EXPLORING THE IMPACTS OF LISTENING TO BINAURAL BEATS MUSIC ON NON-MEDICAL DEPRESSION DISORDERS BY USING EEG SIGNALS

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DECLARATION OF ORIGINAL WORK

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i.Student's Declaration:

I'm Mohammed Hamada Jasim-M20161000223-Faculty of Art, Computing, and Creative Industry.

Hereby declares that the dissertation /thesis for titled (Exploring the Impacts of Listening to Binaural Beats Music on Non-Medical Depression Disorders by Using EEG Signals) is my original work. I have not plagiarized from any other scholar's work and any sources that contain copyright had been cited properly for the permitted meanings. Any quotations, excerpt, reference or re-publication from or any works that have copyright had been clearly and well cited.

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ii. **Supervisor's Declaration:**

I'm Dr. Bilal Bahaa Zaidan- hereby certify that the work entitled (Exploring The Impacts of Listening to Binaural Beats Music on Non-Medical Depression Disorders by Using EEG Signals) was prepared by the above-named student, and was submitted to the Institute of Graduate Studies as a partial / full fulfillment for the conferment of the requirements for Master degree (By Research), and the aforementioned work, to the best of my knowledge, is the said student's work.

_____ _____

Date Signature of the Supervisor

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ABTRACT

Lately, the research on human emotion has attracted the interest of several disciplines, including computer science, cognitive science, and psychology. As such, the aim of study was to examine the effects of binaural beats music on depression disorders. This study was conducted based on an experimental design in which electroencephalography (EEG) was utilized to capture brain signals. The EEGlab toolbox of Matlab was used to extract the relevant features of the brain signals. For feature filtering, brain signals were filtered by using 'Butterworth 5th order'. EEG signals were then converted from the time to the frequency domain by utilizing Fast Fourier Transform (FFT). A sample of 90 depressive participants was exposed to binaural beats music. One-way ANOVA was used to compare the differences in the effects based on three different time intervals, which were labelled as before listening, during listening, and after listening phases. Descriptive and statistical analysis were utilized to analyse the effects of binaural beat music on the subjects' depression level and to examine whether there were significant differences among the intervals. The findings showed that 63.2% of the subjects exhibited positive responses based on either an increasing relaxation level or a decreasing depression level or both, with the remaining subjects exhibiting negative responses. In addition, the most conductive electrodes were found to be the "F3, F7" electrodes, which effectively captured alpha and beta bands from the frontal lobe area of the brain. Furthermore, the one-way ANOVA results indicated that there were no significant differences in the effects among the intervals [F (2, 87) =1, 86, p = 0.161]. Overall, this study highlights the benefits of the use of binaural beats music in the level of depression and to improve the relaxation state of those suffering from depression disorders. For future research, examining the effects of binaural beat music on other aspects of human emotions is recommended.

MENEROKAI IMPAK MENDENGAR RENTAK BINAURALKE ATAS GANGGUAN KEMURUNGAN BUKAN PERUBATAN DENGAN MENGGUNAKAN ISYARAT EEG

ABSTRAK

Kebelakangan ini, penyelidikan pada emosi manusia telah menarik minat yang mendalam dari beberapa disiplin, termasuk sains komputer, sains kognitif, dan psikologi. Kajian ini bertujuan untuk mengkaji kesan muzik rentak binaural terhadap gangguan kemurungan. Kajian ini dijalankan berdasarkan reka bentuk eksperimen. Electroencephalography (EEG) digunakan untuk merakam isyarat otak, di mana kotak peralatan EEGlab Matlab digunakan untuk memperlihatkan ciri-ciri yang berkaitan dengan isyarat otak. Untuk penapisan ciri, isyarat otak telah ditapis dengan menggunakan *Butterworth 5th order*. Isyarat EEG kemudiannya diubah dari domain masa ke domain frekuensi dengan menggunakan Fast Fourier Transform (FFT). Satu sampel yang terdiri daripada 90 peserta didedahkan kepada muzik berdegup binaural. ANOVA sehala digunakan untuk membandingkan kesan antara tiga selang masa yang berlainan, yang dilabelkan sebagai "sebelum mendengar", "semasa mendengar", dan "selepas mendengar". Analisis dan statistik deskriptif digunakan untuk menganalisis kesan muzik berkenaan terhadap tahap kemurungan peserta dan menilai sama ada terdapat perbezaan yang signifikan antara selang masa berkenaan. Dapatan menunjukkan 63.2% daripada subjek menunjukkan respon yang positif melibatkan sama ada peningkatan dalam tahap santaian atau penurunan dalam tahap kemurungan atau kedua-duanya, manakala yang lain menunjukkan respon yang negatif. Di samping itu, elektrod yang paling konduktif adalah elektrod "F3, F7" yang berjaya merakam jalur alpha dan beta dengan berkesan dari bahagian *lobus frontal* otak. Tambahan pula, keputusan ANOVA sehala menunjukkan tiada perbezaan yang signifikan dalam kesan antara selang masa berkeaan [F (2, 87) = 1, 86, p = 0.161]. Secara keseluruhannya, kajian ini menunjukkan kebaikan dalam mendengar muzik rentak binaural untuk mengurangkan tahap kemurungan dan meningkatkan tahap santaian dalam kalangan mereka yang mengalami gangguan kemurungan. Untuk penyelidikan masa depan, penelitian terhadap kesan muzik rentak binaural terhadap lain-lain aspek emosi manusia adalah disarankan.

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ANN	Artificial Neural Network
BCI	Brain computer interface
CG	Control group
DBNs	Dynamic Bayesian Networks
DCAU	Differential caudality
ERP	Event-Related Potential
EMD	Empirical Mode Decomposition
ECG	Electrocardiography
GNB	Gaussian Naïve Bayes
HCI	Human Computer Interface
HHT	Hilbert–Huang Transform
KNN	k-nearest neighbors
LDA	Linear Discriminant Analysis
MIR	Music Information Retrieval
MLP	Multilayer Perceptron Classifier
NH	Normal Hearing
PNN	probabilistic neural network
PCA	Principal component analysis
PSD	Power Spectral Density
RVM	Relevance Vector Machine
rCBF	Regional Cerebral Blood Flow
SampEn	Sample Entropy
SVM	Support Vector Machine

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces the direction of this work, the background that derives into carrying out this research as in section 1.2, problem statement is discussed as in section 1.3. In section 1.4, four objectives are conducted in this study. In section 1.5, research questions are presented. Significance of this research is explained in section 1.6. The scope of this study including and excluding criteria that are done in this work as in section 1.7. Section 1.8 presents the thesis layout.

1.2 Research Background

Emotion is omnipresent and an important factor in human life in interacting and communicating with people. Although emotion is intuitively known to everyone, it is still hard to define (Rahnuma et al., 2011). Besides that, emotion is one of the most important features of human. Without the ability of emotion processing, computers and robots cannot communicate with human in natural way (Murugappan, 2011).

There are various types of stimulations can be used to evoke human emotion such as music, pictures and movies. However, it is a well-known fact that music has various positive effects on users and their mechanism (Ito et al., 2007). Research articles explored the positive impact of music to reduce stress and depression level. Depression and/or stress is a serious problem in today's society. It has a bad influence on the human mind and body as well (Ogawa et al., 2004). Besides, relaxation and calmness evoked by music are widely used to treat a variety of health problems including hypertension, headache, anxiety, insomnia and stress (Chen et al., 2007).

The binaural beats is a music type used to treat people suffering from mental disorders. The binaural beats discovered by Heinrich Wilhelm Dove which are essentially sounds created by a specific physical stimulus. It has been proven to reduce stress level by gaining the relaxation (Naraballobh et al., 2015). Based on another study conducted by (Jirakattayakorn & Wongsawat, 2017) on 40 Hz binaural beat, it can be concluded that listening to a suitable duration of binaural beat (less than 20 minutes) can lead to positive

effects such as decrease in tension and depression while increasing the powerful energy. This could lead to improving working memory function.

Moreover, Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. Based on the cognitive theory of emotion the brain is the center of every human action, physiological signals, facial expressions and voice which are all generated as a result of brain signals (Mohd Aris et al., 2010). For several years, many researchers have focused on brain and physiological effects during listening to music. However, EEG is a technique used to detect human emotions through the brain activities and it is also a suitable device for catching the mental changing.

1.3 Problem Statement

Topics related to the effects of listening to variety types of music therapy have been a subject of interest to several researchers. Binaural beats music which are essentially sounds created by a physical stimulus have been proven to reduce stress level by gaining the relaxation. Various studies have been conducted to study the effect of music on diseases such as deafness, Mild Cognitive Impairment (MCI), Major Depressive Disorder (MDD), William Syndrome, as well as Stroke and Motor neuron disease. Nowadays, depression is one of the most popular brain disorders that effects humans' daily life (Ogawa et al., 2004). Managing an individual's daily life, perception, attention, decision making and memory

directly are the major roles of emotions. In order to communicate with each other, different states of their emotions must be conveyed (Hatamikia & Nasrabadi, 2011).

Moreover, extracting information from EEG is considered as a challenge to the researchers due to several reasons (i.e. artifact, body movement, eyes blinking etc.). State of subject's brain (absent-mindedness) is also reported as a challenge in the literature that faced the researchers previously. In addition to this, limitation of traditional clinics related to musical therapy is a challenge and reasoned a lack of information in the area of musical therapy. Moreover, experience of the subjects since it's the first time for them to attend this type of experiments also a reason might affect the results of this study.

Out of the survey articles, there are two studies focuses on the usage of binaural beat and its impact on human brain. Jirakattayakorn & Wongsawat, (2017) used binaural beat music peace of 40 Hz on Thai subjects. The aim of this study is to determine the effects of binaural beats towards memory as well as several emotional states. They reported, "It can be concluded that listening to a suitable duration of binaural beat (less than 20 minutes) can lead to positive effects such as decrease in tension while increasing the powerful energy".

The other study compared two type of music that is relax music and binaural beat music to investigate the impact of different music stimulus on human emotion (Naraballobh et al., 2015). This study was done to determine the effects that binaural beats have on stress. Depression, Anxiety, Stress Scales (DASS) questionnaire was employed in this study. Based on the experiment conducted by (Naraballobh et al., 2015), only the stress level out

of the three conditions investigated using DASS questionnaire which are, anxiety, depression and stress was determined while listening to binaural beat and relaxing music.

Based on these two studies, it can be concluded that there are limited researches in determining the effects of binaural beats towards depression. Considering the challenges that faced in previous studies and limitation of exploring the effects of such a treatment like musical therapy, this research attempts to identify the effects of listening to binaural beat on human emotion via EEG to help overcome depression problems.

1.4 Research Objectives

1. To investigate an academic literature review related to emotion, music and Electroencephalogram (EEG) analysis via systematic review.
2. To study the impacts of binaural beats music on human emotion represented in non-medical depression disorders through EEG signals.
3. To analyze descriptively the most conductive area and electrodes positions in frontal lobe which provide higher connection during the duration of recording.
4. To compare statistically between the three durations of listening (before, during and after listening) and to compare between the two age groups as well.

1.5 Research questions

1. What are the findings of investigating an academic literature review related to emotion, music and Electroencephalogram (EEG)?
2. What are the effects of listening to binaural beats music on human emotion among people suffering from depression?
3. What is the most conductive electrode and area in the frontal lobe which can provide higher connectivity?
4. Is there any significance differences between the compared durations and the age groups?

1.6 Significance of study

The research expected to make contributions to both human well-being and the discipline of computer science, particularly in understanding human brain when listening to binaural beats. Therefore, studying human emotions and their relationship to binaural beats may help people to overcome or reduce the mental disorders. Furthermore, it can help psychologists, health practitioners and therapists to understand the effects of listening to binaural beats. Electroencephalogram (EEG) is used to understand and analyze the functionality of the brain to identify or detect various mental disorders. Thus, the portability and affordability of the EEG equipment makes it a better choice in comparison with other brain imaging device such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET) and megnetoencephalography (MEG).

The impact of this research is to bring a new approach to meditation based on listening to binaural beats that can be applied in different disciplines to determine the impacts of music. Such an approach can help practitioners analyze patients more affordably. Moreover, the collected data will be analyzed and documented to scientifically indicate that listening to binaural beats is useful as a medicinal approach.

1.7 Scope of Study

This study will be conducted in Malaysia among university subjects to determine the effects of listening to binaural beat music on depression. In addition to this, this study is conducted to determine emotion represented in subjects suffering from depression. Binaural beats in the other side, is the type of music that will be used in the experiment of this study. EEG device channel is the device that will be used to measure the brain signals.

This study will not go through neither the brain map nor its sides. This study will not determine the accuracy neither the types of classifiers. To figure out whether the subjects have depression or not, this study utilized DASS depression, anxiety, stress scales questionnaire. Moreover, the collected data will be analyzed and documented to scientifically indicate that listening to binaural beats useful as medicinal approach.

1.8 Thesis Layout

This thesis consists of five chapters; Chapter One provides a background about the EEG techniques in determining the effects of musical stimulus on human emotion, problem statement, research objectives, research questions, significance and scope of study, the rest of the thesis is organized as follows:

Chapter Two: In this chapter, in-depth investigation was conducted for studying human emotion by utilizing EEG signals. A systematic review protocol is developed for literature review to analyze the challenges, motivations and recommendations and develop a taxonomy for the research articles in the area of EEG aspects related to emotion and music. EEG protocol design and data collection is also conducted and listed down.

Chapter Three: In this chapter, the research methodology and the follow of the research are deigned and reported. In addition to that, the main experiments to achieve the research objectives are designed. This includes data filtering, data transformation, feature extraction, descriptive analysis and statistics analysis.

Chapter Four: This chapter provides the research findings and discussion for the collected results. These results are discussed based on each objective in this study. Results and discussion of three steps of descriptive analysis and two for statistics analysis are reported in this chapter.

Chapter Five: In this chapter, conclusion of this research, future work and thesis conclusion are reported and explained.