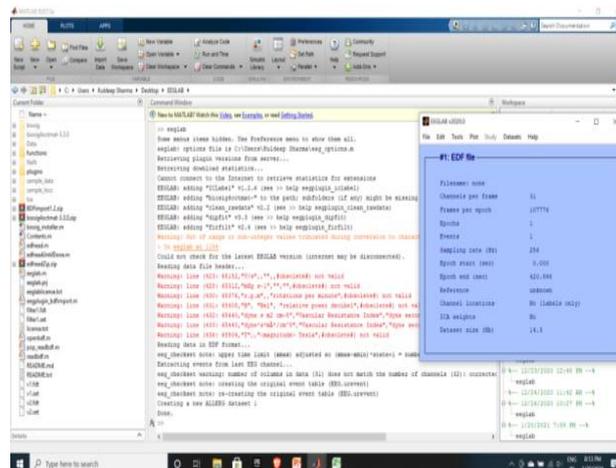


Figure 6 shows EEG signal processing

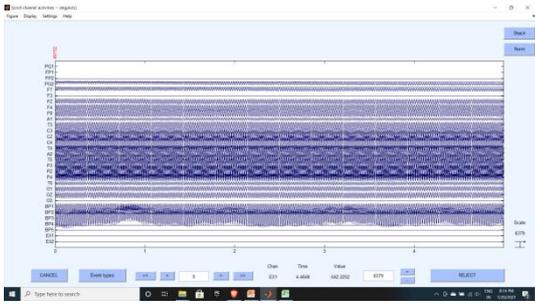


Figure 7 shows EEG signal plot sample

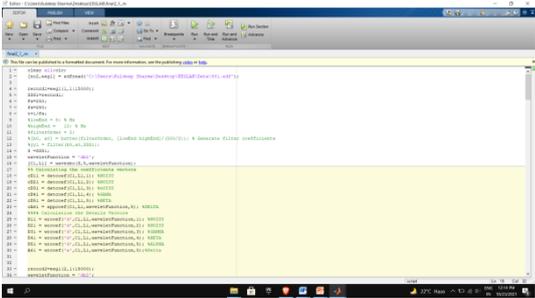


Figure 8 shows code for calculating power

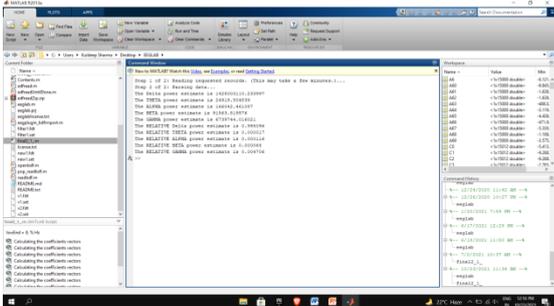


Figure 9 shows Power of signal in different bands calculated

The Beta wave binaural beats are generated using GNAURAL BINAURAL BEAT SOUND GENERATOR and compiled using AUDACITY SOFTWARE. The difference frequency is maintained around 12-14 Hz. To get proper results, for every individual subject according to the patterns of EEG signals, small changes have been done to suit his/her compatibility. To easily follow the beat of the pulses, in the sound track extra sound is also added for individual subjects.

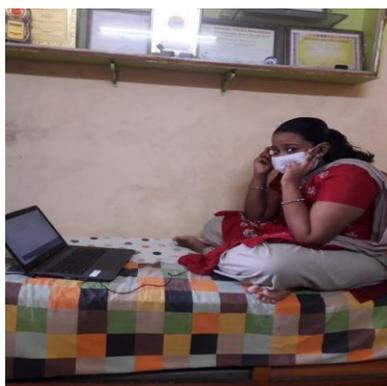


Figure 10 shows picture of a subject listening to beats

The listening of subject to the specialized binaural beats is called the process of Brainwave Entrainment. The subjects which were able to complete the Entrainment Process successfully for continuous three months are selected. Their EEG signal is recorded again and using same algorithm in EEGLAB differences are established between the power ratio of Theta to Beta waves(TBR).

4. OBSERVATIONS AND CONCLUSION

The first conclusion was that the elevation of TBR is indicative of extent of Autism and ADHD problems in individuals. We studied the powers of brainwaves after separating the alpha, beta, gamma, theta and delta waves. Out of our 15 subjects 4 were having ADHD and Autism, both the neurological disorders.

When the EEG signal theta to Beta ratio was determined for these 4 subjects, the elevation was overall more in TBR ratio for subjects 4,5,11 and 12 as compared to other subjects.

When they were observed clinically also by physiotherapists it was confirmed that they had ADHD also along with Autism.

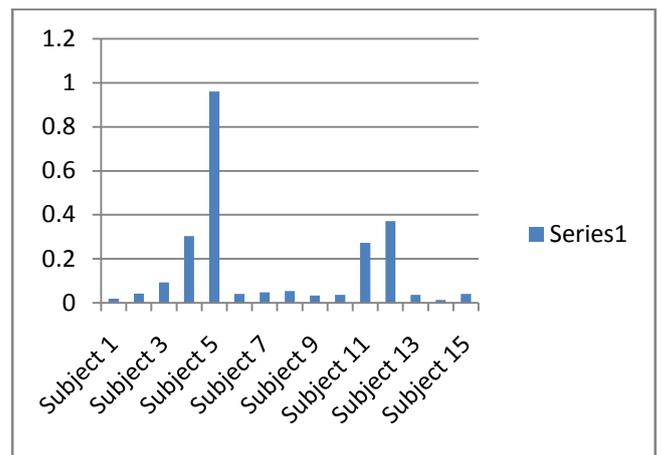


Figure 11 shows TBR ratio for all subjects

The entrainment process was separately done for each individual subject for 3 to 6 months. The binaural beats were designed for each subject after detailed study of individual subject's EEG signal. After the Entrainment process it was observed that in all subjects there were

positive changes that is the TBR reduced to some extent. This analysis was separately done for subjects having only autism and those have ADHD also.

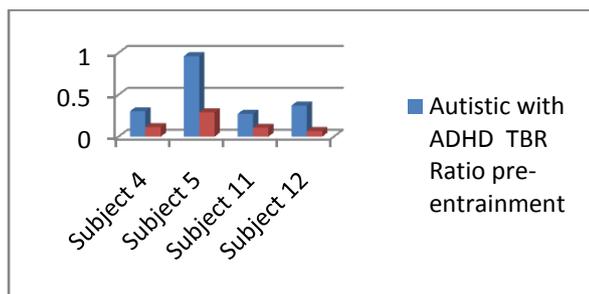


Figure 12 shows Comparison of TBR for ADHD + Autistic Group

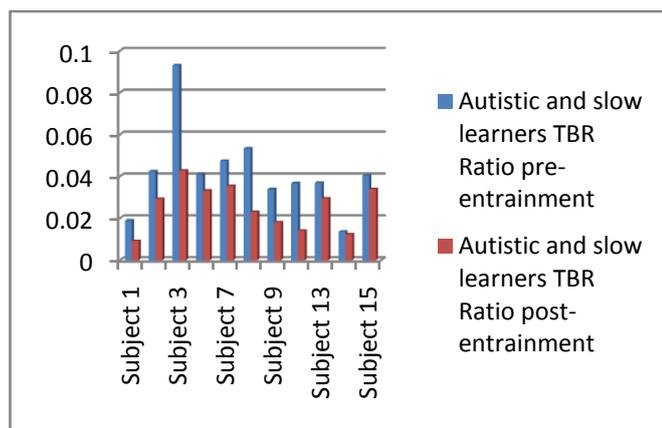


Figure 13 shows Comparison of TBR for Slow learners + Autistic Group

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