Brain Signal Analysis Using Different Types of Music

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Abstract: Music is able to improve certain functions of human body physiologically and psychologically. Music also can improve attention, memory, and even mental math ability by listening to the music before performing any task. The purpose of this study is to study the relation between types of music and brainwaves signal that is differences in state of relaxation and attention states. The Electroencephalography (EEG) signal was recorded using PowerLab, Dual Bio Amp and computer to observes and records the subject brain activity in three condition; before, during, and after listening to different types of music; Light, Rock, Mozart, Al-Quran recitation and Jazz. The brainwave reaction of the subjects is compared during these three conditions. The hypothesis of this study is; Beta wave is increased at attention state and decrease at relaxation state. To analyze the data, Labchart7 software was used. The EEG data that has been recorded is processed using Digital Filter and the features of EEG signal is extracted and recorded by Data Pad that included in Labchart7 software. Then, the data is analyzed from mean of group features and also the average amplitude of Alpha and Beta wave. The results from this study are; the attention state of students is increased (Beta increased) while listening to Rock, AlQuran recitation and Mozart music when compared between during and before condition. Meanwhile, Beta wave is decreased while listening to Light and Jazz music thus showing the decrements of student's state attention. Therefore, the result obtained may help students to choose better type of music or similar to help increases their concentration and focus while study.

Keywords: Electroencephalography, brain, music, beta wave, alpha wave

1. Introduction

Music has capability of cultivating the temperament and sentiment in human and in some ways can as well improve the physiological and psychological functions of human body, including reducing tension, blood pressure and pain. Current music therapies have no clearly individually approach. However, there were previous researches reported on the benefits of listening to music prior to performing any work/task. It is concluded that music can improve attention, memory, and even mental math ability. Music also has the power of alleviating the anxiety and depression [1].

Music can be defined as an organized sound with variation in rhythm, melody, and dynamic patterns which can be performed on different types of instruments [2]. Every sound type has its own power and frequencies, which then can give effect to the listeners either in positive or negative ways. A sound or noise that is very loud and emits power more than 85dB can contribute to permanent hearing loss in humans if they were continuously exposed to it for more than eight hours. Sounds that are unwanted by human are unpleasant and they may leads to other physical condition including stress and hypertension. However, despite the negativity of those points mentioned earlier, there were previous researches which reported that certain types of music can help the learning process, as well as can encourage humans' creativity [3].

In human body, brain is one of the crucial parts as it is the location of nervous system, where the basic cellular building blocks are the neurons. A neuron, which consists of dendrites, will receive signals from other neurons. Then, those signals will be processed by the cell body and the axon will reach out and interact with another neurons. During this communication and coordination of the brain parts with each other, nerve impulses will be sent [4]. Each part of daily life activity including blinking and breathing are controlled together by the brain and the spinal cord. Figure 1 shows parts of the human brain.
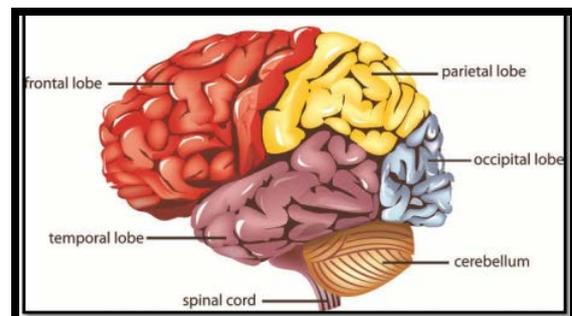

Figure 1: Parts of the human brain

The brain is the crown jewel of the human body. [5] Previous research that studied on the Alpha and Beta waves during visual attention found out that Alpha wave was increased and Beta wave was decreased during a visual spatial attention [6]. Usually, during relaxes and

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31

calm condition, Alpha state is activated. But, during activity that includes thinking and concentrating, the Beta brainwave is activated. Previous research has shown that there were certain relation/connection between the attention or relaxation state with the Alpha and Beta brainwaves. Alpha waves were highly released during relaxation state compared to the attention state. Meanwhile, Beta waves were released higher in the state of attention than in relaxation state.

Since different people have different cultures and educational background, it can be assumed that the response to the same music is as well different. In clinical music therapy, EEG can be analyzed in the way of exploring the effects to the brain waves when different kinds of music were used as stimulus [7]. The effects of music genre preference can be predicted even though genre on its own will not give any effect on the alpha wave activity. However, previous studies found that alpha waves will be more synchronous when participants listen to their preferred genre, as compared to when they listen to a less preferred genre. Greater beta waves were activated in the left temporal brain region due to the arousing nature of fast-paced music [8]. Compared to other relaxation activities, listening to music was highly ranked in helping an individuals' essentials. That is why music has significant effect to people [9]. Previous evidence also suggests that students' math and puzzle solving skills can be improved to a great extend with music. In previous research, the study showed that, as compared to student with no musical background, students with musical background scores better in the Scholastic Aptitude test [10]. The effects of sound especially for treatment have been an active topic to be further studied by researchers, as it is suggested that music can help in reducing the stress, soothing the pain, and energizing the body [11].

For this project, music and nervous system are combined to find the best result in finding the best music therapy for student in helping them to focus in doing their homework or any activities related to their studies. The Electroencephalography (EEG) will be used to collect the data. A study has suggested that Alpha and Beta waves could be associated with the state of relaxation and attention (concentration) [12]. Therefore, the aim of this research is to study the relation between the type of music and brainwave signal that is differences at state of relaxation and attention using Electroencephalography (EEG) by; 1. Studying the characteristic of brain signal using Electroencephalography (EEG), 2. Determining the suitable method that can be used to analyze Alpha and Beta wave in EEG signal, and 3. Analyzing the effects of music on human brain.

2. Materials and Methods

For this project, 15 students consist of male and female from Electrical and Electronic Engineering Faculty of Universiti Tun Hussein Onn Malaysia were involved as subjects for recording of EEG signal. They were around 22- 25 years old and did not have any hearing problem or any brain disease. Subjects were also

advised to get enough rest and sleep at least 6 hours before the experiment was conducted. The subjects were also not allowed to take any medication, alcohol, or caffeine. The subjects were also told earlier not to apply any hair gel during data collection session.

The software of Labchart7 was used to pre-process the signal by filtering raw signal into Alpha and Beta wave of the EEG signal. The features of EEG signal were then analyzed by using method of Paired T-test by using Statistical Package for the Social Science (SPSS). The flowchart in Figure 2 shows a short explanation of the process in determining the effect of music on EEG signal. For data collection, the subjects have been asked to solve mathematical problem such as simple multiplication table. The session was divided into five sub-session as there were five types of music to be listened by the subjects. Each session was divided by three parts which were before, during and after listening to the music. The subjects were asked to take a rest a few minutes at the end of each session before proceed to another session. After that, the data was recorded through pre-processing to get EEG signal. The data is then extracted to get the features before being analyzed by using SPSS.
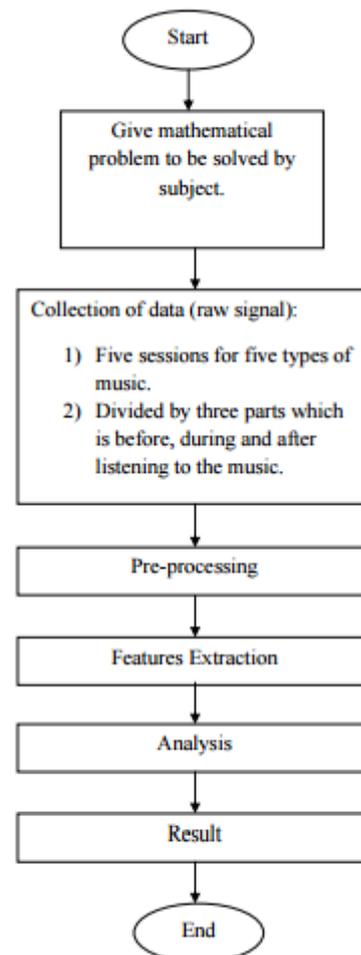

Figure 2: Process in determination of the music effect on EEG signal

For EEG signal extraction, mathematical tool was used which help in getting efficient result for large data set for any cases. Therefore, there were few steps taken for this project which were pre-processing, feature extraction and analysis. These steps are shown in Figure 3.
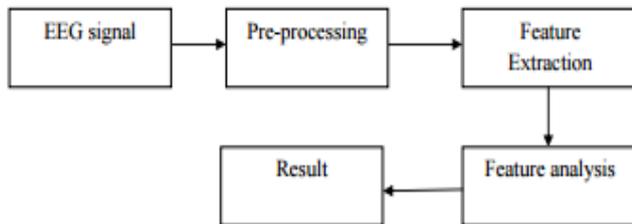

Figure 3: Steps to analyze the EEG signal

2.1 Data collection

Data collection for EEG signal is from a recording of the electrical activity of brain from different electrode that is placed on scalp. Any activity of brain has voltage with relative measurement. The measurement is compared with voltage of referential area. That is why referential area need to be chose which brain activity on that area is approximately to zero. This technique is applied in this experiment by using PowerLab. Dual Bio Amp and Flat Electrodes are used as tools for PowerLab8/35 in obtaining EEG raw signal. Meanwhile, the software of Labchart7 is used for preprocessing and extraction features of EEG signal. Then, SPSS is used to analyze the features that is extracted from Labchart7 by comparing mean of each features using Paired T-test method. Each feature is divided by three parts which is before, during and after listening to the music. The mean for each part is compared by three types of comparison; before-during, during after, and before-after.

2.2 Pre-processing of EEG signal

EEG raw signal obtained contains artifacts from brain activity which is muscle activity, eye blinking, noise from surrounding and others. Therefore, filtering process is used to remove artifacts. Digital filter then filter the EEG signal by removing chosen frequency for each type of wave signal. For this project, only the chosen EEG signal that is filtered by Band-pass Filter is used as project findings.

2.3 Features extraction

Features Extraction is a process to get required information from EEG signal. Features from EEG signal are used to determine the effect of music on the subjects. Features selection is very important in order to process the result analysis further. The features a recorded and extracted from Alpha and Beta wave are from Digital Filter toolbox that act as medium in between. Alpha and Beta waves features are analyzed by using Data Pad which is provided in Labchart7. Its function is like a spreadsheet which user can measure and calculate log parameter from EEG signal data. Each column can be set

with different type of log parameter. This method is repeated for five types of music for both Alpha and Beta waves of EEG signal.

3. Results and Discussion

Based on results of Alpha and Beta wave that is recorded for EEG signal, there are six spectrum features that can be extracted from five types of music which are Light, Rock, Mozart, Al-Quran recitation and Jazz for both type of Alpha and Beta wave. The features that were extracted are Maximum Power Frequency, Mean Power Frequency, Median Power Frequency, Minimum Power Frequency and Standard Deviation Frequency. The graft obtained from mean of some features group showed that there were differences between before, during, and after listening to each type of music. The amplitude of the EEG signal itself shows differences between three conditions of this experiment.

The features analysis was done to ensure the suitable features that can be used to analyze the effect of different type of music towards human brain. The observation was done on the changing of frequency from these three condition; before, during and after listening to the music based on five types of music; Light, Rock, Mozart, AlQuran recitation and Jazz to obtain the result of this project. However, not all features extracted from EEG signal can be used for analysis. After the data was updated, the Minimum Power Frequency, Standard Power Frequency and Mean Power Frequency showed only small differences in frequency that caused these features to be ignored for further analysis.

Before the experiment of this project was done, the instruction for doing the experiment had been given to the subjects. The subjects were asked to think out the solution of multiplication table without speak it out loud. This was done to activate the brain and to reduce the movement and artifacts of EEG raw signal. Therefore, the result may be varied due to the cooperation from the subjects itself. Besides, the concentration level of subjects also may be varied. This is because the ability of those subjects to solve multiplication table depends on their skills in solving mathematical problem. The multiplication tables that were given to them to solve is four, six, seven, eight and twelve table which normally is difficult for people to remember. Moreover, the multiplication table is differs through different type of music to let subjects think of the new thing for each session.

The surrounding also plays an important role for this experiment. The noise from surrounding such as people talking and phone ringing may affect the results of this experiment. This is because, the subjects listen to the music only with 40-55 dB which is like normal people talking and subject still can hear another noise from surroundings. However, the music effect on EEG signal had been tested several times before doing the real experiment in data collection to make sure the procedure of this experiment is correct and acceptable. Based on analysis that has been done, the best feature that can be used to analyze Alpha and Beta is Maximum Power

Frequency feature. From Figure 4, the results show that the mental ability of students was increased when Beta wave was increased during listening to Rock, Al-Quran recitation and Mozart music which leads to increase their concentration while solving mathematical problems (study). Meanwhile, Beta wave was decreased while subjects listening to Light and Jazz music. This is means that the mental ability of students is decreasing at this kind of condition which leads to decrease their concentration while study. Furthermore, Figure 5 shows that the Alpha wave was decreased during listening to five types of music. However, the decrement of voltage is bigger during listening to Light and Jazz music compared to Rock, Al-Quran recitation and Jazz music. Thus, these two types of music; Light and Jazz were not suitable to be listened while studying as it more influence in relaxation state and not in attention state.
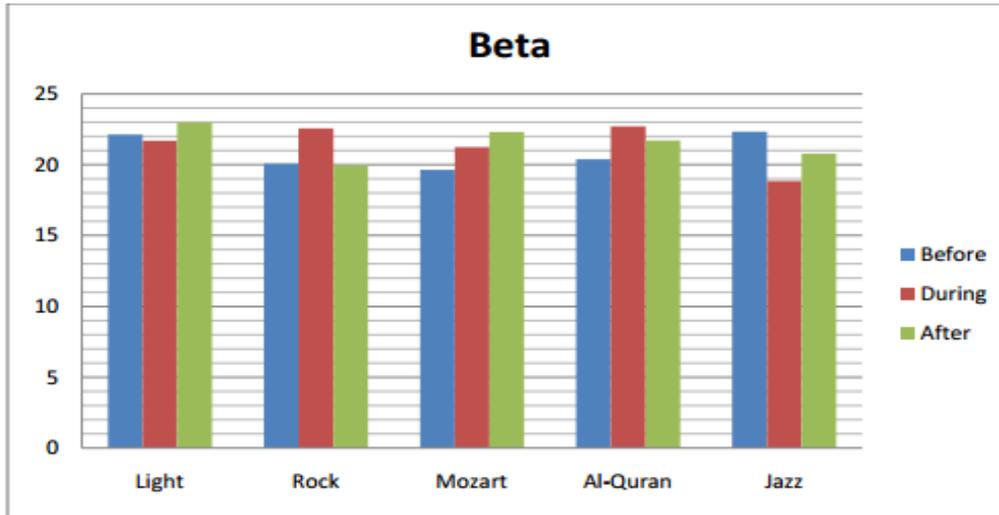

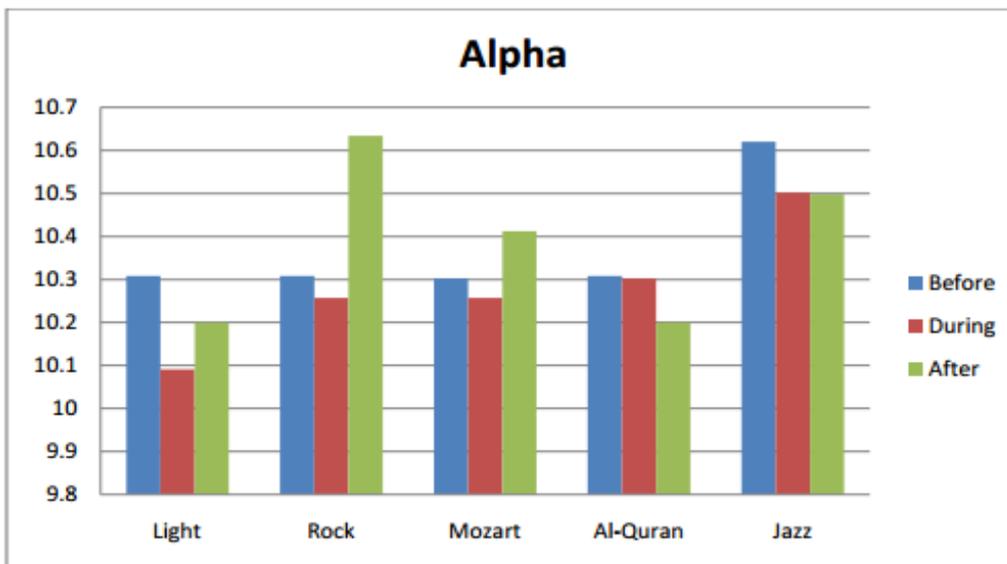Figure 4: Result for Beta wave for 5 different music at 3 different states.

Figure 5: Result for Alpha wave for 5 different music at 3 different states.

4. Summary

This project was done to see the pattern comparison of Alpha and Beta wave that happened and the effect towards brain activity that was analyzed from EEG raw signal based on three conditions which is before, during, and after listening to five types of music; Light, Rock, Mozart, Al-Quran recitation and Jazz. The most practical method to measure the brain activity is Electroencephalography (EEG). Digital Filter was used as the pre-processing technique as it is very effective to estimate the characteristic or features of the EEG signal. This technique was used to record required EEG signal by removing and reducing any noise and artifact in EEG signal caused by hand movements and eye blinking.

The features extraction was done by categorizing the features into different characteristic as they have different values. The result of features extraction which is by finding mean value for each characteristic was recorded in Excel file for further analysis. To make a strong comparison, the average amplitude of EEG signal for

Alpha and Beta wave from different type of music with three conditions was computed. The results show that Beta wave was increased which means the attention states of subjects were also increased during listening to Rock, Al-Quran recitation and Mozart music. The mental ability of students was increased at this kind of condition which leads to the increment of their concentration while solving mathematical problems (study). Meanwhile, Beta wave was decreased while subjects listening to Light and Jazz music. This means that the mental ability of students is 40 decreasing at this kind of condition which leads to decrement of their concentration while study. Furthermore, the Alpha wave was increased while listening to Rock, AlQuran recitation and Mozart music and decreased while listening to Light and Jazz music. Thus, these two types of music; Light and Jazz was not suitable to be listened while studying as it influence in relaxation state and not in attention state. As a conclusion, Beta wave is increased at attention state of brain activity and decreased at relaxation state. Therefore, the hypothesis of this project is accepted.

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