



Faculty of Cognitive Science and Human Development

**Quantitative Analysis of EEG Activity in Mild and Moderately
Depressed Young Adult**

Lim Zi Xiang

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Quantitative Analysis of EEG Activity in Mild and Moderately Depressed Young Adult

Lim Zi Xiang

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(Cognitive Neuroscience)

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“Do not be anxious about anything, but in every situation, by prayer and petition, with thanksgiving, present your request to God.”

Philippians 4:6

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ABSTRACT

Several brain regions that show abnormal activities are known to be linked to depression such as anterior region of the brain and prefrontal cortex (PFC). Besides that, the persistence of default mode network (DMN) on the inferior parietal lobe (IPL) also associated to rumination of negative thoughts. This study aimed to identify the distinction in brain activity of young adults suffering mild and moderate depression in Malaysia. Quantitative Electroencephalography (qEEG) sources were assessed from 12 depressed university students with recommendation from counselors and 12 healthy university students. Participants were then group according to Beck Depression Inventory (BDI) criteria. The results of current study shows significant difference in beta1 ($U = 43.0$, $p = .050$, $r = .34$) and beta2 ($U = 43.0$, $p = .050$, $r = .34$) activities on the anterior region of the brain and heightened theta activity ($U = 41.0$, $p = .038$, $r = .37$) on the PFC in the depressed group. However, IPL in depressed group shows no persistency of alpha activity unlike previous study and has no relation to rumination thoughts ($r_s(24) = -.034$, $p = .44$). Excess beta activity is often found on patients suffering from depression and those with recurrent depression and excess theta on PFC is an indication of dysfunction in attention and working memory. Furthermore, coherence analysis supported the notion of imbalanced functional processes and low coherence on left and right frontal are potential areas for Neurofeedback Training (NFT).

Keywords: qEEG, DMN, Anterior, PFC.

***Analisis Kuantitatif Aktiviti EEG Kemurungan Ringan dan Sederhana dalam Kalangan
Belia***

ABSTRAK

Bahagian otak seperti bahagian anterior dan prefrontal cortex (PFC) yang mengalami ketidakbiasaan adalah tanda-tanda kemurungan. Selain itu, default mode network (DMN) yang berterusan di inferior parietal lobe (IPL) juga berhubungkait dengan pemikiran yang negatif. Kajian ini bertujuan untuk mengenalpasti perbezaan aktiviti otak dalam kalangan belia yang mengalami kemurungan ringan dan sederhana di Malaysia. Quantitative Electroencephalography (qEEG) telah digunakan untuk menilai 12 individu yang mengalami kemurungan dan 12 individu yang sihat. Peserta dibahagikan kepada kumpulan mengikut ciri-ciri Beck Depression Inventory (BDI). Keputusan menunjukkan perbezaan yang significant pada beta1 ($U = 43.0$, $p = .050$, $r = .34$) dan beta2 ($U = 43.0$, $p = .050$, $r = .34$) pada bahagian anterior otak serta aktiviti theta yang berlebihan ($U = 41.0$, $p = .038$, $r = .37$) pada PFC dalam kalangan kumpulan kemurungan. Bagaimanapun, IPL dalam kalangan pesakit kemurungan tidak menunjukkan aktiviti alpha secara berterusan, tidak seperti yang dinyatakan pada kajian terdahulu dan tiada hubungkait dengan ruminasi pemikiran ($r_s(24) = -.034$, $p = .44$). Aktiviti beta yang berlebihan selalu didapati pada pesakit kemurungan dan kemurungan berulang. Theta pada PFC yang berlebihan menunjukkan kegagalan berfungsi di dalam pemerhatian dan daya ingatan. Tambahan pula, analisis koheren menunjuk kepada masalah proses fungsional dan koheren yang rendah pada bahagian frontal kiri dan frontal kanan merupakan bahagian yang berpotensi untuk rawatan Neurofeedback Training (NFT).

Kata kunci: *qEEG, DMN, Anterior, PFC.*

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LIST OF ABBREVIATIONS

Notation

AAPB	Association for Applied Pyschophysiology and Biofeedback
BDI	Beck Depression Inventory
CNS	Central Nervous System
DLPFC	Dorsal Lateral Prefrontal Cortex
DMN	Default Mode Network
dMPFC	Dorsal Medial Prefrontal Cortex
EC	Eyes Closed
EEG	Electroencephalogrpahy
EO	Eyes Open
FFT	Fast Fournier Transform
fMRI	Functional Magnetic Imaging
Hz	Frequency/Relative Power
IPL	Inferior Parietal Lobe
LORETA	Low Resolution Electromagnetic Tomography
MDD	Major Depressive Disorder
Mdn	Median
MRI	Magnetic Resonance Imaging
N	Sample Size
NFT	Neurofeedback Training
OFC	Orbito Frontal Cortex
p	p-value
PET	Positron Emission Tomography

PFC	Prefrontal Cortex
qEEG	Quantitative Electroencephalography
r	Effect Size
rACC	Rostral Anterior Cingulate Cortex
r_s	Spearman's correlation Coefficient
REM	Rapid Eye Movement
ROI	Region of Interest
RRS	Ruminative Response Scale
SD	Standard Deviation
SGH	Sarawak General Hospital
SPECT	Single-photon Emission Tomography
U	Mann Whitney U
vMPFC	Ventral Medial Prefrontal Cortex
Z	Standard Score
μV^2	Absolute Power

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter served to introduce the genesis of current study that came upon review on the prevalence of Depression in Malaysia and the world, as well as the application of qEEG in investigating the brain sources or pattern of those suffering depression. Clear research objectives, hypotheses, definition of terms and conceptual framework was intended to be delivered in this chapter to help anyone that are either involved in the field of cognitive neuroscience or not understand the notion of current study and what this study wanted to contribute in the field of cognitive neuroscience, mental disorders and affective studies.

1.2 Background of Study

According to World Health Organization (WHO), depressive disorder or depression is a mental disorder that causes depressed mood, loss of interest and pleasure, guilt, low self-esteem, anxiety, lethargy, sleep disturbance and drastic changes in bodyweight (Marcus, Yasamy, Ommeren, Chisholm, & Saxena, 2012). The prevalence rate of depression holds 10.4 percent of the approximate 24 percent of mental disorders in primary health care worldwide according to the World Health Report (World Health Organization, 2001). Depression is continuously on the rise and by year 2020, depression will be one of the main causes of worldwide disability. In Asia Pacific region, rates of major depression range from 1.3 to 5.5 % and it is still comparable with other western countries. In Malaysia, depression is most reported and treatable mental disorder. It is predicted to affect

approximately 2.3 million people in Malaysia at some point of their life (Mukhtar & Oei, 2011). The overall prevalence of depression in Malaysia is 3.9 to a whopping 46% in comparison to 9% in United State (Depression, 2011). Prevalence in primary health care in a single study shows a range between 6.7 to 14.4 % in Malaysia. The comparison of prevalence of depression between the elderly in Malaysia also shows that Malaysia have higher rate (6.3 - 18%) of depression in comparison to United State (1 – 2%) (Mukhtar & Oei, 2011). Other depressive disorder statistics such as postpartum depression is shown on Table 1.1.

Table 1.1: Comparison on the prevalence of depression in Malaysia and United State (%)

	Overall	Primary Care	Elderly	Postpartum
Malaysia	3.9 – 46*	6.7 – 14.4*	6.3 – 18*	3.9 – 20.7*
United State	9	6.3	1 – 2*	5 – 25*

*An approximate percentage of the statistics

Note. Data for prevalence of depression in Malaysia from Mukhtar & Oei (2011), and for United State from Depression (2011).

1.2.1 Impact of Depressive Disorders

Depressive episodes occur to everyone in different period of lifetime and if not carefully dealt with will potentially turn chronic and recurrent. It will further disrupt one's ability to take of their daily responsibilities. WHO study also shows cases of depression reported are 50% higher in female than male (Marcus et al., 2012). Depression has impacted individuals, families and communities in different aspect such as stigma and discrimination, socioeconomics, quality of life, and suicide rates. In worldwide, depression has affected 121 million people and severe depression has cause 850 thousand death in a year (Bromet et al., 2011). Families that have members suffering with depression have to

provide physical and emotional supports while facing discrimination themselves, this make coping with members with depression more difficult. In order to cope with members with depression, families need to sacrifice their social circles outside of the family and loss productivity in their work (not taking up overtime work for projects and assignment to spend time with family members). In a study on burden of diseases shows that out of the 31% of burden from neuropsychiatric conditions, 12% of the burden comes from depressive disorders which was also the highest in all neuropsychiatric conditions. In Southeast Asia, 27% of the burden of diseases comes from neuropsychiatric condition but the burden of depressive disorder specifically was uncertain (World Health Organization, 2001).

The economic impacts of depression are often long-term and costly such as health and social service needs that is possibly for a lifetime. Besides that loss of employments of those suffered depression and some of them are breadwinner of the family will affect the family financially. Other non-physical costs such as reduce productivity that was mentioned earlier will bring impact on the families and caregivers as well. According to a few studies of the economic costs of mental disorders done in United States, United Kingdom and Holland showed that the yearly cost of mental disorder can range from 2.5 – 23% of the health services and inpatients expenditure (World Health Organization, 2001).

The impact of depression on the quality of life was another aspect that was measure using a subjective rating for individual in various area of their life. The result shows that Quality of Life (QOL) rating was poor even after recovery from depression due to the stigma and discrimination of mental disorder in society. Those suffers from depression and did not

have basic social and functioning needs met are shown to be the largest predictor of low rating QOL (World Health Organization, 2001).

The current preferred treatment is the combination of anti-depressant and psychotherapy especially in resource-constrained countries such as Uganda, Chile and India. Treatments such as interpersonal psychotherapy, psycho-educational group intervention and psycho-social intervention. Such primary care treatments are considered cost-effective and feasible according to economic analysis (Marcus et al., 2012).

1.2.2 Quantitative Electroencephalography

Brain imaging has been providing insight about structural or functional anomaly in patients with various mental disorders and shown it is linked with brain dysfunctions. These imaging tools includes magnetic resonance imaging (MRI) functional magnetic resonance imaging (fMRI), positron emission tomography (PET) single-photon emission computed tomography (SPECT), conventional electroencephalography (EEG), and quantitative electroencephalography (qEEG). One of the most commonly used non-invasive imaging tool is EEG, and with software that utilized Fast Fourier Transform (FFT) algorithms, brain waves recorded can be quantify into numbers that provides information on the relative and absolute power of different waves. Electrophysiological assessment using EEG and qEEG are the most practical methods as it is relatively simple to be used, inexpensive, mobile equipment (depending on the brand and model). Besides that, it has the most replicated evidence regarding psychiatric and mental disorders in academic and clinical studies. However, adaptation of EEG and qEEG has not been extensive in clinical community due to its lack of psychiatric studies in comparison to electrophysiological

brain research studies even though more than 500 EEG and qEEG studies reports on brain anomaly was in accordance to high proportion of psychiatric patients (Hughes & John, 1999).

The beginning of application of EEG dated back to 1929 when Hans Berger published the first EEG sample of his son. The first EEG sample of his 16 years old son included an approximately 10 Hz which is later called alpha EEG rhythm and a faster desynchronized EEG that was later called beta EEG rhythm (Berger, 1929). Conventional EEG was previously inspected visually until digital equipment was available to quantify the EEG sample power spectrum. This power spectrum analysis are what now known as qEEG and there are often debates on whether qEEG should be analyze without the conventional EEG wave graph (Arns et al., 2011). One of the earliest applications of EEG in depression study was done by Lemere (1936) where the study shows that the ability to produce normal alpha waves is a characteristic that the affective capacity of an individual is normal. Discoveries of EEG and qEEG studies on depression were covered in literature review on previous studies.

1.2.3 Basic qEEG definition

The most basic qEEG recording was usually done in 19 electrodes and position in accordance to the international 10-20 system (Homan, Herman & Prudy, 1987). Normally sample of eyes open and eyes closed are recorded around the time frame of 3-5 minutes because anything longer than it might be compromised with drowsiness. The sample will then be edited to remove any artifacts (air conditioning sound, statics, body movements, and etc.). FFT algorithm will then quantify the sample as mentioned earlier and produced

an averaged frequency for each band known as power spectrum. The frequency range was previously separated to 4 frequency bands which are defined as delta (1.5 – 3.5 Hz), theta (3.5 – 7.5 Hz), alpha (7.5 – 12.5 Hz), and beta (12.5 – 30 Hz) (Hughes & John, 1999). Later another frequency range was introduced defined as gamma (>30 Hz). These averaged frequencies are represented as absolute power (μV^2) and relative power (Hz) (Table 1.2).

Table 1.2: Frequencies, normal occurrence and significance of each frequency bands

Band	Frequency (Hz)	Normal Occurrence	Significance
Delta	1.5 – 3.5	Deep Sleep and Infants	Sign of brain dysfunction, lethargy or cognitive impairment
Theta	3.5 – 7.5	Young Children, lethargy and some characteristics of learning	Often related to attention or cognitive impairment
Alpha	7.5 – 12.5	Eyes closed, relax and self – awareness	Excessive alpha frequency waves might be an indication of learning difficulty and relating with environment
Beta	12.5 – 30 Hz	Alert and anxious	Excessive beta frequency waves might indicate anxiety or irritability
Gamma	>30 Hz	Associated with problem solving and memory consolidation.	N/A

Note. Reprinted from Coben, Linden & Myers (2009)

1.2.4 qEEG and Depression

Many of EEG and qEEG studies reported a high numbers of patients with depression has abnormal brain electrical activity. EEG identified abnormal sleep pattern often exerted on the right hemisphere of the brain of those suffering depression and qEEG studies shows that there are increase alpha and theta activities as well as asymmetry brain electrical activity on the right hemisphere (Hughes & John, 1999).

1.2.5 Brain Default Mode Network and Rumination

According the reviews prior to the study in Raichle et al., (2001), imaging of brain activities have consistently shown a specific region of interest (ROI) activated when a specific task was introduced. This observation was confirmed by comparing subjects performing different tasks or multiple groups of subjects performing similar task. While not performing specific task, activity in that particular region of the brain decreases consistently making Raichle and his colleagues speculate whether it is because (a) the decreasing activity is just an indication of another task-induced activity that coincidentally activates the area that was proposed as the baseline state of the brain or (b) is cause by increasing activity of the baseline state activity that is consistent to subject that is in resting state thus, a 3-group comparison study was performed (2 control groups and 1 compare group). The result in the comparison group shows that baseline state is consistent across different scenario by utilizing the ratio of oxygen used by the brain to the amount oxy-hemoglobin blood supplied to that ROI (Raichle et al., 2001). This activity that increases during resting state are known as task negative network or Default Mode Network (DMN). Another study looked into associating the DMN activity with the possible mental processes that is occurring and its specific ROIs. The study identified the subsystems that interact

with each other to form a network when the subject is in a resting or baseline state (Raichle et al., 2001). The core regions of associations in the brain's DMN are Ventral Medial Prefrontal Cortex (vMPFC)/ rACC, Posterior Cingulate/Retrosplenial Cortex, Inferior Parietal, Lateral Temporal Cortex, Dorsal Medial Prefrontal Cortex (dMPFC) and Hippocampal formation (Figure 1.1). Synthesizing multiple past studies revealed that all core regions or subsystems often interact with each other and appear consistently through different subjects and different approaches of observation and study (Buckner, Andrews-Hanna & Schacter, 2008).

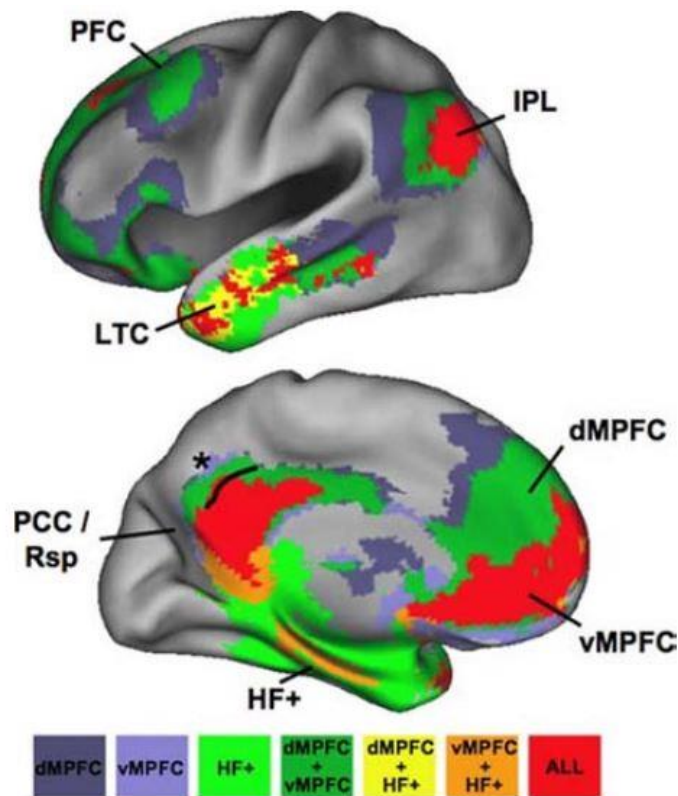


Figure 1.1: Hubs and subsystems within DMN. Reprinted from Buckner et al. (2008).

This study reviewed the association of DMN and the possible mental processes that is happening simultaneously. It reviewed many studies that used Stimulus-Independent

Thoughts approach which involve having thoughts other than the original events in the environment in understanding the mental processes associating with DMN. This approach reviewed that DMN activity is correlated with the activity of daydreaming, a passive cognitive state. Buckner, Andrews-Hanna and Schacter (2008) explored two possibilities of DMN which is (1) engaging in internal mentation that excludes the external environment or (2) monitoring the external environment. The internal mentation coined in this study includes the process of self-reflective thoughts, inferring social and emotional contents, recalling memories and imaginative construction. These activities activate major part of the MPFC and hippocampal formation. Role of monitoring external environment includes attention on the surrounding environment and this hypothesis was related and assess through target-detection tasks.

The association between DMN with depression was studied as well by Berman et al. (2011) to find out if the persistence of DMN activity when a person shift from resting to engaging in task is a sign of rumination in negative emotions and thoughts. The study collected the reading of both depressed and healthy subjects' brain and compared the activation of DMN. Depressed subjects show a higher neural connectivity of DMN and the DMN activity is correlated with the Rumination Response Score (RRS), a self-report questionnaire. The correlation test analysis revealed that both the DMN persistence and RRS score is correlated, suggesting that the persistency in DMN is related to rumination of negative thoughts and emotion.

1.3 Problem Statement

qEEG studies on depressions greatly provided knowledge on how mental disorders are reflected on dysfunction or alteration of brain activity, some studies even show that abnormal changes in brain activity can be an indicator of developing mental disorders or prediction for treatment outcome (Volk et al., 1997). qEEG findings on abnormal brain electrical activity also served as targeted training ROI for Neurofeedback Training (NFT) that helps regulate desired brain waves or frequency bands within specific durations and sessions. According to the Task Force standard by the Association for Applied Psychophysiology and Biofeedback (AAPB) and International Society for Neurofeedback and Research (ISNR), NFT for Depression is rated as Level 2, “Possibly Efficacious” (Yucha & Montgomery, 2008).

Questions that arise from the legitimacy of qEEG findings as accurate reference to depression is the inverse problem that proposed EEG imaging tools are only able to pick up the activity on the cerebral cortex and rather a larger region of interest rather than specific neurons that are now capable to be observed using more precise equipment. Besides that, application of such findings that are mostly coming from United States and Europe might not be that significant in South East Asia countries such as Malaysia. The differences in culture and socioeconomic background are big influence of the sources of depression. Different observation might be found on those suffering from depression and so far no study on depression using qEEG has been done in Malaysia.

Common findings from previous studies regardless of the imaging tools used such as asymmetry activity on both hemispheres in frontal and parietal regions, elevating activity

on the anterior region of the brain and low activity on the dorsal lateral prefrontal cortex (DLPFC) will be some of the targeted ROI together with other ROI from previous studies. Table 1.3 shows the ROI that will be investigated in current study.

Table 1.3: ROIs from previous studies that will be investigated

Hypothesis	Previous Study	Site	Bands
1	Grin-Yatsenko et al. (2010)	Parietal	Theta
			Alpha
		Occipital	Theta
			Alpha
	Ricardo-Garcell et al. (2009)	DLPFC	Theta
			Alpha
2	Li et al. (2015)	T4	Alpha
	Debener et al. (2000); Hagemann et al. (2001)	Anterior vs. Posterior	Alpha
	Debener et al. (2000); Ricardo-Garcell et al. (2009)	Left vs. Right Hemisphere	Alpha
3	Mientus et al. (2002)	PFC	Theta
	Nystrom et al. (1986); Dierks et al. (1993); Knott et al. (2001)	Anterior	Beta1 Beta2

Another area that current study interested to look into is the relationship between DMN and depression. Pizzagalli (2011) hypothesized that DMN activate when self-referencing, introspection and other internal processes is happening. His study also speculated the possibility of rumination (repetitive focus on negative thoughts) occurring on depressed participants when they need to shift from resting state to task-elicited state. This

predominance of DMN found in several studies of DMN and depression (Marchetti, Koster, Sonuga-Barke & De Raedt, 2012; Knyazev et al., 2016) prompted this study to find out if the same observation will be found and if it does, will it be reflected on the Ruminative Response Scale (RRS) that measure the rumination of thoughts.

Current study sought to find out if the results are replicable in Malaysia and investigate if predominance and persistency of DMN activity after resting state a signature of depression and related to rumination of negative thoughts.

1.4 Research Objective

The objective of this study was to identify the distinction in brain activity of mild and moderate depressed young adults.

Specific Objective

The main objective was broken down in to several specific objectives;

- i. Identify region of interest(s) (ROI) that is different in depressed participants in brain activity,
- ii. Verify if DMN activity is different in depressed participants and persist at eyes open state,
- iii. Conduct coherence study for additional analysis on brain activity in both groups.

1.5 Hypothesis

The hypotheses proposed in this study are based on previous studies and aligned to the specific objective mentioned earlier;

Specific objective (i):

Identify region of interest(s) (ROI) that is different in depressed participants in brain activity.

H₀₁: There is no difference in theta & alpha activity at DLPC, parietal and occipital region between depressed and normal participants

H_{a1}: There is difference in theta & alpha activity at DLPFC, parietal and occipital region between depressed and normal participants

H₀₂: There is no difference in alpha activity at T4, anterior - posterior region, and left - right hemisphere between depressed and normal participants

H_{a2}: There is difference in alpha activity at T4, anterior - posterior region, and left - right hemisphere between depressed and normal participants

H₀₃: There is no difference in theta activity at PFC and beta activity at anterior region between depressed and normal participants

H_{a3}: There is difference in theta activity at PFC and beta activity at anterior region between depressed and normal participants

Specific Objective (ii):

Verify if DMN activity is different in depressed participants and persist at eyes open state.

H₀₄: There is no difference in alpha activity at Inferior Parietal Lobe (IPL) region between depressed and normal participants; and no relationship between alpha activity in IPL region and RRS score in eyes open task

H_{a4}: There is difference in alpha activity at Inferior Parietal Lobe (IPL) region between depressed and normal participants; and a relationship between alpha activity in IPL region and RRS score in eyes open task

Specific Objective (iii):

Conduct coherence study for additional analysis on brain activity in both groups.

Research Hypothesis 5:

Depressed participants will display lower or higher coherence in ROIs that is distinct from normal participants.

1.6 Conceptual Framework

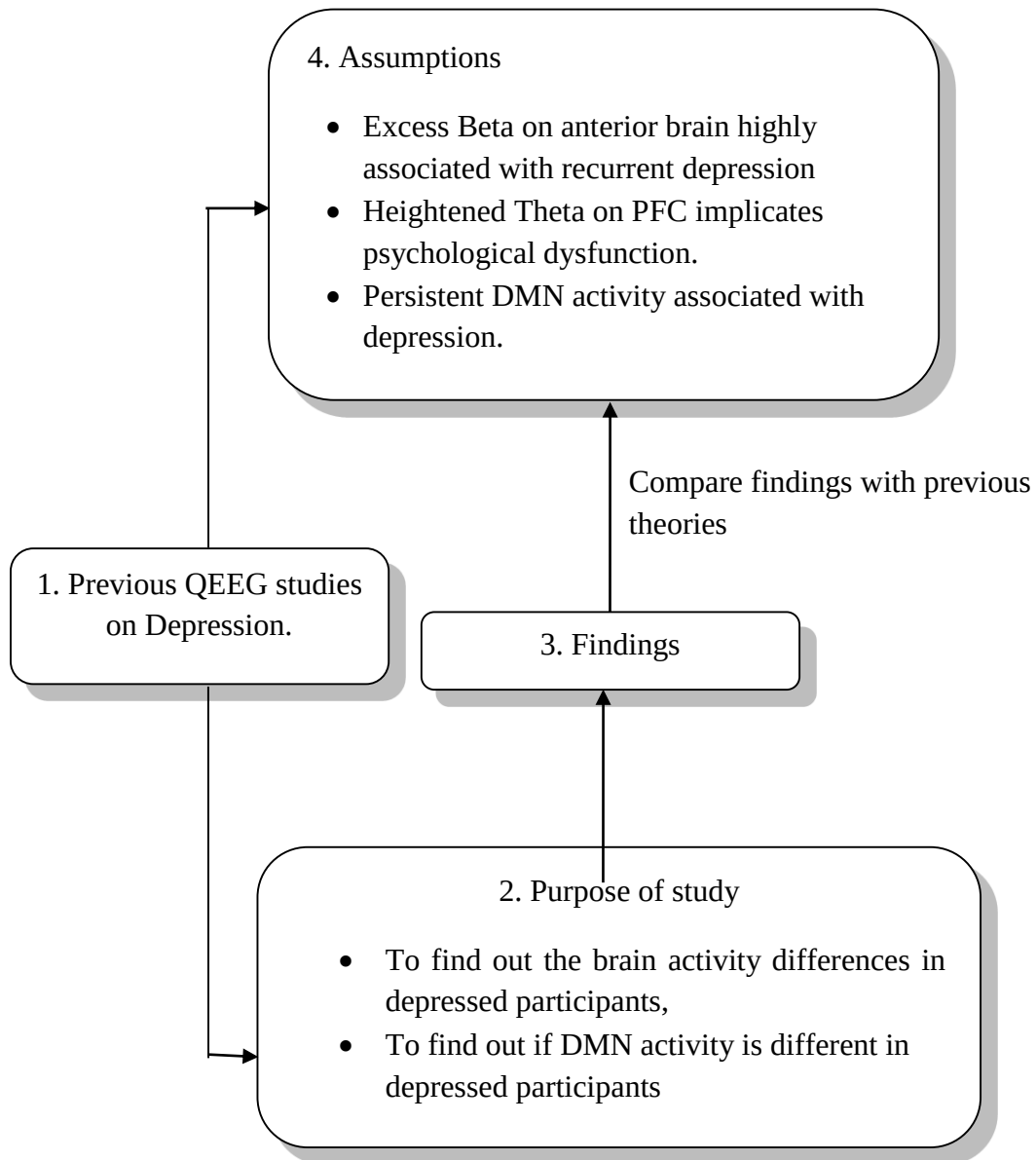


Figure 1.2: Conceptual framework for current study

1.7 Terminology

Default Mode Network

Default Mode Network (DMN) is operationally defined as a network of brain regions that activate during resting state. The opposite of DMN is Task Positive Network (TPN) which is activated when a task is presented. DMN includes Ventral Medial Prefrontal Cortex (vMPFC)/ rACC, Posterior Cingulate/Retrosplenial Cortex, Inferior Parietal Lobe (IPL), Lateral Temporal Cortex, Dorsal Medial Prefrontal Cortex (dMPFC) and Hippocampal formation (Buckner, Andrews-Hanna and Schacter, 2008) but in this study will only focus IPL that is located at the cerebral cortex of the parietal lobe.

Frequency Bands

Frequency Bands is operationally defined as the brain waves captured using Electroencephalography. The frequency bands displayed includes delta, theta, alpha, beta1, beta2, and gamma bands. They are indicator if the brain activity in that particular region of interest (ROI) is slow (delta, theta and alpha) or fast (beta1, beta2 and gamma). The band that has the highest absolute value (μV^2) indicates the most dominant bands on the ROI.

International 10-20 System

The International 10-20 System is operationally defined as guide to the placements of the 19 electrodes on the scalp. The label for Fp refers to Frontal Pole, F refers to Frontal Lobe, T refers to Temporal Lobe, P refers to Parietal Lobe, C refers to Central Lobe and O refers to Occipital Lobe (Homan, Herman and Purdy, 1987).

Mild & Moderate Depression

The categorization for mild and moderate depression was determined by the score of BDI-II that is within 14-28 (Beck et al., 1961).

Quantitative Electroencephalography

Quantitative Electroencephalography (qEEG) is operationally defined a non-invasive tool to study brain electrical activity. qEEG recording pick up the differences in electrical potential throughout scalps via electrodes that is placed according to the international 10-20 system. The electrical potential is then converted into numerical data such as absolute power (μV^2) and relative power (Hz) via Fast Fourier Transform (FFT) algorithm.

Region of Interest

Region of interest (ROI) are areas on the cerebral cortex that was studied based on previous studies that shown significant differences between depressed and normal group.

The ROIs included:

- parietal region (C3, Cz, C4, P3, Pz, P4)
- occipital region (O1, O2)
- DLPFC (F7, F3, F4, F8)
- posterior region (T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2)
- anterior region (Fp1, Fp2, F7, F3, Fz, F4, F8, C3, Cz, C4)
- PFC (Fp1, Fp2)
- Left hemisphere (Fp1, F7, F3, Fz, T3, C3, Cz, T5, P3, Pz, O1)
- Right hemisphere (Fp2, Fz, F4, F8, Cz, C4, T4, Pz, P4, T6, O2)

1.8 Significant of Study

This study contributed to the extension of the knowledge in the field of qEEG and depression researches. This study aimed to confirm theories in previous studies in a localized context, specifically in young adults. Some of the observations found in previous study was able to be replicated in this study, such as the excess beta bands on the anterior region and heightened theta activity on the PFC of the brain (Knott, Mahoney, Kennedy, & Evans, 2001; Mientus et al., 2002). Similar results found in Malaysia that suffered from mild and moderate depression helped raised questions such as whether changes in brain activity due to depression differ depending on culture or does the source of depression (i.e. studies, post-trauma, social issues) reflect differently through changes in different regions of the brain.

Secondly, this study also served to show the consistency of results found in previous studies. Similar findings in different studies from different countries show the reliability of the knowledge gained throughout years of studies and will be useful for development of medication or therapy. While determining the efficacy of qEEG imaging on depression requires meta-analysis that are thorough and more precise, this study helped to support previous findings and answer to uncertainty and questions on the reliability of using qEEG as a method to detect any anomalies in brain activity occurred from people suffered with depression.

1.9 Conclusion

This chapter provided necessary highlight in research objective, hypotheses, framework and terminology that guide the quantitative analysis of EEG study in depression. Chapter two introduced the history of brain imaging studies from multiple imaging tools that contributed to the basis of current study. It covers the details such as sample size, methodology and results of previous studies as references that support this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed on previous studies such as PET/SPECT studies on depression, sleep and wake EEG studies on depression, qEEG studies on depression and fMRI studies on depression. These previously served to provide a long history of the application of using different brain imaging tools to study depression in contrary to the more conventional psychological or psychiatrics studies on depression. The main focus of this chapter served to show the legitimacy of using brain imaging tools as an effective method to understand depression through observing changes or differences in brain activity. Secondly, it also help to inspired ways to study brain anomaly in depression from a different angle and added challenge in understanding the effect of depression in human brain's Default Mode Network (DMN) as well as some previous studies that proved the existence of DMN.

2.2 PET/SPECT Studies on Depression

One of the earliest methods for brain imaging was utilizing blood flow in brain to find region of interest (ROI). In 1992, Bench and his colleagues did a study to find out the association between depression and functional disturbance in one or several cerebral neurotransmitter pathways using PET scan. The study involved 33 depressed participants and 23 non-depressed or normal participants and was assessed using Schedule for Affective Disorders and Schizophrenia (SADS) and Hamilton Depression Rating Scale (HDRS). The result of Bench and colleagues study revealed those suffered depression had decreased blood flow in left anterior cingulate and left dorsal lateral prefrontal cortex

(DLPFC) when resting. The decreased blood flow on DLPFC was reported to be common among major psychiatric syndromes. In comparison for cognitive impairments, blood flow of those suffered depressed increased in the left medial frontal gyrus. This also was reported to be a symptom of impaired higher-order cognitive function (Bench et al., 1992).

Another study by Drevets et al. (1992) on finding functional features that characterized depressed and normal brain pattern with 13 depressed and 22 normal participants that was assessed using HDRS. The result shows that depressed participants has increased blood flow on the left ventral lateral prefrontal cortex (VLPFC) and left amygdala. The increased blood flow on left amygdala was associated with the dysfunction in evaluating affective labels and the abnormal blood flow increase in VLPFC can be a cause of loss experience and expression of emotion related to thoughts.

Mayberg and her colleagues also conducted similar study using SPECT scan to find out if selective dysfunction is present in paralimbic cortex of those suffering depression by measuring brain perfusion. 13 depressed participants was assessed using HDRS, present state examination (PSE) and mini mental state examination (MMSE) and the result of this study revealed that blood flow decreased on both sides of the frontal cortex in depressed participants. Besides that, blood flow decreased was found on the paralimbic cortex, specifically on the cingulate cortex in depressed participants. The abnormal decreased blood flow in paralimbic cortex can contribute to the dysfunction of regulating emotion (Mayberg, Lewis, Regenold, & Wagner Jr., 1994). Table 2.1 shows the summary of previous studies using PET/SPECT scan.

Table 2.1: Previous studies on depression using PET/SPECT scan

Author(s)	Year	Sample Size	Method	Result	Country
Mayberg et al.	1994	13 Depressed (3 M, 10 W)	HDRS, PSE, MMSE	Blood flow (BF) decrease bilaterally in frontal cortex, blood flow decreased in paralimbic, specifically inferior and cingulate cortex in depressed	Maryland, USA
Drevets et al.	1992	13 D, 22 N	HDRS	BF increase in left VLPFC, increase BF on left Amygdala BF decrease in left anterior cingulate and left DLPFC. Comparison on depression related cognitive impairment, BF increased in left medial frontal gyrus	Kansas, USA
Bench et al.	1992	33 D, 23 N	SADS, HDRS		London, UK

2.3 fMRI Studies on Depression

Functional Magnetic Resonance Imaging (fMRI) was commonly used for studying the functional brain activity pattern of those suffering mental disorders, especially depression. A study by Wagner and his colleagues which seek to find out why those suffering depression are not able to inhibit conflicting affective response by deactivating the rostral anterior cingulate cortex (rACC). The study involved 16 depressed and 16 normal participants and went through structured clinical interview for DSM-4 (SCID) before they were recruited for this study. The result revealed hypoactivation on the orbitofrontal subgenual cortex (OFC) and hyperactivation on rACC. The hyperactivation of rACC during Stroop Test confirmed the hypothesis that it can be relate with the inability to inhibit rACC when faced with conflicting affective task. Besides that, the hypoactivation of OFC can be associated with the dysfunction of processing emotions such as aggression, depressed mood and anxiety (Wagner et al., 2008).

Another study by Halari et al. (2009) which aim is to investigate whether adolescent with Major Depressive Disorder (MDD) shows abnormality in brain activation when performing attentional and cognitive control tasks. This study involved 21 MDD and 21 normal adolescents and was assessed with Beck Depression Inventory (BDI), SADS, Rosenberg Self-esteem Scale (RSES) and the Stressful Life Events Schedule (SLES) before being recruited in this study. The result of this study shows there are reduction of activity in DLPFC, inferior prefrontal cortex (IFC) and anterior cingulate gyrus (ACG). This reduced activation on task-relevant areas in different attention and cognitive control tasks suggested dysfunction in neuropsychological performance.

Later fMRI studies in depression such as Herrington and his colleagues' study that aimed to find out the relationship of asymmetric brain activity pattern and emotional processes of those suffering depression. This study included 11 depressed and 18 normal participants that was screen through using the Mood and Anxiety Symptom Questionnaire (MASQ) and Penn State Worry Questionnaires (PSWQ). The result of this study shows both group have leftward activation in DLPFC for pleasant words but the depressed group shows more rightward activation on the DLPFC. This result suggested that there is dysfunction on modulating negative emotions in those suffering depression (Herrington et al., 2010). Table 2.2 shows the summary of previous studies using fMRI.

Table 2.2: Previous studies on depression using fMRI

Author(s)	Year	Sample Size	Method	Result	Country
Herrington et al.	2010	11 D, 18 N	MASQ, PSWQ	both group shows similar leftward lateralization for pleasant words in DLPFC, depressed shows more rightward lateralization in DLPFC	Pennsylvania, USA
Halari et al.	2009	21 MDD, 21 N	SADS, BDI, RSES, SLES	Reduced activation in MDD's DLPFC (Simon Task), IFC (Stop Task) & ACG (Switch Task). hypoactivity on orbitofrontal, subgenual cortex and hyperactivity rACC and negative correlation between the two	Canada
Wagner et al.	2008	16 D, 16 N (all female)	SCID		Germany

2.4 Sleep and Wake EEG Studies on Depression

EEG studies on depression are the earliest brain activity studies using imaging tool and still widely used due to its mobility, inexpensiveness and non-evasive approach. Earliest EEG studies on depression are mostly done by observing sleep wave much like studying epilepsy seizure. Mendels and Hawkins did a study to find out if there is any differences in EEG sleep pattern between depressed patients and non-depressed people. 21 depressed and 15 normal participants were selected and the results from this study shows that depressed group have shorted stage 4 and stage 1 REM sleep. Furthermore, excess awake and drowsy time was found in the depressed group. These sleep disturbance was speculated to be affected by the increased activity of the CNS arousal mechanism; this arousal would cause difficulty in falling asleep. The abnormal sleep pattern was debated to whether it is a

symptom for depression or source that contributes to depression (Mendels & Dawkins, 1967).

Another sleep study was done by Emslie and his colleagues to find out the sleep architecture or pattern of adolescents that suffer MDD by comparing it to normal adolescents. This study recruited 31 depressed and 17 non-depressed participants via BDI, Diagnostic Interview for Children and Adolescents (DICA), Weinberg Screening Affective Scale (WSAS), and Bellevue Index of Depression (BID). The study revealed that depressed participants have shorter REM and overall sleep latency but increased in REM sleep episode. It had a contradictory finding compare to Mendels and Dawkins (1967) study which show less REM sleep. The study do explained that comparing to adult depressed counterparts, adolescent with MDD have longer sleep than adult with MDD and normal adolescent (Emslie et al., 1994).

One of the earliest wake EEG study on depression was done by D'elia and Perris (1973). This study aimed to use mean integrated amplitude (MIA) in EEG to find the left to right (L/R) ratio of both brain hemispheres in depressed patients. This study included 18 depressed patients with psychosis and was evaluated with Cronholm and Ottoson depression scale (CODS) and the result of this study shows a more dominant left hemisphere in depressive patients that correlate with the lower L/R ratio of MIA. This result was speculated as symptom of information overload.

Later EEG and qEEG studies showed an opposite findings on the asymmetry activity on those suffering from depression. A study by Ian Gotlib (1998) was done to find out if there

is a specific brain activity pattern of frontal EEG asymmetry is related to depression. This study involved 77 female participants that are selected via SCID and Inventory to Diagnose Depression (IDD) and the results of this study revealed hypoactivation in left frontal region (F3) according to international 10-20 system that was identified from higher alpha activity in comparison to the right frontal region (F4). The left frontal activation was associated with positive emotion responses and the lack of activation suggests dysfunction that leads to depression (Gotlib, 1998).

According to another EEG study by Fingelkurts and his colleagues explored the hypothesis that impaired functional connectivity occurs in major depression. This study used HDRS and SCID to screen through and selected 12 depressed and 10 normal participants. The result of this study shows that short cortex functional connection was larger on left hemisphere than right hemisphere in depressed group and long cortex functional connection was larger on the right hemisphere compared to the left in depressed group. Topologically the right anterior and left posterior part of the brain is what distinguishes the depressed and normal group. The suggested justification of this increase short and long functional connection was associated with the deficiency of serotonin intakes. The left hemisphere was reported to process lexical semantic relationship and the addition efforts found on the left hemispheres of depressed group indicated difficulty in processing. The overloaded long functional connection on the right hemisphere on depressed group indicated inability to appropriately process information with ambiguous context (Fingelkurts et al., 2007). Table 2.3 shows the summary of previous studies using EEG.

Table 2.3: Previous studies on depression using EEG

Author(s)	Year	Sample Size	Method	Result	Country
Fingelkurts et al.	2007	12 D, 10 N	SCID, HDRS	Short cortex functional connection was larger for the left than right hemisphere in depressed. Long cortex functional connection was larger for the right than left hemisphere in depressed. The right anterior and left posterior differ in depressed	Finland
Gotlib	1998	Study 1: 77 female (30 H 31 PD, 16 D)	IDD, SCID	Hypoactivation in left frontal (F3, F4) in depressed and previously depressed	California, US
Emslie et al.	1994	31 D, 17 N	DICA, BDI, BID, WSAS	Depressed had shorter REM latency, shorter sleep latency more REM sleep, and less stage 3 sleep	Texas, USA
D'elia et al.	1973	18 patients	CODS	Dominant left hemisphere in depressed that correlate with the lower L/R ratio of mean integrated amplitude (MIA)	Sweden
Mendels et al.	1967	21 D, 15 N	n/a	short stage 4 and REM, excess awake and drowsy time, increase activity of CNS arousal mechanism in depressed	North Carolina, USA

2.5 qEEG Studies on Depression

qEEG studies as mentioned earlier took advantage of the development of computer and utilized FFT algorithm to quantify brain waves into power spectrum and it is highly replicable compared to the conventional EEG. One of the earliest qEEG on depression study was by Nystrom, Matousek and Hailstrom (1986) that aimed to test whether different

subgroups of depression can be identified using qEEG. 32 Outpatients were recruited into the study using Comprehensive Psychopathological Rating Scale (CPRS) and the results show that currently depressed patients displayed elevated delta on the temporal region whereas the recurrent depressed patients were found to have higher alpha activity (alpha asymmetry) on the left temporal and parietal – occipital region. Beta dominance was also found on the anterior region of the brain of those having recurrent depression. Recurrent depressed patients with alpha asymmetry have higher scores for anxiety and so seem to correlate with anxiety syndrome in depression. One of the most referenced qEEG studies on depression is Henriques and Davidson's study on alpha asymmetry. The aim is to find out the pattern of EEG asymmetry on the scalp that differentiate depressed and normal group. 15 depressed and 13 normal participants were recruited via SADS and the results revealed that depressed group shows decreased left frontal activation area (F3) compared to the right frontal area (F4). This difference of anterior brain pattern in depressed group are likely a reflection of disruption of emotional processes and stress management that link to subcortical structures such as amygdala and thalamus (Henrique & Davidson, 1991).

Milos Matousek in 1991 did a follow up study from Nystrom, Matousek and Hailstrom (1986) to investigate if different subgroups of depression have different brain pattern. The study involved 23 outpatients screened through with RDC-III and the result confirmed the previous study by Nystrom and colleagues with increased beta and alpha asymmetry on the parietal-occipital area. In addition, decreased theta was found as well on depressed patients (Matousek, 1991). Another qEEG study by Dierks, Becker and Maurer (1993) to investigate brain electrical activity differences between depressed and normal group was conducted with 22 depressed patients. The results of this study revealed higher delta power

on the posterior and higher alpha and beta on the anterior part of the brain. This study also associated the slow blood flow found using PET scan corresponds to slow waves activity in qEEG and vice versa. Similar to Drevets et al. (1992) study, higher beta on the anterior region of the brain speculated to be a cause of loss experience and expression of emotion related to thoughts (Dierks, Becker & Maurer, 1993).

Knott, Mahoney, Kennedy, and Evans (2001) study on inter and intra hemispheric power between depressed and normal with 70 depressed and 23 normal participants also shows increased beta activity on the anterior region of the brain. Many studies has reported that augmented beta on anterior region is a sign of recurrent depression (Pollock & Schneider, 1990; Matousek, 1991). Besides that, it is also associated with cognitive, behavioural and emotional activation (Knott, Mahoney, Kennedy, & Evans, 2001). Study by Ricardo-Garcell et al. (2009) that included 36 MDD patients aimed to study the EEG source of depression also found higher beta activity on the anterior region of the brain. In addition, higher delta in posterior and higher alpha in anterior was also reported. The increased alpha and beta activity implied dysfunction in neural activity.

Another study investigated the brain electrical source differences between depressed and normal participants by using different approach which involved low resolution electromagnetic tomography (LORETA) that improved the spatial resolution of qEEG. The study included 80 depressed and 37 normal participants. The depressed participants go through SCID interview before being recruited for this study. The results of this study revealed increase in delta, beta1 and beta2 activities on medial PFC, medial OFC and ACC but the most significant increase activity on ACC is theta activity and; alpha activity on

DLPFC and lateral portion of OFC. Although prior to this study shows that decreased activity on ACC, DLPFC and OFC are relatively normal, some previous study does found this differences was found in depressed patient that responded well to antidepressants treatments compared to those that did not respond well (Korb, Cook, Hunter, & Leutcher, 2008). Grin-Yatsenko, Baas, Ponomarev, and Kropotov (2010) used another method that analyses power spectrum in segment called the Independent Component Approach (ICA) to find abnormal brain electrical activity in depression. This study included 111 early depression and normal participants and the results of this study shows increased theta and alpha activity on the parietal and occipital lobes. The increased theta and alpha activity reflected a decrease of cortical activity on parietal and occipital lobes. Besides that, this study also found augmented beta activity on the anterior region that linked to symptom of anxiety in depression.

Debener et al. (2000) also hypothesized that alpha asymmetry is a trait markers for depression so previous studies was replicated in this study to find out the temporal stability of anterior EEG in larger sample size. 15 patients and 22 normal participants were recruited via BDI self-report questionnaires. The study revealed that depressed patients have higher alpha activity on the right than left anterior region of the brain. This finding contradicted with previous studies that found opposite. Another study using LORETA was done by Saletu, Anderer and Saletu-Zyhlarz that investigate the qEEG brain activity of un-medicated depressed subjects and the effect of non-sedative and sedative antidepressants. This study 60 depressed menopausal women, 60 healthy menopausal women and 30 healthy controls. This study found that depressed with low theta activity over the cerebral cortex correlated with high HDRS scores. Alpha symmetry was found on depressed

participant as well on the frontal area of the brain which is commonly related to the reduced left frontal activation that handles positive emotions (Saletu, Anderer and Saletu-Zyhlarz, 2010).

Alpha asymmetry on depression is the most commonly found brain pattern (Stewart, Coan, Towers, & Allen, 2014; Saletu, Anderer and Saletu-Zyhlarz, 2010; Gotlib, 1998; Henrique & Davidson, 1991; Nystrom, Matousek and Hailstrom, 1986), according to Jaworska, Blier, Fusee, and Knott (2012) study on assessing resting frontal and parietal asymmetry by comparing 53 MDD to 43 normal participants brain electrical activity. Alpha asymmetry was found in both frontal and parietal area of the brain. The parietal cortex has been linked with emotional arousal and suggested that right parietal hyperactivation which in turn caused hyperarousal of anxiety according to previous studies. Besides that, augmented theta activation on ACC was found as well in depressed participants and implicated dysfunction in emotional processing. Another alpha symmetry focus qEEG study on depression was by (Stewart, Coan, Towers, & Allen (2014) to find out if task-elicited EEG study will be more sensitive than the usual resting EEG, This study involved 306 depressed participants that were recruited through BDI screening. The result of this study found higher posterior alpha in depressed participants as well as higher left frontal alpha activity than right (Stewart, Coan, Towers, & Allen, 2014).

Li and her colleagues' qEEG on depression are the main reference to current study with the main objective to investigate the brain electrical source of mildly depressed. This study included 9 mildly depressed and 9 normal participants and was screened through via BDI scores. The finding of this study revealed higher alpha activity was found at temporal

region (T4) and higher theta activity was found on frontal-central region (C4). The higher theta activity on C4 was speculated to associate with anxiety symptom and attention bias towards negative information according to the Overall Anxiety Severity and Impairment Scale (OASIS) (Li et al., 2015). Table 2.4 shows the summary of previous studies using qEEG.

Table 2.4: Previous studies on depression using qEEG

Author(s)	Year	Sample Size	Method	Result	Country
Li et al.	2015	9 HC and 9 Mild Depression	BDI	Depressed higher alpha in T4 and higher theta in C4	Lanzhou, China
Stewart et al.	2014	306 participants	BDI	Higher posterior alpha in depressed, higher alpha in left than right in frontal	Arizona, USA
Jaworska et al.	2012	53 MDD (29 F, 24 M), 43 N (23 F, 20 M)	SCID-IV, HDRS, MADRS	Higher frontal alpha in MDD, alpha asymmetry in MDD, high theta in depressed ACC	Ontario, Canada
Saletu et al.	2010	60 women, MD, 30 women, MND, 30 HC	n/a	Low theta waves on scalp=high HDRS, alpha asymmetry frontal	Vienna, Austria
Debener et al.	2000	15 patients, 22 control	n/a	Higher alpha activity on the right than left	New York, USA
Grin-Yatsenko et al.	2010	111 early depression, 526 normal	n/a	Increase theta and alpha in parietal and occipital lobe	Rotterdam, Netherlands
Korb et al.	2008	80 D (48 W 32 M), 37 N (20 W 17 M)	SCID-I/P	Increased delta, beta1, beta2 in mPFC, mOFC and ACC. Increase theta in ACC. Increase Alpha in DLPFC and OFC (all frontal areas).	California, USA

Table 2.4 continued

Ricardo-Garcell et al.	2009	36 patients	HDRS	Higher delta in posterior, higher alpha and beta in anterior	Queretaro, Mexico
Knott et al.	2001	70 M Depressed, 23 M Normal	HAM-D	Increase beta in anterior region	Ontario, Canada
Dierks et al.	1993	22 Patient (9 W, 13 M)	HDRS, CGI	higher delta in posterior, higher alpha and beta in anterior	Wurburg, Germany
Matousek	1991	23 outpatients (10 M, 13 W)	RDC-III	Increase beta, decrease theta, alpha asymmetry in P-O (seen in those with high anxiety score for recurrent)	Sweden
Henriques et al.	1991	15 D, 13 N	SADS	Depressed and normal differ in anterior activation. Decrease left frontal activation (F3&F4) higher left alpha	Wisconsin, USA
Nystrom et al.	1986	32 outpatients (20 W, 12 M)	CPRS	Primary MDD - increase delta on T, Recurrent MDD - alpha asymmetry (T and P-O), Beta-dominant pattern (Anterior)	Sweden

2.6 qEEG and fMRI Studies on Default Mode Network

Current study also aimed to investigate and find out DMN activity differences between the depressed and healthy control. Several previous studies used fMRI, qEEG or both imaging tools to study signatures of DMN across the cerebral cortex and deeper regions of the brain such as the amygdala and thalamus. A study on DMN signatures investigated the association of EEG networks that form a baseline brain activity helped bringing insight on DMN. This study involved 15 male subjects and the result revealed 6 replicable brain networks that constantly activate during resting state. This 6 network was briefly

mentioned on earlier chapter and each resting state network (RSN) correlates with certain frequencies. RSN 1 (Inferior Parietal Lobe) positively correlates with alpha and beta waves. RSN 2 (middle frontal gyrus) negatively correlates with alpha and beta. RSN3 (temporal-occipital region) correlates positively with all frequency. RSN 4 (bilateral superior temporal cortex) correlates with delta, theta and beta waves. RSN 5 (medial frontal gyrus) correlates positively with beta waves whereas RSN 6 (medial-ventral PFC) with gamma waves (Mantini et al., 2007).

Another study by Scheeringa, Bastiaansen, Petersson, Oostenveld, Norris, & Hagoort (2008) used both EEG and fMRI to investigate if frontal theta EEG activity correlates negatively with DMN in resting state. In a study of 20 participants the results shows that frontal theta activity decreases when DMN activity increased. According to another study by Knyazev and colleagues on the investigating EEG correlation with DMN in both resting and task-elicited states, alpha waves was found to be dominant and robustly associated with DMN, especially DMN on the posterior regions.

Study on DMN of those suffering with depressive disorder also shed some lights on the effect of depression on DMN and the rumination of thoughts. Studies by (Marchetti, Koster, Sonuga-Barke, & Raedt, 2012) and (Knyazev et al, 2016) revealed depressive symptom is associated with the predominance of DMN over task positive network (activation during task-elicited state) when depressed participants went from resting state to task eliciting state. Observation of self-referential process was found when DMN was activated during resting state probed to suggest that when persistence in self-referential state (rumination) was found even when participants are required to perform a task, it is

contributed as a depressive symptom. Table 2.5 shows the summary of previous studies on DMN using fMRI and qEEG.

Table 2.5: Previous studies on DMN using fMRI and qEEG

Author(s)	Year	Sample Size	Method	Result	Country
Knyazev et al.	2016	N=224	BDI	Depressive symptom were associated with predominance of DMN over TPN, depression neural mechanism may already be in action even at preclinical stages	Russia
Marchetti et al.	2012	n/a	n/a	Overpowering DMN over TPN or failure to reduce DMN when go from resting to active is a sign of recurrent depression	Belgium
Knyazev et al.	2011	48 (26 M, 22 W)	n/a	alpha oscillation are most robustly associated with DMN related functional outcomes, DMN at posterior shows alpha activity	Russia
Scheeringa et al.	2008	20 (17 W, 3 M)	n/a	frontal theta activity decreases as DMN activity increases	Netherlands
Mantini et al.	2007	15 Male	n/a	found 6 replicable brain network that fluctuate when change to resting state, RSN 1 positive correlate with alpha & beta, RSN 2 negative correlate with alpha & beta, RSN 3 all, RSN 4 delta, theta & beta, RSN 5 beta, RSN 6 gamma	Washington, USA

2.7 Conclusion

The results from previous studies seem to have several similar observations when replicated at different place and time. The most common observation are the alpha asymmetry or hypoactivation on left hemisphere of the brain, specifically on the frontal region of the brain (D'elia and Perris, 1973; Nystrom, Matousek and Hailstrom, 1986; Henrique & Davidson, 1991; Matousek, 1991; Gotlib, 1998; Debener et al., 2000; Fingelkurts et al., 2007; Saletu, Anderer & Saletu-Zyhlarz, 2010; Jaworska, Blier, Fusee, & Knott, 2012; Stewart, Coan, Towers, & Allen, 2014). Another consistent finding are decreased DLPFC activity (Bench et al. 1992; Halari et. al, 2009; Herrington et. al, 2010) and increase beta activity on the anterior region of the brain (Nystrom, Matousek and Hailstrom, 1986; Dierks, Becker & Maurer, 1993; Knott, Mahoney, Kennedy, & Evans, 2001). These consistent observations mentioned above were replicated in current study to find out if they are found in depressed participants. All the previous study mentioned are done in the United States, Europe and Russia with the exception of one that was done in China. Current study sought to find out if the results are replicable in Malaysia that has different cultural background and potentially different sources of depression in comparison to other countries mentioned above. Secondly, current study also set to find out if predominance and persistency of DMN activity after resting state a signature of depression and related to rumination of negative thoughts (Pizzagalli, 2011).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the details on the methods and designs used for this study. Many changes was done throughout the period of data collection including procedures, sample size, sampling methods, participants, selection criteria, quantitative electroencephalography (qEEG) protocols, limitations and data analysis methods. Proper explanations and justification will be done to address the changes made as well as the reliability and validity.

3.2 Research Design

The research design used in this study is Cross-sectional Design. Cross-sectional design was used to measure differences between the brain activities of both depressed and normal participants. Besides that, this design allowed both group of participants to be purposefully selected on the existing differences based on the screening test (BDI) rather than random sampling which was further clarified in the sampling method section (Lee, 1994). The objective of this study was to identify the distinction in brain activity of depressed young adults so no observation on changes following any intervention and retest are required. Since this study focused on drawing inferences from existing difference at a single point of time only, thus is feasible to conduct within shorter time frame. The flexibility of cross-sectional study to collect data once per participants using self-report questionnaires and EEG tool are relatively inexpensive and has better accessibility to potential participants as

complicated and multiple data collection sessions can be a hindrance for them to participate.

3.3 Participants and Settings

Total of 24 young adults currently pursuing undergraduate study in university participated in this study. Participants are categorized into two groups, depressed and normal group. There are 12 participants in the depressed grouping and 12 participants in the normal grouping. The grouping was determined by criteria, screening tests and certified counsellors. This study consists of two groups of participants that were recruited through two methods, screening test and recommendation from certified counsellors. The two groups of participants includes those that are categorized as normal by Beck Depression Inventory (BDI Score ≤ 13) and participants with score that is categorized as mildly depressed (BDI score > 13 and ≤ 19) and moderately depressed (BDI score > 19 and ≤ 28) was categorized into depressed candidates (Beck et al, 1961).

The criteria for participants in the depressed group consists of young adults between the age of 18 to 30 that are getting help from Universiti Malaysia Sarawak's student affairs counsellors during the data collection period. They were recommended by certified counsellors and were reviewed again by the head of counsellor of the Student Affairs Counselling Department. The other criteria for depressed group are determined based on Beck Depression Inventory scores. Participants with score that is categorized as mildly depressed (BDI score > 13 and ≤ 19) and moderately depressed (BDI score > 19 and ≤ 28) was categorized into depressed group. Candidates for normal participants also consist of young adults between the ages of 18 to 30. Selection for normal group

participants was done through screening test and those fulfil the BDI score level for non-depressed category (BDI Score ≤ 13) was chosen as sample (Beck et al., 1961).

Participants within the age range of 18 to 30 years old was chosen due to the accessibility of participants, especially for the depressed group which mostly consist of university students that is seeking help from university student affairs counsellors. Participants chosen is free of medication prior to qEEG session to avoid alteration of neural electrical activity that might contribute to inaccurate outcome observe. Depressed clients referred by counsellors are evaluated to not have any psychosis disorder such as Schizophrenia or Bipolar Disorder due to the challenge of having participants to cooperate in this study and the concerned of analysing participants qEEG results, which might compromise the accuracy of analyses.

3.4 Sampling Method

Convenient sampling method was deployed for current study. Corresponding to the nature of the research design used, sampling was done to those who were conveniently available and with the assistance of university counsellors to identify and evaluate the conditions of their clients and determine if they are suitable to participate in this study. There were specific inclusion and exclusion criteria for both depressed and normal participants in this study, convenient sampling was more effective in gathering desired sample in short duration of time. The flexibility to gather sample conveniently also reduce the cost on traveling and printing for this study because there was no need to cast a big net during data collection.

3.5 Data Collection Protocol

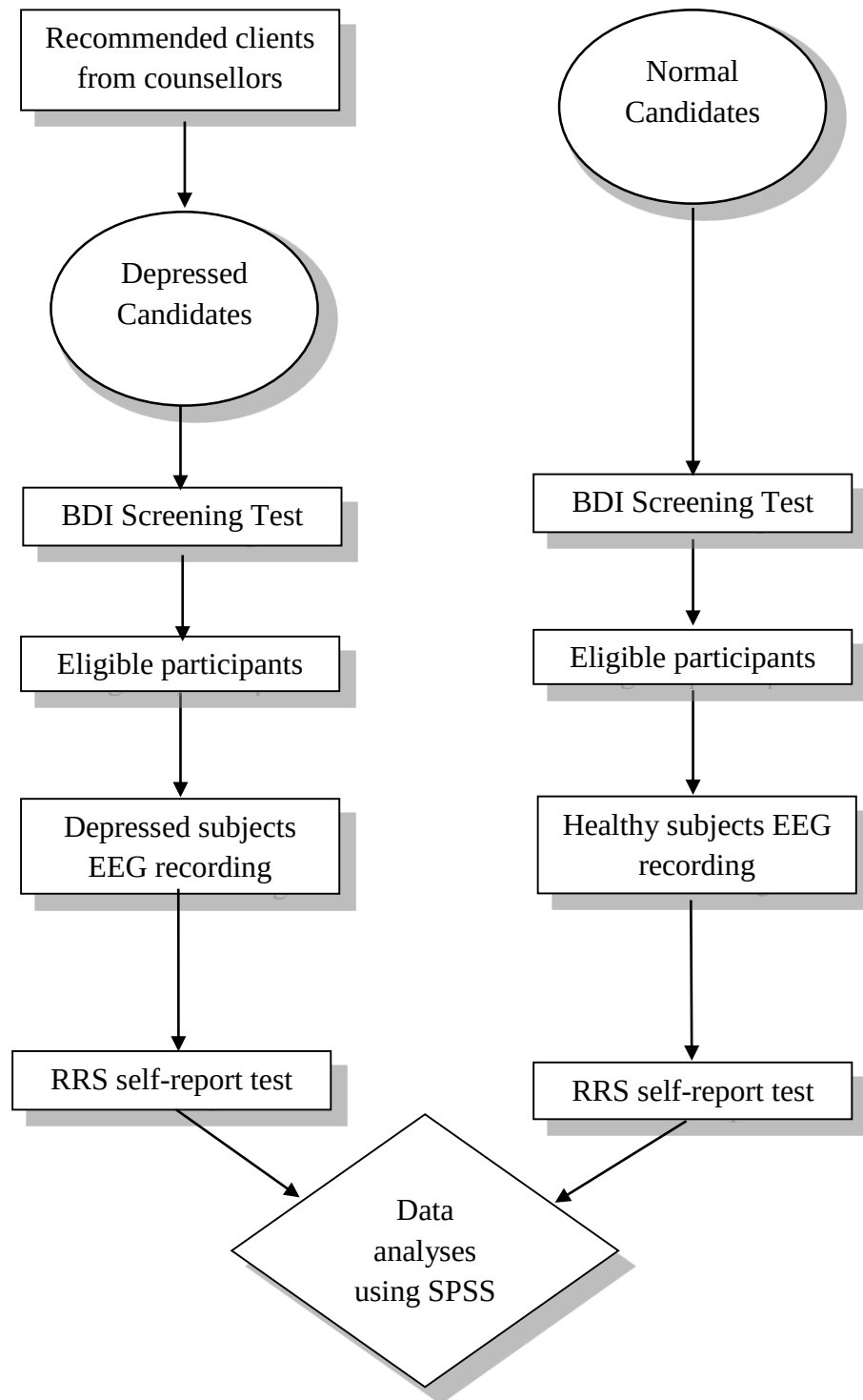


Figure 3.1: Data collection protocol for current study

When the counsellors have referred their client over for this study, appointment was made to set a date for qEEG session. The depressed participants are first brief about the preparation for the session when setting up appointment via phone call. On the day of qEEG session, the participants was brief about the nature and purpose of the study, the procedures and assured the safety in using EEG device before requesting for consent to proceed with study.

Depressed participants proceeded to answering BDI test self-report questionnaires and the scores was calculated and recorded. Then, the participants proceeded to be seated and electrodes were installed on their scalp. Recording sessions took 14 minutes with 4 tasks and each task took 3.5 minutes. After all recording was checked, the electrodes were removed and participants were ushered to the washroom to clean-up. The participants were requested to answer another self-report questionnaire, RRS after clean-up and were properly debriefed. Participants were also asked if they are comfortable to share their medical history briefly for more information that will help the study in analysing the data.

3.6 Instrumentation

Beck Depression Inventory (BDI) test is an instrument designed to measure the behavioural manifestation of depression (Beck et al., 1961). The test consist of 21 categories which is, sadness, pessimism, past failure, loss of pleasure, guilty feelings, punishment feelings, self-dislike, self-criticalness, suicidal thoughts, crying, agitation, loss of interest, indecisiveness, worthlessness, loss of energy, changes in sleeping pattern, irritability, changes in appetite, concentration difficulty, fatigue, and loss of interest in sex. The range of severity in each category is from 0 to 3 (neutral to severe). The final score

from 0-13 indicates no/minimal depression, 14-19 indicates mild depression, 20-28 indicates moderate depression and 29-63 indicates severe depression. The higher total score indicate more severe depressive symptoms (Beck et al., 1961). The purpose of this test will be used to categorize the depressed and non-depressed using and not for the purposes of diagnosing.

3.6.1 Ruminative Response Scale

After EEG recording, participants will be required to fill in another self-report test; Rumination Responses Scale (RRS) to find out the behavioural rumination scores (Berman et al., 2011). Ruminative Response Scale is 22 self-report questions that measure the ruminative coping mechanism when someone is experiencing depression. This ruminative coping mechanism involves self-focused attention on negative thoughts or moods in a persistent and repetitive cycle (Treynor, Gonzalez & Nolen-Hoeksema, 2003). The purpose of RRS score was used for correlational study to find out if there is association between persistent brain electrical activity and rumination of negative thoughts. The reliability of RRS was questioned because RRS have questions that are in the commonly used BDI, thus in Treynor, Gonzalez & Nolen-Hoeksema (2003) study, similar questions was removed and correlation studies were conducted. The result proved that RRS is still a reliability self-report questionnaire to predict depressive symptoms.

The initial demographic of the potential subjects in this study may not understand or fluent in English. Therefore, the RRS self-report questionnaire needed to be translated to Bahasa Melayu, which is Malaysia's national language. The process of translation for this questionnaire is based on the article from Regmi, Naidoo and Pilkington (2010). According

to Regmi, Naidoo and Pilkington (2010), the strategy in translation and transliteration by Brislin (1970) model is the best method for cross cultural research. The translation for RRS is based on Brislin (1970) model where by two bilingual experts in Bahasa Melayu and English were hired for translation. The first bilingual expert did a forward translation from the original language, which is English to Bahasa Melayu. Then, another bilingual expert did a backward translation for the translated RRS from Bahasa Melayu back to English without looking at the original RRS self-report questionnaire. After both translations were done, translated RRS from both sources and targeted languages is reviewed by another language expert lecturer. Comparison from both translated questionnaires shows 71% accuracy in the forward and backward translation. The review concluded that we do not require both bilingual experts to come together to revisit the translations and all the minor correction was done guided by the language expert.

3.6.2 Quantitative Electroencephalography

Electroencephalography (EEG) is an imaging tool that records the electrical brain activity on human scalp. The EEG imaging tool model used in this study was Mitsar EEG-201 system amplifier and this imaging tool worked together with software developed by Mitsar, WinEEG. WinEEG processed electrical brain activity picked up by the electrodes and provided spectral analyses with absolute and relative power frequencies in all 6 bands (delta, theta, alpha, beta1, beta2 & gamma). The underlying computational algorithm in spectral analyses in qEEG is through Fast Fourier Transformation (FFT) algorithm. The Mitsar EEG-201 requires a longer setup time during an EEG session in comparison to others EEG imaging tools in the market because it comes with separated caps and electrodes. Besides that, Electro gel is required in every sites and all equipment has to be

cleaned before the next session. Although it involves meticulous process during setup, Electro gel helps reduces the impedance level and separated electrodes are easier to replace if there is faulty electrode during the setup session.

A 19 channels EEG imaging tool is use to record EEG activity continuously from 19 sites according to the international 10-20 system (Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, T3, T4, Cz, P3, P4, T5, T6, Pz, O1, O2) with A1 and A2 as reference. Impedances are kept below 5 k Ω , 250Hz sampling rate, and a bandpass filter of 0.3-50Hz were adjusted. These electrodes are attached to an elastic cap (Electro-Cap international. Inc) after measuring the participants' head size and is wear on by them. The participants were asked to go through 2 tasks during the EEG recording which include Eyes Open (EO) task and Eyes Closed (EC) task that alternate from Open – Closed - Open. The duration for each task was 3.5 minutes, which is within the recommended duration of EEG recording (Pollock & Schneider, 1990).

3.7 Data Analysis Methods

The standard montage used for all analyses is the Average Montage (Av). Average Montage is a monopolar montage with one electrode per channel and all 19 channels was referred to the average value of all channels (as shown in Figure 3.2).

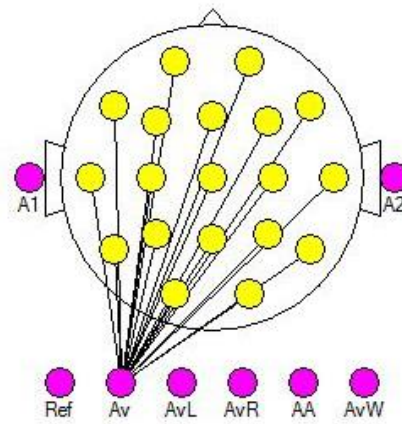


Figure 3.2: Diagram of Average Montage (Av) in Mitsar WinEEG

3.7.1 Mann Whitney U Test

Non-parametric Mann Whitney U Test was used on most of the analyses corresponding to each hypothesis that was made in this study to find out the significant differences between depressed and normal participants neural electrical activity via qEEG. The data collected from 24 participants (12 depressed, 12 normal) was shown to be mostly not normally distributed. Each participant was also observed independently without repetition within the group or in two groups (Mann & Whitney, 1947). As well as with a small sample size ($n < 60$), thus considered Mann Whitney U Test to be more suitable and sensitive to detect significant differences in this study. Non-parametric test was performed using IBM SPSS Statistics software (Mann & Whitney, 1947).

3.7.2 Spearman's Correlation

Spearman's correlation was proposed to find out if persistent DMN are associated with rumination of negative thoughts. Due to the small sample size and non - normally

distributed qEEG data, Spearman's Rank Correlation is more sensitive to measure the strength and direction of the association between DMN and RRS score (Spearman, 1904).

3.7.3 Coherence Analysis

The addition of coherence analysis in this study was to support the findings from qEEG spectral analyses. Coherence studies essentially look into phase difference of two sites. This consistency or coherence of two sites will tell the degree of relationship between them. The coherence analysis was performed using Mitsar WinEEG software that was used for EEG recording and qEEG spectral analysis. The data first removed the artifacts before performing coherence analysis. This coherence analysis was able to measure connectivity of two sites based on total shared energy (as shown in Figure 3.3). The highest the coherence is marked by 1 and the lowest coherence are 0 (Biver, North & Thatcher, 2009).

3.8 Challenges in Data Sample Selection

The first part of data collection, recruiting suitable participants via a BDI screening test was executed on the beginning of 3 March 2016. The screening test day was set on Hospital Sentosa's clinic day (Monday and Thursday). A room was prepared for screening test and as the out patients of Hospital Sentosa come for their appointment, the psychiatrics assessed their patients and those that meet the criteria of mild or moderate depression without psychosis was asked if they are interested to participate in the study. The clinic day appointments for outpatients are from 8:00 a.m. to 12:00 p.m. The afternoon session of the clinic day is reserved for new patients.

The screening test room was set up from 8 a.m. to 1 p.m. on 3 March 2016. The outcome of the recruitment and screening test was not fruitful. The reason of the lack of attendance was investigated and found out that not many patients with mild or moderate depression came for check-up. The patients that was present for their appointment declined the offer to participate in this study after the brief explanation from the psychiatrics. There might be lack of clarity on the safety of qEEG recording when psychiatrics brief about this study to the patients.

The psychiatric suggested two options in gathering potential candidates for data collection:

- i. Look through the directories of patients in Hospital Sentosa, select an amount of potential candidate and approach them personally or;
- ii. Contact the Head of Psychiatric Department in Sarawak General Hospital (SGH) and collect data from there.

The data collection in Hospital Sentosa was proceeded again on the following Monday (7 March 2016) but the result was similarly unsuccessful. There for option (i) was executed on the following Wednesday (9 March 2016).

After briefed by the psychiatric in charged, candidate selection was proceeded at their directories on non-clinic day. 30 candidates, age range from 19-50 with preliminary diagnose of depression was selected. After that, selection the nurses proceed to gather their records in the files and record room. Most of the preliminary diagnose was inaccurate, the candidates was mostly referred cases from different hospitals and clinic with records of

schizophrenia, major depressive disorder, bipolar disorder and mental retardation. The reviewing concluded with no potential candidates available for data collection.

A letter of permission for visitation and conducting study in Sarawak General Hospital (SGH) was requested on 8 March 2016 (Tuesday) from the Deputy Dean of Postgraduate Studies in Faculty of Cognitive Science and Human Development. The letter was only ready on the 22 March 2016. A meeting with the Child and Adolescence Psychiatric was on the 24 March 2016. The meeting was not fruitful either as the psychiatric mentioned the rarity of pure depression patients without psychosis in psychiatry department in hospital or clinic.

This study scope of respondent was changed to students in Universiti Malaysia Sarawak that shown symptom of depression through the help of Counsellors in the student affair department. Letter of approval was sent to the Counselling department and the Head of Counsellor agreed to refer clients that fulfilled the criteria for this study. The data collection period was conducted on the Rehab Facility Centre in the university for 8 months, from April until November 2016.

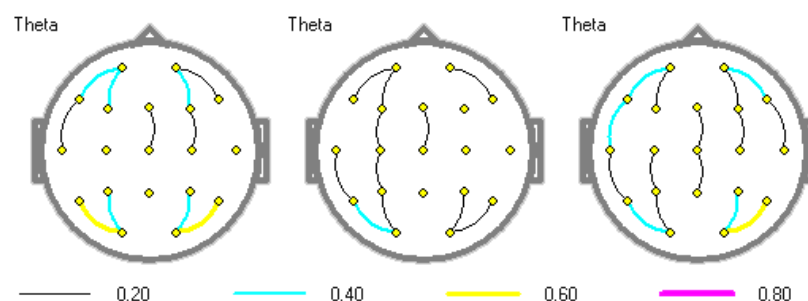
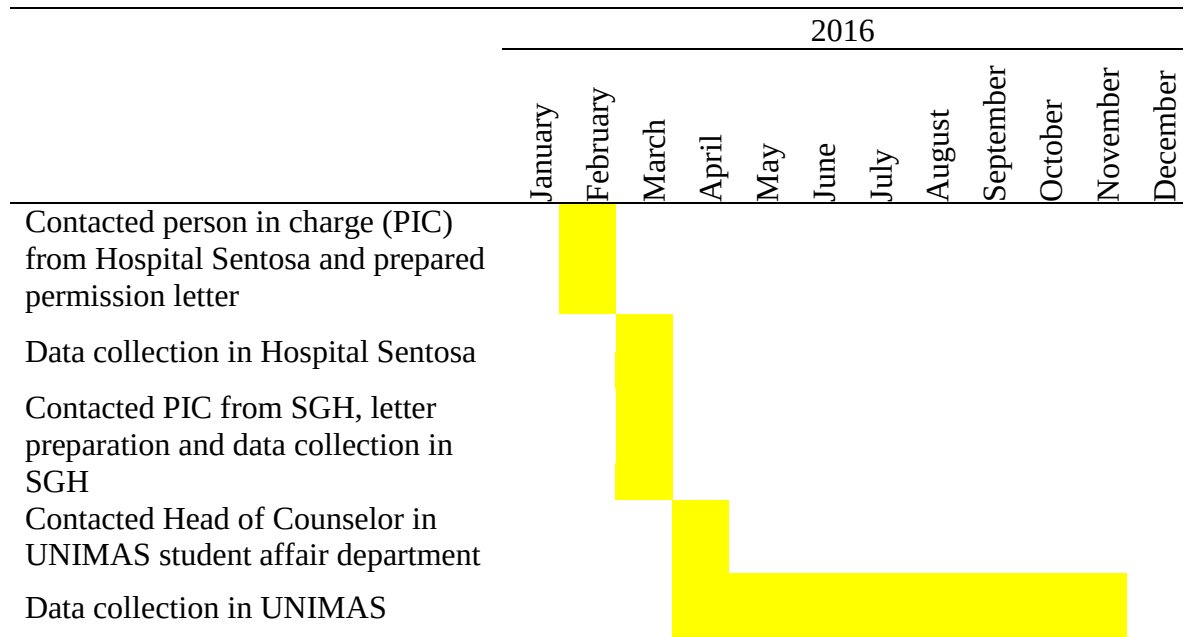


Figure 3.3: Example of Coherence Diagram in Mitsar WinEEG program

3.9 Data Collection Gantt chart

Table 3.1: Gantt chart for data collection



3.10 Ethical Consideration

Ethical standard in this study is considered according to the principles of research ethics by Smith (2003), which includes consciousness regarding the relationship with participants. Participants for depressed group was referred from university counsellors after careful assessment and consideration, thus, has no relationship with the researchers that was involved in conducting the data collection session, data analysis and throughout the entire study. Normal participants on the other hand was recruited through publicity and verbal agreement to participate before setting up appointed for informed consent and qEEG session.

Besides that, informed consent in this study includes:

- Explaining the purposes of two self-report questionnaires and the interpretation of result is solely for categorization, not diagnosis.
- There is no known psychological or physiological risks associated with qEEG, which is a non-invasive imaging method.
- The tasks included during qEEG session.
- Informed participants that there will be a proper debrief of the rationale of study after data collection session.
- Participation is entirely voluntary and eligible to stop and leave the session at any time without any consequences.
- Participation in the study will not be cover by any insurance.

Consent for publication of study was also introduced to the participants for any future publication in conferences, colloquium or journal article. Respect of confidentiality and privacy aspect also was considered in this study whereby any personal information given in this study will not be disclosed to anyone with the exception of researchers and supervisor involved in this study. A brief inquiry of their past medical history was done with the consent from participants' counsellor for additional information that helped in understanding the data analysed.

3.11 Conclusion

This chapter concluded the methodology used in this study. All procedures are followed to ensure the reliability, validity and in the boundary of the ethical consideration. The methodologies are translated to the results of this study and the following chapter discussed the findings.

CHAPTER 4

RESULTS

4.1 Demographic Data

Table 4.1: Descriptive Statistics for the Age of Participants (N=24)

	N	Mean	SD	<i>p</i>
Group 1 (Depressed)	12	20.7	2.27	.002
Group 2 (Normal)	12	22.4	1.08	

Total qEEG data recorded from participants in both groups are 26, two data was excluded from both groups respectively. One normal group data was excluded due to faulty setup whereby both reference sites, A1 and A2 was not properly attached with electrogel. Another qEEG data from depressed group was excluded because participants was under antidepressants and her BDI score exceeded the criteria set (BDI score = 39, severe depression). 12 depressed participants and 12 normal participants' data were included in the analysis. Among the 12 depressed participants, 10 were female and 2 were male. In the normal group, there are 4 female and 8 male participants. Table 4.1 shows the average age of depressed group was 20.7 years old (SD = 2.27) and the average age of normal group was 22.4 years old (SD = 1.08). The depressed group consists of 7 Bumiputeras, 3 Chinese and 2 Indians; and that of the normal group consists of 4 Bumiputeras, 4 Chinese and 4 Indians (as shown in Table 4.2).

Table 4.2: Demographic Table for Participants' Race

	N	Bumiputera	Chinese	Indian
Group 1 (Depressed)	12	7	3	2
Group 2 (Normal)	12	4	4	4

4.2 Beck Depression Inventory

Table 4.3: Descriptive Statistics for BDI scores of Participants (N=24)

	N	Mean	SD	<i>P</i>
Group 1 (Depressed)	12	17.5	4.19	.000
Group 2 (Normal)	12	7.00	3.98	

As mentioned earlier, the criteria for inclusion of depressed participants is based on BDI test with score less than 13 for normal group and score within 14-28 for depressed group (included mild and moderate depression scores). Table 4.3 shows the mean BDI score of depressed group was 17.5 (SD = 4.19) and for the normal group was 7.0 (SD = 3.98).

4.3 Ruminative Response Scale

Table 4.4: Descriptive Statistics for RRS scores of Participants (N=24)

	N	Mean	SD	<i>P</i>
Group 1 (Depressed)	12	58.7	8.60	.000
Group 2 (Normal)	12	38.5	11.1	

RRS self-report questionnaires was collected from participants and used for correlational study and Table 4.4 shows the mean RRS score was 58.7 (SD = 8.60) for depressed group and 38.5 (SD = 11.13) for normal group.

4.4 Absolute Activity

Comparison of qEEG absolute activity on all bands and all 19 sites was done using Mann Whitney test. Table 4.5 and 4.6 shows the sites on each band that showed significant difference between depressed and normal group in eyes open and eyes closed tasks. All 24 participants (12 depressed and 12 normal) data was not normalized as the criteria of Mann Whitney test assumed the data are not normally distributed. The significant differences from each sites was supported by effect size (r) that reveals the magnitude of the differences.

In eyes closed task, Table 4.5 reveals that most significant differences were found at absolute beta2 again. Differences in beta2 activity seem to be spread across the cortex and were higher in depressed participants with the exception of both Fp1 and Fp2 sites in the pre-frontal area, as well as C3 sites. Mann Whitney test reported higher beta2 activity in depressed group at T4 (Mdn = 9.30), $U = 18.0$, $p = .001$, $r = .64$; T5 (Mdn = 1.84), $U = 39.0$, $p = .030$, $r = .39$; P4 (Mdn = .96), $U = 43.0$, $p = .049$, $r = .34$; T6 (Mdn = 1.67), $U = 25.0$, $p = .003$, $r = .55$; and O2 (Mdn = 1.92), $U = 39.0$, $p = .030$, $r = .39$. Meanwhile, higher beta2 activity was found higher in normal group at Fp1 (Mdn = 3.75), $U = 41.0$, $p = .039$, $r = .37$; Fp2 (Mdn = 3.85), $U = 42.0$, $p = .044$, $r = .35$ and C3 (Mdn = 1.19), $U = 38.5$, $p = .027$, $r = .40$. Figure 4.1 and 4.2 shows the grand average of qEEG spectral power in each frequency bands.

Table 4.5: Mann Whitney Test for EC Task

Bands	Site	Mann-Whitney U	Z	Exact Sig. (1- tailed)
Theta	Fz	42.5	-1.70	.046
	T6	38.5	-1.94	.027
Beta1	F7	35.0	-2.14	.016
	C3	36.0	-2.08	.019
	O1	42.0	-1.73	.044
	O2	42.5	-1.70	.046
Beta2	Fp1	41.0	-1.79	.039
	Fp2	42.0	-1.73	.044
	C3	38.5	-1.94	.027
	T4	18.0	-3.12	.001
	T5	39.0	-1.91	.030
	P4	43.0	-1.68	.049
	T6	25.0	-2.71	.003
	O2	39.0	-1.91	.030

Eyes Open Task was primarily collected for the purpose of correlational study with Ruminative Response Scale self-report questionnaire. This task is similar to the first eyes open task but yielded different results. Significant differences between two groups are manifested at absolute gamma activity. Absolute beta2 activity is dominating on the temporal region as suggested in Table 4.6. Mann Whitney test reported higher absolute beta2 activity in depressed participants at F7 (Mdn = 4.98), $U = 43.0$, $p = .050$, $r = .34$; T3 (Mdn = 6.61), $U = 37.0$, $p = .022$, $r = .41$; T4 (Mdn = 2.59), $U = 34.0$, $p = .014$, $r = .45$; T5 (Mdn = 1.48), $U = 37.0$, $p = .022$, $r = .41$ and T6 (Mdn = 4.50), $U = 40.5$, $p = .035$, $r = .37$ compare to the normal participants (refer to Table 4.6).

Table 4.6: Mann Whitney Test for EO Task

Bands	Site	Mann-Whitney U	Z	Exact Sig. (1- tailed)
Beta1	F7	37.0	-2.02	.022
	F8	38.0	-1.96	.026
Beta2	F7	43.0	-1.67	.050
	T3	37.0	-2.02	.022
	T4	34.0	-2.19	.014
	T5	37.0	-2.02	.022
	T6	40.5	-1.82	.035

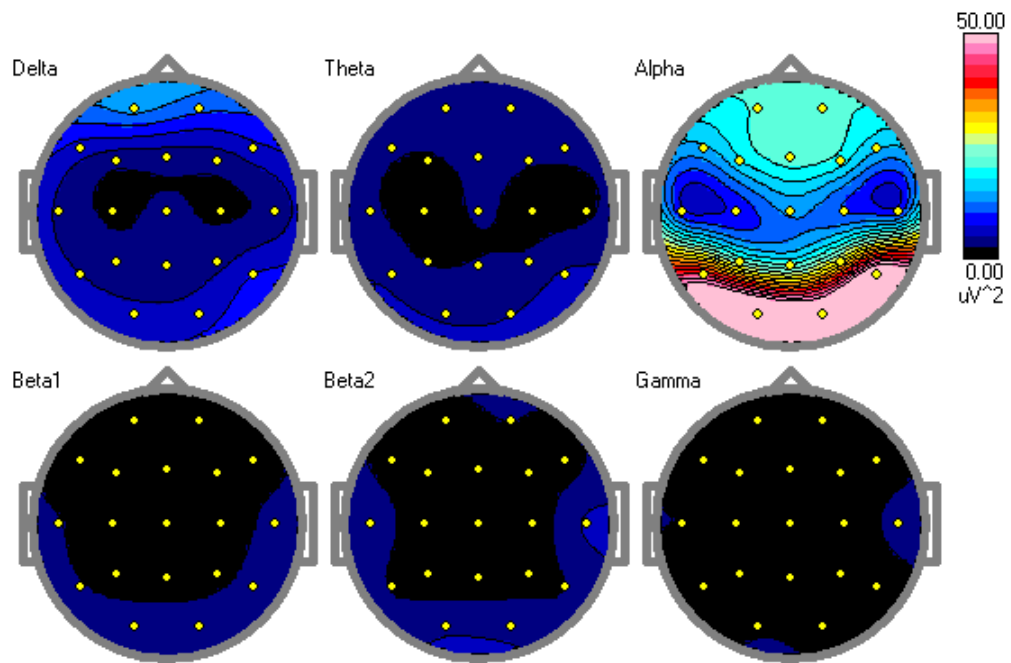


Figure 4.1: Grand average maps of qEEG power spectra for Depressed Group in EC task

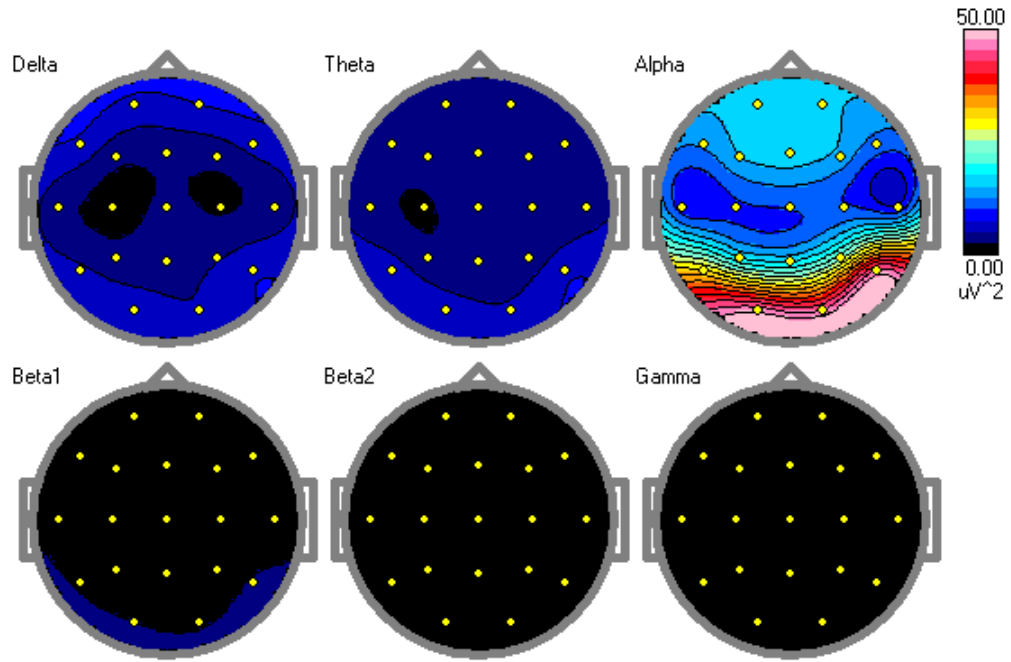


Figure 4.2: Grand average maps of qEEG power spectra for Normal Group in EC task

4.5 Hypotheses Testing

According to the hypotheses proposed on earlier chapter to find out region of interest(s) (ROI) that is different in depressed participants, the results of Mann Whitney U Test are shown on from Table 4.7 to Table 4.18.

H_{01} : There is no difference in theta & alpha activity at DLPC, parietal and occipital region between depressed and normal participants

H_{a1} : There is difference in theta & alpha activity at DLPFC, parietal and occipital region between depressed and normal participants

Table 4.7: Mann Whitney Test for Comparison in Depressed and Normal Group (1)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	1.43	1.23	57.0	-.87	.21
Eyes Open	1.20	1.95	56.0	-.92	.19

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in theta activity at parietal region in eyes closed task for depressed participants (Mdn = 1.43) and normal participants (Mdn = 1.23), $U = 57.0$, $p = .21$, $r = .18$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in theta activity at parietal region in eyes open task for depressed participants (Mdn = 1.20) and normal participants (Mdn = 1.95), $U = 56.0$, $p = .19$, $r = .19$ (refer to Table 4.7).

Table 4.8: Mann Whitney Test for Comparison in Depressed and Normal Group (2)

Task	Mdn (D)	Mdn(N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	5.82	8.00	70.0	-.12	.47
Eyes Open	1.20	1.95	56.0	-.93	.19

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in alpha activity at parietal region in eyes closed task for depressed participants (Mdn = 5.82) and normal participants (Mdn = 8.00), $U = 70.0$, $p = .47$, $r = .024$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in alpha activity at parietal region in eyes open task for depressed participants (Mdn = 1.20) and normal participants (Mdn = 1.95), $U = 56.0$, $p = .19$, $r = .19$ (refer to Table 4.8).

Table 4.9: Mann Whitney Test for Comparison in Depressed and Normal Group (3)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	1.72	2.15	68.0	-.23	.42
Eyes Open	3.60	1.83	58.0	-.81	.22

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in theta activity at occipital region in eyes closed task for depressed participants (Mdn = 1.72) and normal participants (Mdn = 2.15), $U = 68.0$, $p = .42$, $r = .047$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in theta activity at occipital region in eyes open task for depressed participants (Mdn = 3.60) and normal participants (Mdn = 1.83), $U = 58.0$, $p = .22$, $r = .16$ (refer to Table 4.9).

Table 4.10: Mann Whitney Test for Comparison in Depressed and Normal Group (4)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	14.6	21.6	72.0	.000	.51
Eyes Open	3.93	3.57	63.0	-.52	.32

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in alpha activity at occipital region in eyes closed task for depressed participants (Mdn = 14.6) and normal participants (Mdn = 21.6), $U = 72.0$, $p = .51$, $r = .000$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in alpha activity at occipital region in eyes open task for depressed participants (Mdn = 3.93) and normal participants (Mdn = 3.57), $U = 63.0$, $p = .32$, $r = .11$ (refer to Table 4.10).

Table 4.11: Mann Whitney Test for Comparison in Depressed and Normal Group (5)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	2.07	1.99	71.0	-.058	.49
Eyes Open	2.64	1.69	59.0	-.75	.24

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in theta activity at DLPFC in eyes closed task for depressed participants (Mdn = 2.07) and normal participants (Mdn = 1.99), $U = 71.0$, $p = .49$, $r = .012$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in theta activity at DLPFC in eyes open task for depressed participants (Mdn = 2.64) and normal participants (Mdn = 1.69), $U = 59.0$, $p = .24$, $r = .15$ (refer to Table 4.11).

Table 4.12: Mann Whitney Test for Comparison in Depressed and Normal Group (6)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	5.61	4.88	66.0	-.35	.38
Eyes Open	3.44	3.53	57.0	-.87	.21

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in alpha activity at DLPFC in eyes closed task for depressed participants (Mdn = 5.61) and normal participants (Mdn = 4.88), $U = 66.0$, $p = .38$, $r = .072$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in alpha activity at DLPFC in eyes open task for depressed participants (Mdn = 3.44) and normal participants (Mdn = 3.53), $U = 57.0$, $p = .21$, $r = .18$ (refer to Table 4.12).

H₀₂: There is no difference in alpha activity at T4, anterior - posterior region, and left - right hemisphere between depressed and normal participants

H_{a2}: There is difference in alpha activity at T4, anterior - posterior region, and left - right hemisphere between depressed and normal participants

Table 4.13: Mann Whitney Test for Comparison in Depressed and Normal Group (7)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	3.34	5.22	59.0	-.75	.24
Eyes Open	4.15	4.36	63.5	-.17	.32

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in alpha activity at T4 site in eyes closed task for depressed participants (Mdn = 3.34) and normal participants (Mdn = 5.22), $U = 59.0$, $p = .24$, $r = .15$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in alpha activity at T4 site in eyes open task for depressed participants (Mdn = 4.15) and normal participants (Mdn = 4.36), $U = 63.5$, $p = .32$, $r = .035$ (refer to Table 4.13).

Table 4.14: Mann Whitney Test for Comparison in Depressed and Normal Group (8)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	5.54	8.01	58.0	-.81	.22
Eyes Open	3.63	3.02	52.0	-1.16	.13

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in eyes closed task for anterior region (Mdn = 5.54) and posterior region (Mdn = 8.01) for depressed participants, $U = 58.0$, $p = .22$, $r = .17$. This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in eyes open task for

anterior region (Mdn = 3.63) and posterior region (Mdn = 3.02), $U = 52.0$, $p = .13$, $r = .24$ (refer to Table 4.14).

Table 4.15: Mann Whitney Test for Comparison in Depressed and Normal Group (9)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	6.72	7.41	70.0	-.12	.47
Eyes Open	3.58	3.79	66.0	-.35	.38

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in eyes closed task for left hemisphere (Mdn = 6.72) and right hemisphere (Mdn = 7.41) for depressed participants, $U = 70.0$, $p = .47$, $r = .024$. This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in eyes open task for left hemisphere (Mdn = 3.58) and right hemisphere (Mdn = 3.79), $U = 66.0$, $p = .38$, $r = .071$ (refer to Table 4.15).

H_{03} : There is no difference in theta activity at PFC and beta activity at anterior region between depressed and normal participants

H_{a3} : There is difference in theta activity at PFC and beta activity at anterior region between depressed and normal participants

Table 4.16: Mann Whitney Test for Comparison in Depressed and Normal Group (10)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	3.17	2.23	41.0	-1.79	.038
Eyes Open	2.79	4.00	65.0	-.40	.36

This result reject null hypothesis. Mann-Whitney test indicated that there is difference in theta activity at PFC in eyes closed task for depressed participants (Mdn = 3.17) and normal participants (Mdn = 2.23), $U = 41.0$, $p = .038$, $r = .37$. This result does not reject null hypothesis. Mann Whitney test indicated that there is no difference in theta activity at OFC in eyes open task for depressed participants (Mdn = 2.79) and normal participants (Mdn = 4.00), $U = 65.0$, $p = .36$, $r = .082$ (refer to Table 4.15).

Table 4.17: Mann Whitney Test for Comparison in Depressed and Normal Group (11)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	1.96	1.08	43.0	-1.67	.050
Eyes Open	2.77	1.34	38.5	-1.94	.027

This result reject null hypothesis. Mann-Whitney test indicated that there is a difference in beta1 activity at anterior region in eyes closed task for depressed participants (Mdn = 1.96) and normal participants (Mdn = 1.08), $U = 43.0$, $p = .050$, $r = .34$. This result reject null hypothesis. Mann Whitney test also indicated that there is a difference in beta1 activity at anterior region in eyes open task for depressed participants (Mdn = 2.77) and normal participants (Mdn = 1.34), $U = 38.5$, $p = .027$, $r = .40$ (refer to Table 4.17).

Table 4.18: Mann Whitney Test for Comparison in Depressed and Normal Group (12)

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	2.39	1.86	43.0	-1.67	.050
Eyes Open	2.97	2.19	51.0	-1.21	.12

This result reject null hypothesis. Mann-Whitney test indicated that there is a difference in beta2 activity at anterior region in eyes closed task for depressed participants (Mdn = 2.39)

and normal participants (Mdn = 1.86), $U = 43.0$, $p = .050$, $r = .34$. This result does not reject null hypothesis. Mann Whitney test also indicated that there is no difference in beta2 activity at anterior region in eyes open task for depressed participants (Mdn = 2.97) and normal participants (Mdn = 2.19), $U = 51.0$, $p = .21$, $r = .25$ (refer to Table 4.18).

Table 4.19 and Table 4.20 show the mean for each frequency bands of both depressed and normal group. The results show dominant alpha activity on Inferior Parietal Lobe (IPL) during eyes closed task.

Table 4.19: Descriptive Statistics for IPL Bands of Depressed Participants in EC Task

Bands	N	Mean	SD
Delta	12	3.48	2.19
Theta	12	2.15	1.56
Alpha	12	18.3	21.0
Beta1	12	2.05	.99
Beta2	12	1.85	1.29
Gamma	12	.75	.42

Alpha activity showed mean of 18.3(SD = 21.0), which is significantly higher than all the other bands shown in Table 4.19. It is the most dominant bands on IPL region during eyes closed resting state of depressed participants.

Table 4.20: Descriptive Statistics for IPL Bands of Normal Participants in EC Task

Bands	N	Mean	SD
Delta	12	3.38	4.83
Theta	12	2.41	3.47
Alpha	12	17.5	21.0
Beta1	12	1.67	1.16
Beta2	12	1.60	1.48
Gamma	12	.62	.41

Normal participants alpha activity showed mean of 17.5(SD = 21.0), which is also significantly higher than all the other bands shown in Table 4.20. It is the most dominant bands on IPL region during eyes closed resting state.

IPL regions then shows significant reduction in alpha activity from eyes closed to eyes open task for both depressed and normal participants.

Table 4.21: Mann Whitney Test for Comparison on EC and EO Task

Group	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Depressed	10.74	2.06	31.0	-2.37	.009
Normal	9.14	3.01	33.0	-2.25	.012

Mann-Whitney test indicated that there is a difference in alpha activity at IPL region in depressed participants for eyes closed (Mdn = 10.74) and eyes open task (Mdn = 2.06), $U = 31.0$, $p = .009$, $r = .52$. Mann Whitney test also indicated that there is a difference in alpha activity at IPL region in normal participants for eyes closed (Mdn = 9.14) and eyes open task (Mdn = 3.01), $U = 33.0$, $p = .012$, $r = .46$ (refer to Table 4.21).

Hypotheses 4 are tested to find out if DMN activity is different in depressed participants and, if DMN activity persists at eyes open state in depressed participants. The results are shown on Table 4.22 and Table 4.23

H₀₄: There is no difference in alpha activity at Inferior Parietal Lobe (IPL) region between depressed and normal participants; and no relationship between alpha activity in IPL region and RRS score in eyes open task

H_{a4}: There is difference in alpha activity at Inferior Parietal Lobe (IPL) region between depressed and normal participants; and a relationship between alpha activity in IPL region and RRS score in eyes open task

Table 4.22: Mann Whitney Test for Comparison in Depressed and Normal Group

Task	Mdn (D)	Mdn (N)	Mann-Whitney U	Z	Exact Sig. (1-tailed)
Eyes Closed	10.7	9.14	70.0	-.12	.47
Eyes Open	2.05	3.01	52.5	-1.13	.14

This result does not reject null hypothesis. Mann-Whitney test indicated that there is no difference in alpha activity at IPL region in eyes closed task for depressed participants (Mdn = 10.7) and normal participants (Mdn = 9.14), $U = 70.0$, $p = .47$, $r = .024$. This result does not null hypothesis. Mann Whitney test also indicated that there is no difference in alpha activity at IPL region in eyes open task for depressed participants (Mdn = 2.05) and normal participants (Mdn = 3.01), $U = 52.5$, $p = .14$, $r = .23$ (refer to Table 4.22).

Table 4.23: Spearman Correlation Matrix among RRS and Alpha Activity in EO Task

	<i>M(SD)</i>	RRS	Alpha
RRS	58.7(8.60)	-	-.034
Alpha	18.3(21.0)	-.034	-

Note. RRS = Ruminative Response Scale. Alpha = Alpha activity. * $p < .05$

This result does not reject null hypothesis. A Spearman's correlation was computed to assess the relationship between alpha activity in IPL region and RRS scores and indicated that there is no correlation between the two variables, $r_s(24) = -.034$, $p = .44$ (refer to Table 4.23).

4.4.1 Crosscorrelation Coherence

Coherence analysis was introduced in this study to find out if depressed participants will display lower or higher coherence in ROIs that is distinct from normal. Figures below are the grand average diagram of qEEG intra-hemisphere and inter-hemisphere coherence for depressed (Figure 4.3, 4.4 & 4.5) and normal group (Figure 4.6, 4.7 & 4.8).

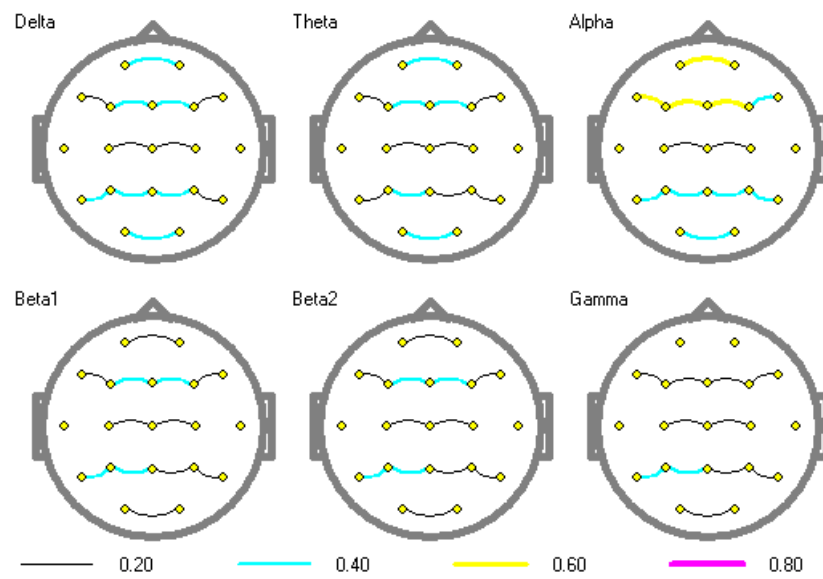


Figure 4.3: Grand average diagram of qEEG coronal intra-hemisphere coherence for Depressed Group

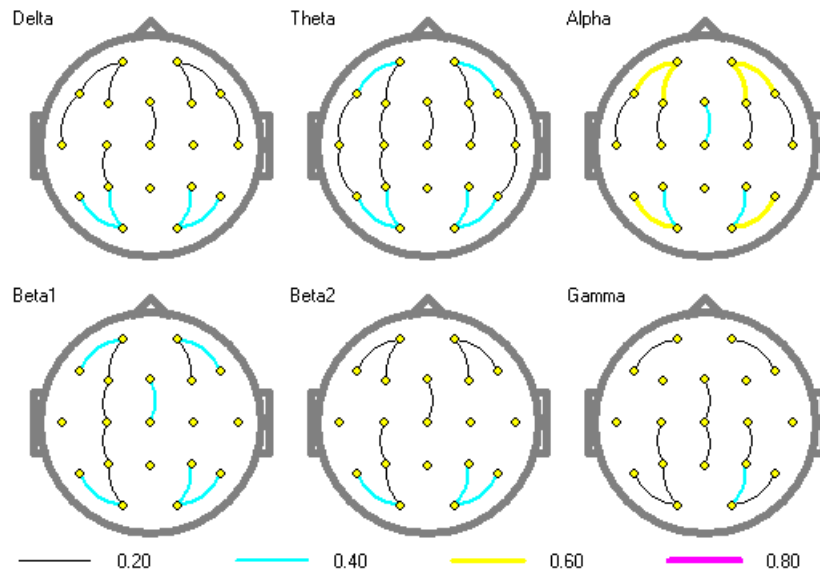


Figure 4.4: Grand average diagram of qEEG sagittal intra-hemisphere coherence for Depressed Group

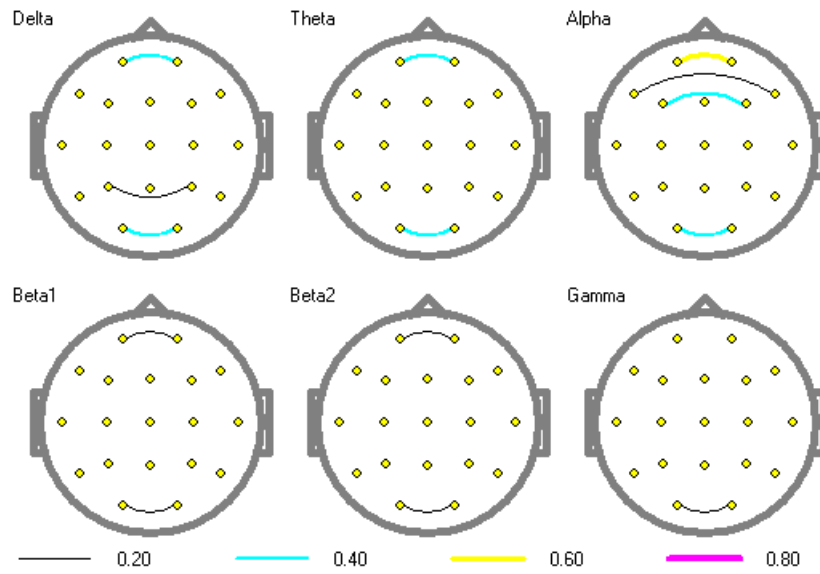


Figure 4.5: Grand average diagram of qEEG inter-hemisphere coherence for Depressed Group

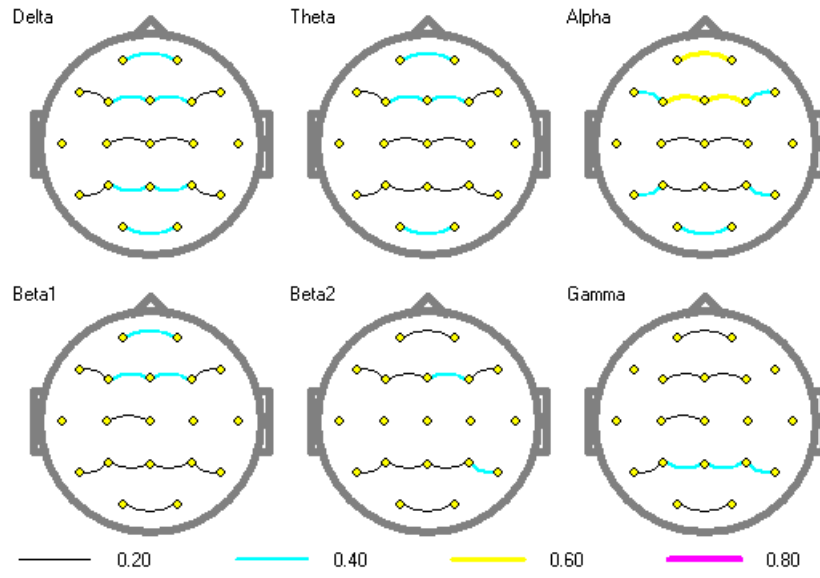


Figure 4.6: Grand average diagram of qEEG coronal intra-hemisphere coherence for Normal Group

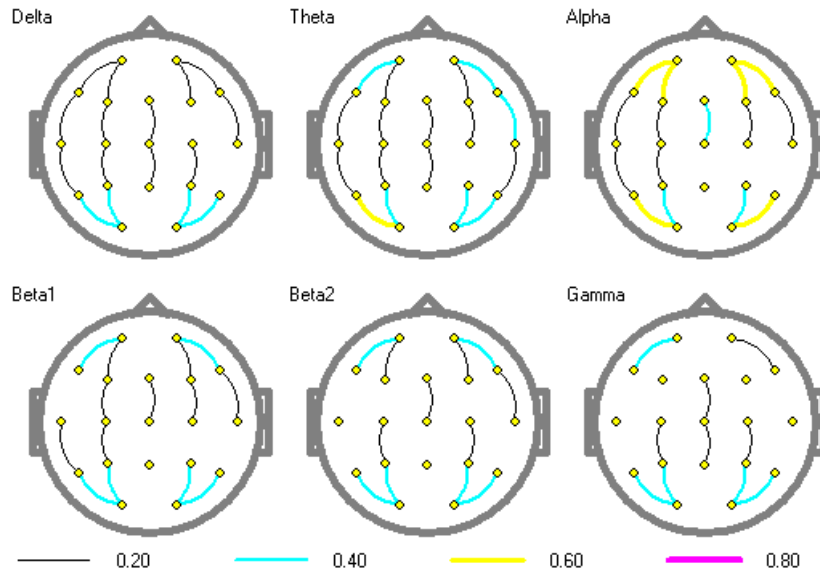


Figure 4.7: Grand average diagram of qEEG sagittal intra-hemisphere coherence for Normal Group

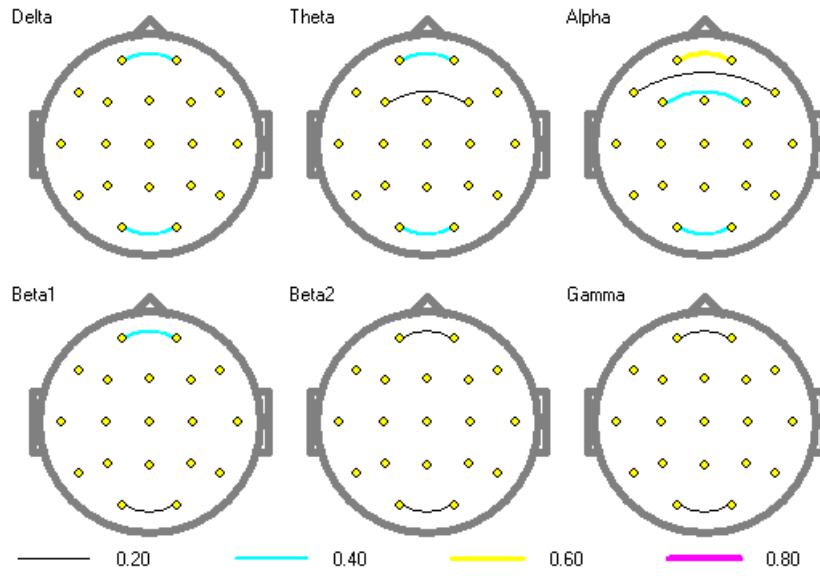


Figure 4.8: Grand average diagram of qEEG inter-hemisphere coherence for Normal Group

Visually, there are higher coherences found across the scalp in different area of the brain in depressed group. In theta band, higher coherence was found on (P3-Pz) but lower coherence on (F8-T4), (Cz-Pz), (T5-O1), and (F3-F4) in depressed group. Higher coherence in alpha was found on (F7-F3), (P3-Pz) and (Pz-P4) whereas, lower coherence was found on (T3-T5) and (C3-P3) in depressed group.

Higher coherence in beta1 on (Cz-C4), (T5-P3), (P3-Pz), and (Fz-Cz) was found in depressed group whereas lower coherence was found on (F4-C4), (F8-T4), (T3-T5), (P3-O1), and (Fp1-Fp2). In beta2, higher coherence was found on (F3-Fz), (C3-Cz), (Cz-C4), (T5-P3), and (P3-Pz) in depressed group. Besides that, lower coherence in beta2 was found on (P4-T6), (Fp1-F7), (Fp2-F8), (F8-T4), (P3-O1), and (C4-P4).

4.5 Conclusion

This chapter concluded with all the results based on the specific objective set on the earlier chapter. While most hypotheses tested was insignificant, the findings does show promising results on the area of PFC and anterior region of the brain. Study on DMN did not show significant persistence of alpha activity during EO state. Besides that, coherence study shows significantly lower and higher coherence on specific ROIs. All these findings was justified on the next chapter as well as the conclusion of this study, discussing the limitations that was found and recommendation on what future study can pick up from current study. Furthermore, contribution of this study was mentioned in the last chapter.

CHAPTER 5

CONCLUSION

5.1 Introduction

The sample size of this study is 24 participants, 12 depressed and 12 normal participants. In comparison to many previous studies, this study is considered small sample size. Although there are many limitations, which will be covered in this study, significant results was found in this study and the results are aligned with some of the previous studies. This cross-sectional study design provided to be a beginning or a stepping stone to deeper understanding the nature of mild depression on how the exhibited difference reflect dysfunction in cognitive and emotion processes and why similar brain activity was exerted across different studies in those suffering depression.

Present chapter lists out the conclusion of findings in each analysis, contributions coming from current study findings and recommendation for future works that allows further in-depth study that may provide more understanding on the relationship between DMN and rumination of thoughts.

5.2 Discussion

All the presented hypotheses were based on previous studies that were reviewed earlier. Previous studies has reported different results on the comparison of qEEG absolute power activity between depressed and normal participants and Table 5.1 shows which studies yield similar result with current study.

Table 5.1: Result from all Hypotheses Based on Previous Studies

Hypothesis	Previous Study	Site	Bands	Result
1	Grin-Yatsenko et al. (2010)	Parietal	Theta	Not Significant
		Occipital	Alpha	Not Significant
			Theta	Not Significant
		DLPFC	Alpha	Not Significant
2	Ricardo-Garcell et al. (2009)	T4	Theta	Not Significant
			Alpha	Not Significant
		Anterior vs. Posterior	Alpha	Not Significant
		Left vs. Right Hemisphere	Alpha	Not Significant
3	Debener et al. (2000); Hagemann et al. (2001); Debener et al. (2000); Ricardo-Garcell et al. (2009)	PFC	Theta	Significant
		Anterior	Beta1	Significant
			Beta2	Significant
			Beta2	Significant

Higher theta and alpha activity at parietal region was observed during eyes closed in Grin-Yatsenko, Baas, Ponomarev, and Kropotov (2010) studies on participants with early depressive disorder but was not found to be significant in this study. Grin-Yatsenko, Baas, Ponomarev, and Kropotov (2010) study also reported significantly higher theta activity on the occipital region during eyes closed task, as well as higher theta and alpha activity during eyes open task but none were not found to have any differences between depressed and normal participants in this study. Alpha activity on T4 area was also studied based on the findings of Li et al. (2015) that shows significant higher alpha activity in mildly depressed participants on T4 region of the brain, but not found to be significantly different in this study. Previous study by Ricardo-Garcell et al. (2009) reported increased theta and alpha activity on the DLPFC during eyes closed qEEG recording in group of patients suffers MDD but was not found in current study. Previous studies also reported the higher alpha activity on the posterior region of the brain compared to the anterior region in

participants with medium depressive episodes (Debener et al., 2000; Hagemann, Naumann & Thayer, 2001) but current study with mild and moderately depressed participants show no sign of alpha asymmetry between anterior and posterior region of the brain.

The most popular study on depression using qEEG will be the study on alpha asymmetry in both left and right hemispheres. Previous studies by Debener et al. (2000) and Ricardo-Garcell et al. (2009) are some of the notable study in the area of hypoactivity on the left hemisphere of the brain, which reflected by higher alpha activity on the left hemisphere. Current study looked into the comparison of both hemisphere on depressed participants but found no significant difference in alpha activity.

Hypothesis was also tested based on Mentius et al. (2002) study on the PFC which reported to have higher theta activity in MDD participants. Current study tested on the same region (PFC) but contradicted Mentius and colleagues study that shown significant lower theta activity. Significant difference was also found when anterior region between depressed and normal participants was compared. Both beta1 and beta2 activity during eyes closed task on the anterior region of the brain was higher in depressed participants compared to the normal participants. The results seem to agree with the findings in Knott, Mahoney, Kennedy, and Evans study in year 2001.

Heightened beta activity on the anterior region of the brain in was studied and addressed in multiple previous studies regarding cognitive processes, emotion and attention. One of the earlier study was done by Ray and Cole (1985) that reported strong beta activation during positive and negative emotional tasks, and cognitive tasks. In Nystrom, Matousek and

Hallstrom (1986) study also shows positive correlation of beta dominated pattern qEEG and depression, although not much explanation was provided with such findings. John, Prichep, Fridman, and Easton (1977) study shows that participants with bipolar depression have an overall elevated beta activity on the cortex, specifically on the frontal region. Another study by Dierks, Becker and Maurer (1993) also show similar results, augmented beta on the anterior part of the brain in depressed patients compare to the healthy patients. The depressed group show slow frequency range on the posterior region while, faster frequency was located on the anterior region of the brain compared to the healthy patients.

Another study by Matousek (1991) shows that EEG pattern with increase beta activity is highly associated with recurrent depression. Besides that, heightened beta activity shows some contradictory result compare to it preceding studies such as negative correlation with anxiety and but associated with features of MDD. Increased beta activity is also negatively correlated with psychomotor retardation that is core symptom of major depression (Nieber & Schlegel, 1992). Pharmacotherapy studies also indicated relationship of augmented beta in depression through results of decreased beta activity after treating depressed patients with tricyclic antidepressants and amitriptyline (Tarn, Edwards & Sedgwick, 1993).

Comparison between depressed and normal participants in this study revealed another significant difference on PFC region of the brain. The result of Mann Whitney non-parametric test shows that the theta activity on PFC region of the depressed participants is significantly higher than the normal participants. Higher theta activity on PFC region of the depressed was found opposing to previous study by Mentius et al. (2002) but similar to previous studies by Goldberg, David and Gold (2003) that found hypoactivity on the

prefrontal lobe of the schizophrenics and depressives, which mostly an indication of psychological dysfunction. This is associated with deficits in attention, planning and working memory. Another study on hypoactivation on the prefrontal lobe is symptom of impaired higher-order cognitive function which is common to those that is suffering from major depression. Higher order cognitive functions which include problem solving, planning and inhibition that were found impaired in Bench et al. (1992).

Another study by Drevets et al. (1992) results suggested that hypoactivity on the prefrontal region disrupted the frontal-limbic circuitry that connects prefrontal cortex and amygdala that is involves in modulation emotion. This decrease in prefrontal cortex was also duplicated in a later study by Mayberg, Lewis, Regenold, and Wagner (1994) that show as the prefrontal cortex is connected to the paralimbic regions, the decrease in activity implicated selective dysfunction of the paralimbic region. This dysfunction supports the concept of effect on mood and emotion modulation in our brain.

The third specific objectives of this study are looking into the association between brain's Default Mode Network (DMN) and depression. Many DMN subsystems are located on the inner brain area (Buckner, Andrews-Hanna & Schacter, 2008) and it raised difficulty for EEG to accurately pinpoint region of interest (ROI). Therefore, this study focused on the subsystem that is located on the cerebral cortex, Inferior Parietal Lobe (IPL) which is located on P3 and P4 according to the international 10-20 system. As suggested by Chen et al. (2008) studies on DMN using qEEG, alpha activity was found to be evenly distributed on both hemisphere over the posterior area of the brain (similar area as P3 and P4) and was reported to significant reduction from EC to EO state. Chen and colleagues study was done

on 15 healthy participants to observe the shift in brain activity from EC to EO states of the DMN. Similar results was found on this study where both groups shows significant higher alpha activity on IPL region compare to other bands activity in EC state. According to Kynazev, Slobodskoj-Plusnin, Bocharov, and Pylkova (2011), self-referential thoughts during resting state was found to be associated with increased alpha activity on the posterior DMN subsystem. This study confirmed the finding in both studies mentioned above.

Mann Whitney test shows that both group alpha activities was significantly reduce from EC to EO state and there are no noticeable difference and persistency of alpha reduction in depressed group. The reduction of alpha activity of during presence of external task and activation on Task Positive Network (TPN) such as DLPFC indicates the end of self-referential thoughts (Chen et al., 2008). Mann Whitney test also indicated that there is no excessive alpha activity on depressed group when compared to the normal group which contradicted with Berman, Peltier, Nee, Kross, Deldin, and Jonides (2011) finding on excessive DMN activity in depressed participants. This study Spearman's rho correlation study shows no relationship between DMN activity and rumination of thoughts as well, therefore, unable to proof that alpha activity in DMN is an indicator for persistent or excessive rumination of thoughts.

5.2.1 Coherence Analysis

Some of the cross-correlation coherence analysis findings correspond to the findings from the spectrum analysis and Mann Whitney U test. The reduced coherence found in depressed group when compared to the normal group often suggests that the neurons on

that site are operating independently (Thatcher, North & Biver, 2005). Besides that, low beta2 coherence on the left frontal (Fp1-F7) and right frontal (Fp2-F8) area might indicate reduced inter-hemisphere synaptic connection which also means an imbalance of functional processes (Knott, Mahoney, Kennedy, & Evans, 2001). Low beta1 coherence on frontal (Fp1-Fp2) and right frontal-central (F4-C4) so far has no findings that explain the observations but it is worth to take note as it shows difference in the depressed group. The low coherence areas can be suitable sites for NFT for improving depressive disorder.

5.3 Conclusion

1. Excess Beta bands in Anterior Region

- i. Mann Whitney U test indicated significant higher beta1 and bands on the anterior region of the brain in the depressed group in comparison to the normal group.
- ii. Strong beta activation happened during emotional and cognitive tasks.
- iii. Excess beta band was recorded on the anterior region in people with depression and bipolar depression according to previous studies.
- iv. Excess beta band on the anterior region was also associated with people that have recurrent depression.
- v. A pharmacotherapy study also indicated similar result with decreased beta activity after treatment with antidepressant.
- vi. Some previous studies of excess beta activity showed negative correlation with anxiety and psychomotor retardation that are symptoms of depression.

2. Heightened Theta band in Orbitofrontal Cortex

- i. Mann Whitney U test indicated significant higher theta bands on the PFC of the brain in the depressed group in comparison to the normal group.
- ii. Heightened theta band on PFC was found of those suffering schizophrenia and depression.
- iii. Previous study also showed that increase theta activity on PFC is an indication of psychological dysfunction such as deficits in attention and working memory.
- iv. Another study showed impairment on higher order function such problem solving, planning and inhibition was found in those with high theta activity on PFC.
- v. PFC that is connected to the paralimbic regions disrupt the modulation of mood and emotion when hypoactivation (increased in slow bands) occurred.

3. No indication of persistency in Default Mode Network

- i. ROI in this study was the Inferior Parietal Lobe (IPL) which is part of the Default Mode Network (DMN).
- ii. Dominant alpha activity on IPL during resting state indicated self-referential thoughts.
- iii. Both depressed and normal group IPL have a dominant alpha activity during resting state.
- iv. Alpha activity was significantly reduced in Eyes Open state in the normal group; this observation was consistent with previous studies.
- v. Alpha activity on IPL in depressed group reduced as well from Eyes Closed to Eyes Open state; therefore does not show any indication of persistency.

- vi. No evidential correlation of alpha activity on IPL during eyes open state with RRS scores since the premises of the correlation is the confirmation of persistent alpha activity during eyes open state and Spearman's correlation indicates no significant relationship.

4. Low coherence in frontal area.

- i. Coherence analysis shows low beta2 coherence on left and right frontal area.
- ii. Indication of low inter-hemisphere synaptic connection.
- iii. Low beta2 coherence also suggested imbalance functional processes.
- iv. Potential area for neurofeedback training to improve depressive symptom.

5.4 Contribution of Work

The contribution outlined in previous chapter is:

- i. Confirmation on some of the previous studies theories in Malaysia and specifically in young adults. Similar results was produced that aligned with the observation of excess beta activity on anterior region of the brain and higher theta activity found on the PFC of the brain and;
- ii. Exhibit consistency of results and help supports previous findings. Consistency of the results across different studies strengthen the reliability of using qEEG imaging method in finding out anomalies in brain electrical activity of those suffering depression.

5.5 Limitation

Adjustment was done throughout the data collection and analysis phase. The limitations of current study are the following:

- i. Difficulty in recruiting depressed participants that are suitable and stable to participate in a full qEEG session in hospitals.
- ii. Difficulty in recruiting depressed participants in university counselling department in terms of availability and willingness to participate.
- iii. It is a cross-sectional study because longitudinal study is not feasible due to the time constraints but the actual data collection period took 10 months and had to stop and proceed to data analysis and writing.
- iv. Unable to generalize the findings due to the lack of sample so can only serve as insight on exploring and confirming findings from previous studies.

5.6 Recommendation for Future Work

Further studies and research works are needed to be carried out, focusing on a few areas:

- i. Larger sample should be collected for both depressed and normal group for generalization using parametric test. Alpha activity on depressed group's IPL will be more reliable with larger sample size to observe if there is persistency from eyes closed to eyes open state.
- ii. Conduct a longitudinal study so the data collection can be more effective in gathering large sample for future work.

- iii. The result of correlation test between DMN and RRS in larger sample size could be a stronger evidence to support persistency of alpha activity or DMN activity as indication of persistent rumination of thoughts.

5.7 Concluding Remark

The objective of this study is to identify the differences in brain activity of mildly and moderately depressed young adults in Malaysia and specifically to find out the ROIs that exert different brain electrical activity, to find out if DMN activity is different in depressed participants and whether does DMN activity persist at eyes open state using EEG imaging tool and SPSS statistical analysis tool. The research findings shows that the beta1 ($p = .050$) and beta2 ($p = .050$) activity on the anterior region of the brain, and theta activity ($p = .038$) on OFC are significantly higher in depressed group. While no indication of persistency in alpha activity in DMN ($p = .009$) was found on the depressed group thus unable pinpoint if it is related to the rumination of thoughts, findings on both anterior region and OFC shows that there are differences in brain activity of mildly depressed young adults in Malaysia. Therefore, these findings satisfy the objective of this study.

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APPENDICES

Appendix A: Beck Depression Inventory

BECK DEPRESSION INVENTORY

Nama Pesakit : _____

Therapist : _____

Tarikh : _____

Arahan: Ini adalah soal-selidik. Dalam soal-selidik ini terdapat beberapa kenyataan. Sila baca keseluruhan kenyataan dalam setiap kategori. Kemudian pilih kenyataan yang menggambarkan dengan jelas perasaan anda pada hari ini, iaitu sekarang. Bulatkan nombor disebelah kenyataan yang anda pilih. Jika lebih daripada satu daripada kenyataan itu ada berkenaan dengan anda bulatkan setiap satu.

Pastikan anda membaca semua kenyataan dalam setiap kumpulan sebelum membuat pilihan.

1. ☐ 0 Saya tidak merasa sedih.
☐ 1 Saya merasa sedih.
☐ 2 Saya merasa sedih sepanjang masa dan tidak dapat lari daripadanya.
☐ 3 Saya sedih dan tidak gembira yang tidak tertahan.
2. ☐ 0 Saya tidak lemah semangat untuk menghadapi masa depan.
☐ 1 Saya merasa lemah semangat mengenai masa depan.
☐ 2 Saya tidak mempunyai apa-apa untuk dirancang pada masa depan.
☐ 3 Saya merasa tiada harapan pada masa depan dan keadaan tidak dapat diperbaiki.
3. ☐ 0 Saya tidak merasa seperti orang yang gagal.
☐ 1 Saya merasa saya telah gagal lebih daripada orang biasa.
☐ 2 Apabila melihat kembali kepada kehidupan saya, semua yang saya lihat adalah banyak kegagalan.
☐ 3 Saya merasa gagal sepenuhnya sebagai seorang manusia.
4. ☐ 0 Saya merasa puas hati dengan perkara yang biasa saya buat.
☐ 1 Saya tidak gembira dengan perkara yang biasa saya buat.
☐ 2 Saya tidak lagi mendapat kepuasan dengan apa-apa.
☐ 3 Saya tidak puas hati dan bosan dengan segala-galanya.
5. ☐ 0 Saya tidak merasa bersalah.
☐ 1 Saya kadang-kadang merasa bersalah.
☐ 2 Saya selalu merasa agak bersalah.
☐ 3 Saya selalu merasa bersalah.
6. ☐ 0 Saya tidak merasa kena hukuman.
☐ 1 Saya merasa saya mungkin akan kena hukuman.
☐ 2 Saya menjangka akan kena hukuman.
☐ 3 Saya merasa kena hukuman.
7. ☐ 0 Saya tidak merasa kecewa.
☐ 1 Saya merasa kecewa.
☐ 2 Saya rasa meluat dengan diri saya sendiri.
☐ 3 Saya bencikan diri saya sendiri.
8. ☐ 0 Saya tidak merasa lebih teruk daripada orang lain.
☐ 1 Saya menkritik diri sendiri atas kelemahan dan kesilapan yang saya lakukan.
☐ 2 Saya menyalahkan diri sepanjang masa atas segala kesalahan.
☐ 3 Saya menyalahkan diri sendiri atas semua perkara jahat yang berlaku.
9. ☐ 0 Saya tidak terfikir untuk membunuh diri.
☐ 1 Saya terfikir untuk membunuh diri tapi saya tidak akan melakukannya.
☐ 2 Saya mahu membunuh diri.
☐ 3 Saya mahu membunuh diri jika ada peluang.
10. ☐ 0 Saya tidak menangis lebih dari biasa.
☐ 1 Saya menangis lebih dari biasa.
☐ 2 Saya menangis sepanjang masa sekarang.
☐ 3 Saya biasanya boleh menangis, tetapi sekarang tidak walaupun saya hendak menangis.

11. 0. Saya tidak lagi mudah sakit hati sekarang.
 1. Saya lebih mudah tersinggung dan sakit hati.
 2. Saya merasa sakit hati sepanjang masa sekarang.
 3. Saya tidak sakit hati langsung dengan perkara yang selalunya menyakitkan hati saya.
12. 0. Saya tidak hilang minat dengan orang lain.
 1. Saya kurang berminat terhadap orang lain seperti dahulu.
 2. Saya telah hilang kebanyakan daripada minat saya terhadap orang lain..
 3. Saya telah hilang semua minat terhadap orang lain.
13. 0. Saya membuat keputusan seperti biasa.
 1. Saya lebih banyak menangguh untuk membuat keputusan.
 2. Saya mempunyai masalah untuk membuat keputusan.
 3. Saya tidak lagi dapat membuat keputusan.
14. 0. Saya tidak merasa saya kelihatan lebih teruk daripada dahulu..
 1. Saya bimbang saya kelihatan tua atau tidak menarik .
 2. Saya merasa ada perubahan kekal pada rupa saya yang membuatkan saya tidak menarik.
 3. Saya percaya bahawa saya kelihatan hodoh.
15. 0. Saya boleh berkerja dengan baik seperti biasa.
 1. Saya perlu berusaha lebih untuk memulakan sesuatu.
 2. Saya perlu memaksa diri untuk membuat sesuatu.
 3. Saya tidak boleh membuat apa-apa.
16. 0. Saya boleh tidur seperti biasa.
 1. Saya tidak boleh tidur lena seperti biasa.
 2. Saya terbangun 1-2 jam lebih awal dan sukar untuk kembali tidur.
 3. Saya bangun beberapa jam lebih awal dan tidak dapat kembali tidur.
17. 0. Saya tidak merasa lebih letih dari biasa.
 1. Saya lebih mudah letih daripada biasa.
 2. Saya merasa letih selepas membuat apa-apa perkara.
 3. Saya terlalu letih untuk berbuat apa-apa.
18. 0. Selera makan saya tidak kurang dari biasa.
 1. Selera makan saya tidak sebaik dahulu.
 2. Selera makan saya sangat kurang sekarang.
 3. Saya tidak berselera langsung.
19. 0. Saya belum kehilangan berat badan, jika ada, kebelakangan ini.
 1. Berat badan saya susut lebih 5 paun.
 2. Berat badan saya susut lebih 10 paun.
 3. Berat badan saya susut lebih 15 paun.
 Saya sengaja mengurangkan berat badan dengan mengurangkan makan
 Ya Tidak
20. 0. Saya tidak lebih bimbang terhadap kesihatan daripada biasa..
 1. Saya bimbang terhadap masalah fizikal seperti pedih dan sakit, atau masalah perut, atau sembelit.
 2. Saya sangat bimbang terhadap masalah fizikal sehingga sukar memikirkan perkara lain.
 3. Saya sangat bimbang terhadap masalah fizikal sehingga tidak dapat memikirkan perkara lain.
21. 0. Saya tidak perasan sebarang perubahan minat saya terhadap seks.
 1. Saya kurang berminat terhadap seks sebagaimana biasa..
 2. Saya sangat kurang berminat terhadap seks sekarang.
 3. Saya tidak berminat terhadap seks langsung.

Appendix B: Ruminative Response Scale



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Ruminative Response Scale

Nama: _____

Manusia sentiasa berfikir dan akan melakukan pelbagai perkara berbeza apabila dalam kemurungan. Sila baca setiap item di bawah dan nyatakan sama ada anda hampir tidak pernah, kadang-kadang, kerap, atau hampir selalu berfikir atau melakukan setiap satu apabila anda berasa murung, sedih, atau tertekan. Sila nyatakan apa yang anda biasanya lakukan, bukan apa yang anda fikir anda perlu lakukan.

(1) hampir tidak pernah (2) kadang-kadang (3) kerap (4) hampir selalu

No.	Penyataan	Skor
1	berfikir betapa sendirinya anda berasa	3
2	berfikir "Saya tidak dapat melakukan tugas saya jika saya tidak menghilangkan perasaan kemurungan ini"	1
3	berfikir tentang perasaan keletihan dan kurang sihat	1
4	berfikir bagaimana sukarnya untuk menumpukan perhatian	2
5	berfikir "Apa yang telah saya lakukan sehingga saya berada di dalam situasi ini?"	1
6	berfikir mengapa anda pasif dan kurang motivasi	2
7	menganalisa peristiwa yg baru berlaku dan cuba untuk memahami mengapa anda ada kemurungan	1
8	berfikir mengapa anda seolah-olah tidak merasa apa-apa lagi	1
9	berfikir "Mengapa saya tidak dapat meneruskan kehidupan ini?"	1
10	berfikir "Mengapa saya selalu bertindak balas dengan cara ini?"	2
11	bersendirian dan berfikir mengapa anda berasa begini	2
12	menulis dan menganalisa apa yang anda fikirkan	1
13	berfikir tentang situasi yang baru berlaku dan ingin mencari cara penyelesaian yang lebih baik	3
14	berfikir "Saya tidak dapat menumpukan perhatian jika saya terus berasa begini."	2
15	berfikir "Mengapa saya mempunyai masalah yang lain dari orang lain?"	2
16	berfikir "Mengapa saya tidak boleh menguruskan pelbagai perkara dengan cara yang lebih baik?"	3
17	berfikir betapa sedihnya anda berasa	1
18	berfikir tentang semua kelemahan, kegagalan dan kesilapan anda	1
19	berfikir bagaimana anda hilang motivasi untuk melakukan apa-apa	1
20	menganalisis personaliti anda untuk cuba memahami mengapa anda ada kemurungan	1
21	membawa diri jauh dari orang lain untuk berfikir tentang perasaan anda	2
22	berfikir betapa marahnya anda dengan diri sendiri	2
Jumlah Skor		37

Appendix C: Consent Form

INFORMED CONSENT FORM BORANG PERSETUJUAN

Study Title/Tajuk Pengajian: Quantitative analysis of EEG activity in mild and moderately depressed young adult/*Analisis kuantitatif aktiviti EEG kemurungan ringan dan sederhana dalam kalangan belia.*

Researcher/Penyelidik:

Lim Zi Xiang, 016-415 4045, email/emel: 15020266@siswa.unimas.my

Purpose of Research/ Tujuan Penyelidikan:

The purpose of this study is to identify the brain electrical activity with mild depression in Sarawak and the relationship of persistent brain Default Mode Network (DMN) with rumination of negative thoughts.

Tujuan kajian ini adalah untuk mengenalpasti aktiviti elektrik otak dengan kemurungan ringan di Sarawak dan hubungan antara desakan DN otak dan ruminasi fikiran.

The procedures and risks for the study are explained below:

1. The study involves a pre-recording screening test, non-invasive imaging session and a post-recording self-report questionnaire.
Kajian ini meliputi ujian saringan, sesi pengimejan otak tanpa invasif dan soal selidik selepas pengimejan.
2. The pre-recording screening test is a self-report test that helps to select suitable candidates to participate in the study.
Ujian saringan adalah soal selidik yang membantu penyelidik mencari calon yang sesuai untuk kajian ini.
3. There EEG recording sessions has no known physiological or psychological risks associated with your participation in this study. The study takes approximately 60 minutes to complete excluding the screening test.
Sesi pengimejan EEG kajian ini tiada sebarang risiko fisiologikal dan psikologikal. Kajian ini akan mengambil masa lebih kurang 60 minit.
4. The EEG recording includes an eyes open test, eyes close test and a figure weight test that requires participants to solve logic questions.
Pengimejan EEG meliputi ujian mata buka, ujian mata tutup dan ujian logik.
5. After EEG recording, you will be required to answer another self-report questionnaire.
Calon perlu menjawab lagi satu soal selidik selepas pengimejan EEG.
6. You will be fully debriefed as to the rationale and hypothesis underlying this experiment upon the completion of your participation.
Anda akan diberikan penjelasan mengenai hipotesis kajian selepas calon mengambil bahagian dalam kajian ini.
7. Participation is entirely voluntary. In other words, you are free to leave the experiment at any time, and this will have no bearing nor will it have any other undesirable consequences.
Penyertaan kajian ini adalah secara sukarela, calon berhak meminta izin untuk berhenti sepanjang masa kajian dijalankan dan mengundur diri daripada kajian ini tanpa sebarang ganti rugi.
8. Participation of this study will not be cover by any insurance.
Semua sukarelawan yang mengambil bahagian dalam kajian ini tidak dilindungi insuran.



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Sarawak, MALAYSIA.

Consent for Participation
Borang Keizinan Penyertaan Kajian

I agree to participate in the study which just has been described to me. The study involves answering questionnaires and solving logic problems during recording.

Saya telah bersetuju untuk menyertai penyelidikan yang diterangkan dengan jelas bahawa kajian meliputi menjawab soal selidik dan penyelesaian soalan logik semasa rakaman.

I have read and understood the information presented above about the procedures and risks involved in this study and have received satisfactory answers to my questions related to this study.

Saya telah membaca dan memahami prosedur dan risiko kajian ini dan telah mendapat penjelasan yang memuaskan mengenai kajian ini

I understand that if I have any questions or concerns resulting from my participation in this study, I may contact the researcher (Lim Zi Xiang, 016-415 4045, email: 15020266@siswa.unimas.my).

Saya memahami jikalau ada persoalan atau kebimbangan untuk menyertai kajian ini, saya boleh hubungi penyelidik kajian ini.

Data on my performance will be used exclusively for scientific purposes and will be recorded and maintained in confidential by, and available only to, Lim Zi Xiang, His research supervisor Assoc Prof Dr. Norsiah Fauzan and researchers working under same supervision.

Data prestasi saya akan digunakan untuk tujuan kajian saintifik sahaja dan kesulitan adalah dijamin.

Data akan didedahkan kepada penyelidik-penyelidik dibawah penyelia penyelidik Profesor Madya Dr. Norsiah Fauzan sahaja.

I am aware that I may withdraw from the study at any time without penalty. With full knowledge of all foregoing I agree, of my own free will, to participate in this study.

Saya boleh menamatkan penyertaan saya dalam kajian ini tanpa penalti. Dengan ini, saya bersetuju untuk menyertai kajian penyelidikan ini.

Volunteer Name/ Nama Sukarelawan

Volunteer Signature/Tandatangan Sukarelawan

Date/ Tarikh

Witnessed/Saksi



Faculty of Cognitive Science and Human Development
Universiti Malaysia Sarawak,
94300 Kota Samarahan,
Sarawak, MALAYSIA.

Consent for Academic Publication
Borang Keizinan bagi Penerbitan Akademik

To participate in this study, candidate also has to agree on the terms below:
Untuk menyertai kajian ini, peserta mesti setuju kepada syarat-syarat dibawah:

I understand that the materials that will be published will not disclose my name and all prevention will be done to ensure the confidentiality but total confidentiality is not guaranteed.

Bahan yang diterbitkan tanpa dilampirkan dengan nama saya dan setiap percubaan yang akan dibuat untuk memastikan ketanpanamaan saya. Saya memahami, walaubagaimanapun, ketanpanamaan yang sempurna tidak dapat dijamin.

Material that will be published in weekly/monthly/bimonthly/quarterly/biennially is widespread across the world. Most publications is accessible by medical doctors, non-medical scientists and journalists.

Bahan yang akan diterbitkan dalam penerbitan mingguan/bulanan/dwibulanan/suku tahunan/dwi tahunan merupakan satu penyebaran yang luas dan tersebar ke seluruh dunia. Kebanyakan penerbitan ini akan tersebar kepada doktor-doktor dan juga bukan doctor termasuk ahli saintis dan ahli jurnal.

The materials will also be shown in e-journal across the world. Some website is open for all people on the internet.

Bahan tersebut juga akan dilampirkan pada laman web jurnal diseluruh dunia. Sesetengah laman web ini bebas dikunjungi oleh semua orang.

The materials will also be published in books by journal publishers.

Bahan tersebut juga akan digunakan sebagai penerbitan buku oleh penerbit jurnal.

All materials will not be used for commercial or marketing purposes.

Bahan tersebut tidak akan digunakan untuk pengiklanan ataupun bahan untuk dibungkus.

Volunteer Name/ Nama Sukarelawan

Volunteer Signature/Tandatangan Sukarelawan

Date/ Tarikh

Witnessed/Saksi

Appendix D: qEEG Form

QEEG FORM

0601

Name: [REDACTED] Sex: F (M)

Date/ Time: [REDACTED] 11:10am

D.O.B: [REDACTED] Age: 22

Trainer: [REDACTED] Height: 171 Weight: 89

Time Duration	Task	Remarks/ Observation
11:32:06 11:35:41	Eyes Open	
11:36:10 11:39:32	Eyes Close	F4 - T3 36
11:39:58 11:43:19	E02	F8 + T4 38-40 T3 F8 F7 68, 93 → mouth movement
11:43:56 11:47:01	pw	

* Device condition: _____

Trainer Coordinator: _____

Appendix E: Permission Letter

Fakulti Sains Kognitif dan Pembangunan Manusia

Faculty of Cognitive Sciences and Human Development

Nur Hurunain Binti Amran

Fakulti Sains Kognitif dan Pembangunan Manusia

Universiti Malaysia Sarawak

94300, Kota Samarahan,

Sarawak



www.unimas.my

Pengarah,
Hospital Sentosa,
Jalan Penrissen
93250, Kota sentosa,
Kuching,
Sarawak.

26 Oktober 2015

Tel : 082-612321
Faks: 082-610495

Tuan/ Puan,

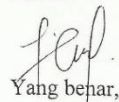
Permohonan Mengadakan Lawatan Penyelidikan Sarjana Di Hospital Kota Sentosa, Kuching

Merujuk kepada hasil perbincangan dengan pihak tuan pada tempoh hari yang lalu, sukacita dimaklumkan, saya wakil pelajar Sarjana Kognitif Neurosains (secara penyelidikan) dibawah penyeliaan Assoc. Prof. Dr Norsiah Fauzan, bersetuju untuk mengadakan lawatan sambil belajar di Hospital Kota Sentosa.

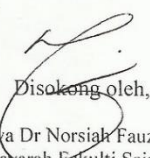
2. Untuk maklumat tuan, kajian yang kami jalankan berkenaan dengan penyakit kemurungan (*Depression*), stress, dan kemerosotan kognitif tahap ringan (*Mild Cognitive Impairment*). Sehubungan dengan itu, kami memohon jasa baik dari pihak tuan untuk membenarkan kami untuk melawat persekitaran hospital dan melihat instrument atau inventori yang digunakan oleh pihak hospital dan proses atau prosedur yang terlibat dalam mengendalikan kes- kes berkenaan.

3. Sehubungan dengan itu, saya berharap agar permohonan ini diluluskan untuk menjalankan lawatan penyelidikan ini demi meningkatkan kualiti penyelidikan dalam bidang Kognitif Neurosains. Segala perhatian dan kerjasama dari pihak tuan amatlah dihargai dan saya dahului dengan ucapan ribuan terima kasih. Sebarang maklumbalas atau pertanyaan boleh diajukan di talian 018-9868268 atau melalui emel: nainamran@gmail.com

Sekian.


Yang benar,

Nur Hurunain Amran
(MS 15020133)


Disokong oleh,

Prof Madya Dr Norsiah Fauzan
(Penyelia dan Pensyarah Fakulti Sains Kognitif
dan pembangunan Manusia)



94300 Kota Samarahan, Sarawak, MALAYSIA | Tel + 60 82 581 578 | Fax + 60 82 581 579

UNIMAS/NC-16.02/04-05 Jld. III (18)

18 Mac 2016

Dr. Selvasingam Ratnasingam
Department of Psychiatry
Hospital Umum Sarawak
Jalan Hospital, 93586
Kuching Sarawak

Dr.,

**Permohonan Kebenaran Untuk Membuat Kutipan Data Berkaitan
Penyelidikan Ilmiah Untuk Pelajar Siswazah UNIMAS**
- Lim Zi Xiang (No. Pelajar : 15020266)

Dengan hormatnya perkara di atas adalah dirujuk.

Dimaklumkan bahawa penama di atas merupakan pelajar siswazah UNIMAS Tahun 2015 bagi program Sarjana dalam bidang Pembangunan Sumber Manusia di Fakulti Sains Kognitif dan Pembangunan Manusia. Dimaklumkan, beliau sedang menjalankan penyelidikan yang bertajuk:-

QEEG Signature of Depression

Sehubungan itu, saya memohon kerjasama dari pihak tuan/puan untuk memberi kebenaran dan bantuan kepada beliau bagi mendapatkan data dan maklumat berkaitan penyelidikan tersebut di organisasi tuan/puan. Maklumat ini akan digunakan untuk bidang kajian penyelidikan beliau sahaja.

Sekiranya terdapat sebarang kemusykilan berhubung perkara ini, mohon untuk terus menghubungi penyelia beliau iaitu Prof Madya Dr Norsiah Fauzan dari Fakulti Sains Kognitif dan Pembangunan Manusia yang boleh dihubungi di talian 082 581515.

Sekian, harap maklum dan terima kasih.

Yang benar



Dr Philip Nuli Anding
Timbalan Dekan (Siswazah & Penyelidikan)

12 June 2018

Puan Saptuyah Binti Barahim
Pegawai Psikologi Kanan
Unit Kaunseling dan Kebajikan Pelajar
Bangunan Hal Ehwal Pelajar dan Alumni
Universiti Malaysia Sarawak
94300 Kota Samarahan
Sarawak

Dear Madam,

Permission to Conduct Research in the Fulfilment of Postgraduate Degree

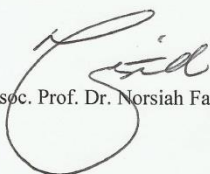
With reference to the matter above, I would like to request permission for the following student from the Faculty of Cognitive Science and Human Development, Universiti Malaysia Sarawak to conduct a study with the help from the Counselling Unit in the Student Affair and Alumni Department.

Student name : Lim Zi Xiang
Student number : 15020266
Program : Cognitive Neuroscience
Research title : Quantitative Analysis of Mild and Moderately Depressed Young Adult
Research phase : Data collection
Principle supervisor : Assoc. Prof. Dr. Norsiah Fauzan
Telephone : 016-415 4045
Email : 15020266@siswa.unimas.my

His research is purely for academic purpose and all information will be kept secure and treated as strictly confidential. The support and cooperation given by you organization for the success of this research is highly appreciated.

Thank you.

Sincerely,


Assoc. Prof. Dr. Norsiah Fauzan



Universiti Malaysia Sarawak
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