RESTING STATE EEG CURRENT SOURCE DENSITY OF NEURAL OSCILLATION: A COMPARISON BETWEEN SCHIZOPHRENIA PATIENTS AND HEALTHY CONTROLS

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?'AKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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PROJEK SARJANA MUDA II

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A COMPARISON BETWEEN SCHIZOPHRENIA PATIENTS AND HEALTHY CONTROLS

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DEDICATION

Special for the beloved parents and siblings who have a lot of support in order to complete this study may all appreciate the sacrifice you are rewarded by Allah SWT.

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"In the name of Allah, the most Gracious, most powerful, and the most Merciful"

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ABSTRACT

The aim of our study was to detect changes in the distribution of electrical brain activity in schizophrenia patients compared to healthy controls. 15 patients with Schizophrenia (nine males; mean age ± standard deviation, 32.00 ± 9.38) and 15 matched healthy controls (nine males; mean age ± standard deviation, 32.65 ± 9.78 years) provided written informed consent and were enrolled in this study. Continuous EEG activity was recorded using Ag/AgCl electrodes mounted in a 64 channel actiCAP system (Brain Products, Munich, Germany). The frequency band that involves is delta (1.5-6 Hz), theta (6-8 Hz), alpha (8-12 Hz), and beta (12-30Hz). The objective of this project is to determine the EEG oscillation (frequency bands) that is significantly different between patients and healthy control and to determine the brain region that is responsible for the differences. Firstly, pre - processing will be done by filtering, down sampling, manual artifact detection to remove muscle artifact and artifact detection - using independent component analysis (ICA) to remove eye - blink and heartbeat, re-referencing and baseline correction. Next, the pre-processed data will be analyzed using Loreta software. Then, the oscillatory analysis will be conducted to determine the EEG oscillations (frequency bands) that are significantly different between patients and healthy controls. The results is show by comparing a schizophrenia patients and healthy controls, it was found a trend towards significant current density increase in the delta, theta, alpha, and beta frequency band. Lastly, the brain regions that are responsible for the differences at alpha and beta are cingulate gyrus (limbic lobe) and anterior cingulate (limbic lobe).

ABSTRAK

Tujuan eksperimen ini dijalankan ialah untuk mengkaji perubahan aktiviti otak yang terdapat pada pesakit Schizophrenia berbanding dengan orang yang tidak mempunyai penyakit ini. 15 pesakit Schizophrenia (sembilan lelaki; min umur ± sisihan piawai, 32.00 ± 9.38) dan 15 orang tanpa penyakit (sembilan lelaki; min umur ± sisihan piawai, 32.65 ± 9.78 tahun) telah diuji dan direkod dengan menggunakan EEG dengan kebenaran syarat bertulis. EEG direkod dengan menggunakan elektrod Ag / AgCl dipasang dalam sistem actiCAP 64 saluran (Brain Products, Munich, Jerman). Julat frekuensi yang terlibah adalah delta (1,5-6 Hz), theta (6-8 Hz), alpha (8-12 Hz), dan beta (12-30Hz). Objektif projek ini adalah untuk mencari perbezaan antara pesakit berbanding dengan orang sihat dan mencari bahagian otak yang menyebabkan perbezaan antara mereka. Projek ini menggunakan 2 perisian iaitu EEGLAB dan juga Loreta. EEGLAB digunakan untuk memproses data bagi mendapatkan data yang bersih and Loreta digunakan untuk analisa data untuk mencari bahagian otak yang menyebabkan perbezaan antara pesakit dengan orang sihat. Selepas eksperimen dijalankan, ia menunjukkan kawasan otak yang bertanggungjawab bagi perbezaan di alpha dan beta iaitu bahagian otak gyrus cingulate (lobus limbic) dan cingulate anterior (lobus limbic).

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CHAPTER 1

INTRODCUTION

Chapter 1 covers about the introduction part of this Final Year Project of Degree. This chapter will discuss about the project background, objectives of project, scope of project, problem statement, system operation, and organization of thesis.

Project Background

REST is Random Episodic Spontaneous Thoughts. EEG is recorded during, eye closed and awake. For this project, it will focus during eye closed only. Resting state is wakeful rest, mind-wandering, spontaneous thoughts, daydreaming, retrieving memories, stimulus independent thought, and absence of goal-directed neuronal action

and external input. It is not same with inactive brain. Electroencephalography (EEG) is a medical imaging technique that reads scalp electrical activity generated by brain structures.

Neural oscillation coordinate activity across brain areas. This process is found to be perturbed in patients with psychiatric disorder. By using pre - recorded Resting - State EEG, the abnormal patterns of oscillations and the brain regions involved in patients in comparison to healthy controls can be determined. Thus far, we have 15 EEG resting state recordings for patients and 15 for healthy controls. Firstly, pre - processing will be done by filtering, down sampling, manual artifact detection to remove muscle artifact and artifact detection - using independent component analysis (ICA) to remove eye - blink and heartbeat, re-referencing and baseline correction.

Next, the pre-processed data will be analyzed using Loreta software. Finally, the oscillatory analysis will be conducted to determine the EEG oscillations (frequency bands) that are significantly different between patients and healthy controls. The frequency band that involves is delta (1.5-6 Hz), theta (6-8 Hz), alpha (8-12 Hz), and beta (12-30Hz).

Objectives and Scopes of Project

This part will discuss about the objectives of the project and the scope of work regarding this project.

Project Objectives

This project is carried out on the following objectives:

i. To identify and remove EEG data artifacts (ocular, muscle noise, cardiac, electrode) using methods such as ICA.

ii. To compare oscillatory activity in specific frequency bands (delta, theta, alpha, beta) between patients with Schizophrenia and healthy controls.
iii. To determine the EEG oscillations (frequency bands) that is significantly different between patients and healthy controls.
iv. To determine the brain regions that is responsible for the difference in Schizophrenia patients and healthy control.

Scope of Project

This project concentrates on determining the EEG oscillation that is significantly different between schizophrenia patients and healthy control. Then continue with determining the brain region that is responsible for the differences. The software that was used to complete this project is Eeglab, Matlab, and Loreta.

By using the pre-recorded resting-state EEG, EEG data artifact can be identified and removed using ICA method. For the project limitation it only determines the EEG oscillation that is significantly different between patients and healthy control. Then, the brain region also can be determined between patients and healthy control. The functional connectivity is not covered for this project.

Problem statements

Neural oscillations coordinate activity across brain areas. This process is found to be perturbed in patients with psychiatric disorders. Next, previous studies show inconsistencies of reported findings regarding neural oscillations and the brain regions involved in patients with Schizophrenia.

From the first paper, it state that schizophrenia patient was characterized by augmented low-frequency power and reduce alpha band power. It also had more

negative symptoms which are larger third ventricles, larger frontal horns of the lateral ventricles, increased cortical sulci width, and greater ocular motor dysfunction.[1]

Next, the other paper state that low frequency including delta, theta, slow alpha and slow beta were abnormal in schizophrenia. Low frequency abnormality (delta and theta) may be associated with generic variants of catechol-O-methyltransferase in schizophrenia.[3]

Hence, in this study the disturbed oscillations and the brain region will be investigated in patients with Schizophrenia.

System Operation

This project concentrates on determining the EEG oscillation that is significantly different between schizophrenia patients and healthy control. Then continue with determining the brain region that is responsible for the differences. The software that was used to complete this project is Eeglab, Matlab, and Loreta.

Study about the resting state and EEG is a part of the literature review in order to understand more about this project. The other literature review is about previous studies regarding neural oscillations and the brain regions involved in patients with Schizophrenia.

By using the pre-recorded resting-state EEG, EEG data artifact can be identified and removed using ICA method. For the project limitation it only determines the EEG oscillation that is significantly different between patients and healthy control. Then, the brain region also can be determined between patients and healthy control. The functional connectivity is not covered for this project.

The software that will be used for pre-processing EEG data (including ICA) is EEGlab and Matlab. The step for pre-processing the data are filtering, down sampling,

artifact rejection, re-referencing, baseline correction and segmentation. Lastly, oscillatory analysis will be conducted with Loreta software.

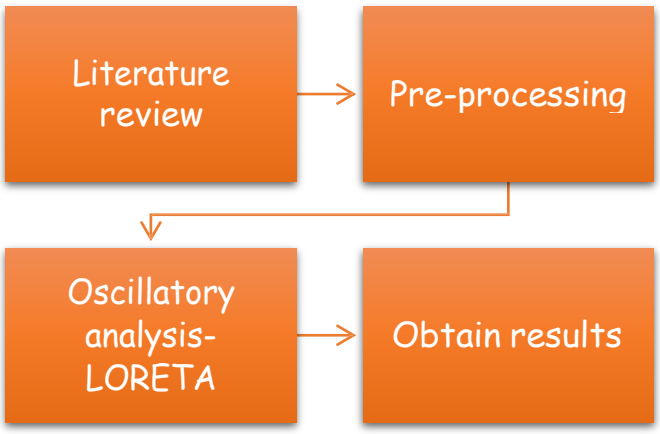

Figure 1.1 Overall Block Diagram of the project

Organization of thesis

The report consists of five chapters which is Chapter 1 will discusses about the introduction of the project which includes the objectives of the project, scope of the project, problem statements, and system operations.

In the second chapter, it narrates the literature review regarding the project, which including substantive findings.

The next chapter 3 discusses about the methodology and approach that has been taken on how the project is done. It also discussed about software development that has been applied in this project.

Then, chapter four will discuss more on the results and analysis of this project.

Last chapter which is chapter five consists of conclusion, some improvements and recommendation for future work related to this project.

CHAPTER II

LITERATURE REVIEW

A literature review is a text of a scholarly paper, which includes the current knowledge, including substantive findings, as well as theoretical and methodological contributions to this project. This chapter review of articles, books and journals to understand about the concept that needs to know in order to complete this project.

Resting State Electroencephalogram (EEG)

EEG is recoded in the resting state position. 15 patients with Schizophrenia (nine males; mean age ± standard deviation, 32.00 ± 9.38) and 15 matched healthy controls (nine males; mean age ± standard deviation, 32.65 ± 9.78 years) provided written

informed consent and were enrolled in this study. 15 patients with Schizophrenia and 15 healthy controls (HC) were included in the study. Patients who met the DSM-IV criteria for SZ were recruited through the Psychosis Center of the Department of Psychiatry of the University Medical Center Hamburg-Eppendorf. HC were recruited via the internet and word-of-mouth from Hamburg and its surrounding area.

Exclusion criteria for all participants were current substance abuse or dependence, presence of major somatic or neurological disorders. For HC, additional exclusion criteria were any previous psychiatric disorder or treatment. Handedness was assessed with the German version of the Edinburgh Handedness Manual (Oldfield, 1971).

Resting State

Resting state is wakeful rest, mind-wandering, spontaneous thoughts, daydreaming, retrieving memories, stimulus independent thought, and absence of goal-directed neuronal action and external input.

Electroencephalogram (EEG)

An electroencephalogram (EEG) is a medical imaging technique that reads scalp electrical activity generated by brain structures. It was used to sense different related to electrical activity of the brain. EEF can track and record the brain wave pattern. The most important uses of EEG are to diagnose and monitor seizure disorder. It will help to identify the causes of the other disorders such as seizure disorder, brain tumor, head injury, encephalopathy, encephalitis, sleep disorder, stroke, and dementia. For this project, it will focus for schizophrenia patients.

EEG may be used for various applications such as in neuromarketing, human factor, social interaction, psychology, neuroscience, clinical and psychiatric studies. In neuromarketing EEG is used for detect the brain processes that drive consumer decisions, brain areas that are active when we purchase a product/service, and mental states that the respective person is in when exploring physical or virtual stores. Next, for human factor EEG is used to identify brain processes related to specific personality traits such as intro-/extroversion or social anxiety and brain processes reflecting cognitive and attentional states during human-machine-interaction.

The History of the Electroencephalogram (EEG)

In 1929, a German psychiatrist named Hans Berger, who worked in the city of Jena, announced to the world that it was possible to record the feeble electric currents generated on the brain, without opening the skull, and to depict them graphically onto a strip of paper. Berger named this new form of recording as the electroencephalogram (EEG).

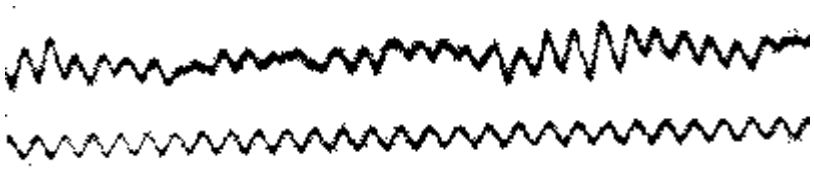

Figure 2.1: The first EEG recorded by Hans Berger, circa 1928.

Berger electrodes were too large to made detailed topographycal studies of the EEG. This was left to W. Gray Walter, a remarkable British scientist, who, in 1936, proved that, by using a larger number of electrodes pasted to the scalp, each one having a small size, it was possible to identify abnormal electrical activity in the brain areas around a tumor, and diminished activity inside it.

Impressed with the possibilities of building bidimensional maps of the EEG activity over the brain surface, W. Gray Walter invented the toposcope in 1957.

This was a remarkably complex device and showed Grey Walter's inventiveness (besides being a physician, he was also an engineer). It had 22 cathode ray tubes (similar to a TV tube), each of them connected to a pair of electrodes attached to the skull. The electrodes (and their corresponding tubes) were arranged in a bidimensional geometrical array, such as that each tube was able to depict the intensity of the several rhythms which compose the EEG in a particular area of the brain (the frontal, parietal and occipital lobes). This array of CRT tubes, were photographed face up, so that a kind of phosphorescent spiral display showed simultaneously which kind of rhythm was present in a particular part of the brain.

Gray Walter asked his subjects to perform several mental tasks, with the result that the EEG rhythms were altered in different ways, times and parts of the brain. He was the first to prove, for instance, that the so-called alpha rhythm (present during a resting state) disappears from almost all the brain during a mental task which demands awareness, being substituted by a faster rhythm, the beta waves.

The topographic study of brain electrical activity was born again only when fast desktop computers became available in the 80s. Thus, EEG brain topography was developed and is widely in use today. It is also called Color Brain Mapping.

Current Source Density

Current source density is class of methods of analysis of extracellular electric potentials recorded at multiple sites leading to estimates of current sources generating the measured potentials.