Alpha and Beta Brainwave Characteristics to Binaural Beat Treatment

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***Abstract*— This paper presents the affect of binaural beats tone of 10Hz (Deep Meditation) to Alpha and Beta brain wave using EEG. Thirty three (33) right handed students (22 females and 11 males) were randomly selected from Universiti Teknologi MARA (UiTM) Shah Alam. They were willing to be involved after their examination period to investigate this research work. Nowadays, people easily get stressed due to several external factors like family problems, money problem, life satisfaction and other similar factors. Hence, some people meditate by listening to the sound related to relax mode like binaural beats in order to release stress. In this paper, EPOC EMOTIV electroencephalography (EEG) instrumentation with 14 electrodes is used. During data collection, all subjects must close their eyes. The EEG data recorded is processed offline using a program which is developed in MATLAB and the data is further analyzed using Microsoft Excel. The increase on Alpha brainwave and decrease on Beta brainwave after listening to binaural beat shows that subjects are affected by stimuli given. The majority of the subjects are affected by the binaural beat.**

I. Introduction

Generally, the human brain has the same structure as other mammals. The brain is the most complex part of the human body. Brain wave activity is measured by the number of waves, or electrical frequencies that occur in a given unit of time that are measured in Hertz (Hz) [1]. This organ is very important because intelligence, senses, body movements, and behaviors depend on it. There are four types of basic human brainwave; Delta, Theta, Alpha and Beta waves which structure the electroencephalography (EEG). These paper is focusing on the affect of binaural beat on Alpha and Beta waves. The activity of the brainwaves can be measured and recorded using electroencephalography (EEG).

TABLE I. Types of Brain Waves

Types of brainwaves	Condition
Beta (15Hz-30Hz)	Awake, normal alert consciousness
Alpha (9Hz-14Hz)	Relax, calm, meditation, creative visualization
Theta (4Hz-8HZ)	Deep relaxation and meditation, problem solving
Delta (1Hz-3Hz)	Deep, dreamless sleep

Table 1 shows types of brainwaves [2, 3]. Alpha wave is associated with a relaxed and calm condition while Beta wave is associated with busy thinking, focus and alert. Delta wave is the slowest band of brain waves, linked with deep sleep while Theta wave associated with deep relaxation. The EEG is the recording of the oscillation of brain electrical activity from electrode along the scalp [4].

In the field of neural engineering, EEG has been widely used to describe brain activities [5]. There are many uses of EEG such as diagnostic application of EEG is in the case of epilepsy [6, 7] and spinal injury [8, 9]. Some of the research work is developing a system to measure EEG and acceleration of the athlete's body [10]. Since stress is related to the brain activity, EEG is used to evaluate people who are having problems associated with brain function. As stress is related to the brain activity, it can help relieve stress by measuring the level of the Alpha and Beta brainwaves [11] .

Everyone experiences stress at times. Stress can be defined as negative condition that can affect the person's mental and physical health. The cause of stress may be differ from one person to another. Stress comes from different sources in reaction to some psychosocial factors for example time pressure, responsibility; economic problems or physical factors, such as noise and heat; or biological conditions and psychological factors [12]. Khosrowabadi, Chai et al. [12] proposed Brain-Computer Interface (BCI) to classify EEG correlates to chronic mental stress. Perceived Stress Scale 14 (PSS-14) is used to measure the mental stress level and classify them into stressed and stress-free groups.

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The binaural beats can change our brain frequency towards the desired state either relax state or improve alert state. The brain responds by synchronizing its own electric cycles to the same rhythm of the stimulating binaural-beats audio. The results of binaural beats entrainment towards the brainwave can be determined by monitoring the EEG readings, which can be analyzed to capture the altered brain wave patterns and qualities they exhibit [13]. For example, at the left ear gave 400Hz and right ear gave 410Hz. The difference between left and right ear is 10Hz. Due to that, a stimulus of 10Hz gives relaxing effect to the person while applying to the brain. The present brain frequency expected to change towards the applied stimulus. The entrainment of brain wave is also known as the Frequency Following Response (FFR) where the response is shifted with respect to the applied stimulus. Deep meditation is used to give a relaxing mode to the subject, obtained from Brain Wave Generator software. There is a paper investigated the affect of binaural beat where subjects wore the sensor on their foreheads and listened to five kinds of binaural beat sounds such as 6, 8, 10, 12, and 14 Hz for 60 seconds per sound [14].

II. METHODOLOGY

This paper analyzes the affect of binaural beat to Alpha and Beta brainwaves. The data collection from UiTM involves thirty three (33) student randomly picked as a sample selected.

A. Stimuli

Binaural beat tones of 10HZ (Deep meditation) are produced by Brain Wave Generator software. The binaural beat tones have been tested in the lab and proven to be 10Hz. There are more than 20 built- in (preset) brainwave entrainment programs for different purpose Brain Wave Generator.

B. Data Collection

Depression Anxiety and Stress Scale (DASS) questionnaire consists of 42 items is utilized to measure the level of stress among UiTM's students. The results and the scoring of the stress level is then calculated by summing the scores for the related items. The validated Malay version of the Depression Anxiety Stress Scales (DASS) questionnaire was used in two major automotive assembly plants in Malaysia to measure the negative self-perceived emotional states of stress, anxiety and depression among male automotive assembly workers [15]. Each of the three DASS scales contains 14 items, divided into subscales of 2–5 items with similar content. Park and Lee, et al. [16] represent that Korean Occupational Stress Scales (KOSS) and Depression Anxiety Stress Scales (DASS) questionnaire is used to observe the relationship between occupational stress and depression, anxiety, and stress symptoms among white-collar male workers in an automotive company. The method is similar to this research by using the DASS questionnaire.

C. Equipment

Emotive is a wireless device that is being used to collect data of EEG signals. EMOTIVE EPOC is user friendly and it has been used in other researches [17, 18]. In this research, EPOC EMOTIV is used to capture the EEG brain wave signal. EPOC EMOTIV consists of 14-channel (AF3, AF4, F3, F4,F7, F8, FC5, FC6, P3 (CMS), P4 (DRL), P7, P8, T7, T8, O1, O2 where CMS and DRL are the references) with digital notch filters at 50Hz and 60 Hz. The placement of the electrodes follows the International 10/20 System of Electrode Placement. The sampling rate is 128 Hz. The EEG test poses no significant risks, and is pain-free. Figure 1 shows EPOC EMOTIV electrodes from the side view.

Figure 1: EPOC EMOTIV electrodes from side view

Figure 2 shows the position of electrodes along the scalp. A sound isolating earphone is a suitable device in this experiment. Earphone is used in this experiment. This is to make sure that sound transferred from the laptop is isolated and in the same time to minimize the external noise. Other equipment that is used is eye mask. The eye mask is wore to avoid stress arise around the eyes due to forcing the eyes to be closed during the experiments. EPOC EMOTIVE gives the researcher more information about student mind and body for exploration, feedback and learning.

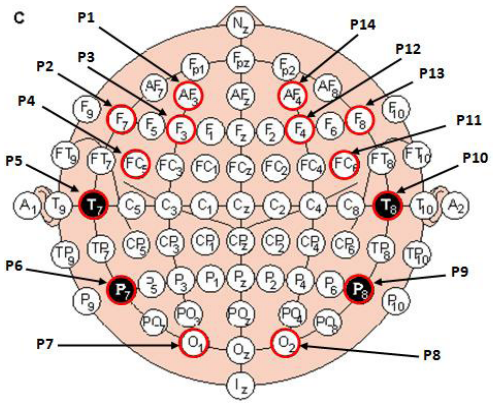

Figure 2: EPOC EMOTIV EEG Electrodes Placement

D. Signal Processing

The raw EEG data is recorded and processed offline using a program which is developed using MATLAB since EEG signals were captured in time basis and it needs to be converted to frequency basis using Fast Fourier Transform (FFT). Beforehand, the raw data will undergo an artifact remover process. Then, the feature extraction process will take place where the Energy Spectral Density (ESD) feature is extracted. The data is further analyzed using Microsoft Excel and presented in graphical forms.

E. Procedure of Data Collection

The subjects will first complete the DASS questionnaire and signing the consent form. Then, the subjects were asked to sit comfortably with the eyes closed in a dimly light air conditioned room during EEG recording. Figure 4 shows the time frame procedure of the EEG recording.

Figure 4: Time frame procedure of EEG recording

III. Result and Discussion

The results and the scoring of the negative emotional are then calculated by summing the score for the related items. These results can be divided into two groups; stress and normal.

TABLE II. The Result of The DASS Questionnaire

Normal	Percentage %	Stress	Percentage %
14 subjects	42%	19 subjects	58%

Table 2 shows the result of the questionnaire where the majority of the participants are stressed (58%) and 42% are in normal condition. According to the results of the DASS questionnaire, the stress condition is higher compared to the normal condition. The reason is most of the subjects are a final year students whom are busy thinking about their projects and the experiment was conducted after examination period. The students may still feel stress due to their final exam and final year project.

Figure 4 shows graphs plot of the before and after binaural beat for Alpha left and Alpha right hemisphere. Theory of Alpha waves are associated with relax, calm, meditation and creative visualization. Supposedly, Alpha brainwave will increase after listening to binaural beat and the subjects become more relax because of the binaural beat. From the graph in Figure 4, overall, it can be seen that more subjects experience increases in alpha after listening to the binaural beat. The alpha increment is observed to be experienced at both left and right hemispheres. It shows that most of the subjects become more relaxed after listening to the binaural beat and the student is affected by the binaural beat.

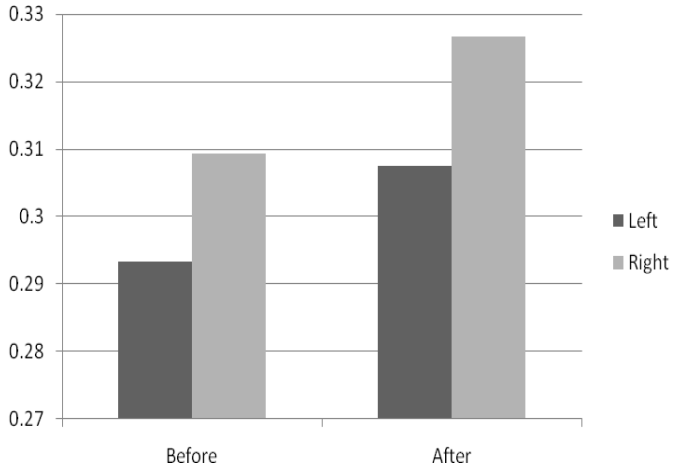

Figure 4: Before and after binaural beat for Alpha left and Alpha right hemisphere

Figure 5 shows that the graph plot of the before and after binaural beat for Beta left and Beta right hemisphere. Both Beta brainwaves in left and right hemisphere of brain are decreases after listening to binaural beat. If Beta waves related to active thinking or stress are dominant and a 10Hz stimulus is induced, the brain activity will change and get synchronized with the frequency [19]. Theoretically, Beta brainwave is related to awake and normal alert consciousness. Then, the decreasing in the Beta brainwave shows that the subjects are not in awake and alert consciousness condition. In simple word, the subjects became calmer after listening to binaural beat.

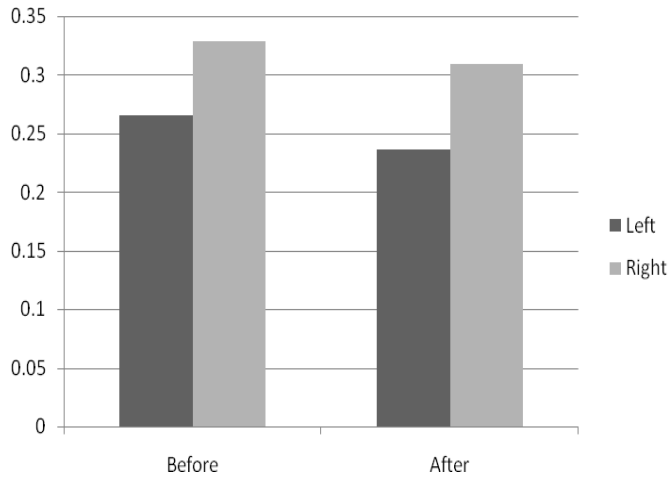

Figure 5: Before and after binaural beat for Beta left and Beta right hemisphere

Theoretically, the Alpha brainwave is related to relax state. Figure 6 shows that 61% of the subjects experience increment in the Alpha brainwave after listening to the binaural beat and the subjects become more relaxed because of the stimuli given. The other 39% of subjects are experiencing decrement in the Alpha brainwave after listening to binaural beat. This happens when some of the subjects are not able to relax after listening to the binaural beat sound. It could not be that the only one time experience is not enough to bring down the level beta wave. It has to be listened from time to time in order to achieve the desired state. This is because the binaural beat acts same as supplement that needs to be taken daily to achieve an optimum result.

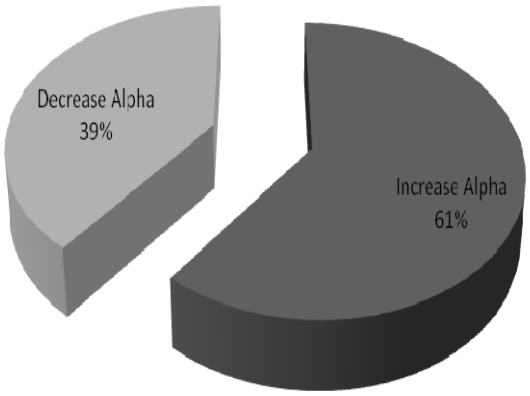

Figure 6: Decrease and increase Alpha distribution after binaural beat

Beta brainwave is linked with focused and active thinking. In theory, the decrease on Beta brainwave after listening to the binaural beat verifies that the particular subjects are affected by stimuli given. Figure 7 shows that 52% of subjects experience in increasing in Beta brainwave. This might be due to fact that most of the subjects are a final year students whom are busy thinking about their projects. This might contribute to the things that make them unable to be in a relax condition during EEG recording. The other 48% of the subjects are affected by the binaural beat sound based on the result which shows a decrement in Beta brainwave after listening to binaural beat.

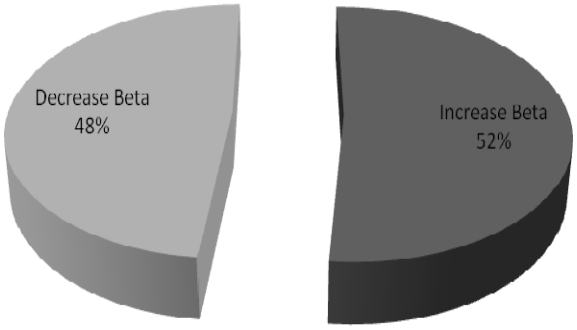

Figure 7: Decrease and increase Beta distribution after binaural beat

IV. CONCLUSION

This paper presents the analysis of Alpha and Beta brainwave affected by binaural beat utilizing the feature Energy Spectrum Energy (ESD). Result from DASS questionnaires shows majority of the subjects are stressed. All subjects claimed that they are stressed because of the examination period before EEG recording is conducted. For alpha wave, 61% of the subjects are having a positive effect after listening to the 10Hz binaural beat sound while 39% of the subjects are experiencing increment. Overall, from the results, it is shown that the binaural beats sound is indeed can give some effects on the brainwaves generally, alpha and beta waves specifically. The results could be refined by collecting more data in the future. The effects of the binaural beat could be further explored by increasing the number of days for the subjects to listen to the binaural beats. The number of the subjects are also should be increased in the future in order to have a more refine analysis.

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