Faculty of Cognitive Science and Human Development

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

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Master of Science
2018

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

Lim Zi Xiang

A thesis submitted

In fulfillment of the requirements for the degree of Master of Science

(Cognitive Neuroscience)

Faculty of Cognitive Science and Human Development
UNIVERSITI MALAYSIA SARAWAK
2018

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ACKNOWLEDGEMENT

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

Philippians 4:6

First of all, I want to thank God for His provision in every area that I am lacking. I would also like to thank my family who has always supported me financially, emotionally and spiritually. A special gratitude to my main supervisor, Assoc. Prof. Dr. Norsiah Fauzan for her willingness to guide and support me in throughout my research. In addition, I would also like to thank my co-supervisor, Dr. Kartini bt Abdul Ghani for her encouragements and guidance whenever I seek help from her. I would not have been able to complete my thesis without them. Specials thanks to my proposal defense evaluators: Dr. Tan Kock Wah and Drs. Muhamad Sophian that has given me valuable feedback to improve my research.

I would also like to acknowledge my senior and fellow researchers, Nur Hurunain and Hartini who have unconditionally helped me in my research and taught me so much in my field of study. I am really touched as they never once expect any returns from their assistances.

Lastly, I would also like to give thanks to all my brothers and sisters in Hope Kota Samarahan for their fervent prayers, encouragements and supports during the course of my postgraduate study.

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 Quantitatif 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.*

TABLE OF CONTENTS

Page

DECLARATION i

ACKNOWLEDGEMENT ii

ABSTRACT iii

ABSTRAK iv

TABLE OF CONTENTS v

LIST OF TABLES ix

LIST OF FIGURES xi

LIST OF ABBREVIATIONS xii

CHAPTER 1: INTRODUCTION 1

1.1 Introduction 1

1.2 Background of Study 1

1.2.1 Impact of Depressive Disorders 2

1.2.2 Quantitative Electroencephalography 4

1.2.3 Basic qEEG definition 5

1.2.4 qEEG and Depression 7

1.2.5 Brain Default Mode Network and Rumination 7

1.3 Problem Statement 10

1.4 Research Objective 12

1.5 Hypothesis 13

1.6 Conceptual Framework 15

1.7 Terminology 16

1.8 Significant of Study 18

1.9 Conclusion 19

CHAPTER 2: LITERATURE REVIEW 20

2.1 Introduction 20

2.2 PET/SPECT Studies on Depression 20

2.3 fMRI Studies on Depression 22

2.4 Sleep and Wake EEG Studies on Depression 24

2.5 qEEG Studies on Depression 27

2.6 qEEG and fMRI Studies on Default Mode Network 33

2.7 Conclusion 36

CHAPTER 3: METHODOLOGY 37

3.1 Introduction 37

3.2 Research Design 37

3.3 Participants and Settings 38

3.4 Sampling Method 39

3.5 Data Collection Protocol 40

3.6 Instrumentation 41

3.6.1 Ruminative Response Scale 42

3.6.2 Quantitative Electroencephalography 43

3.7 Data Analysis Methods 44

3.7.1 Mann Whitney U Test 45

3.7.2 Spearman's Correlation 45

3.7.3 Coherence Analysis 46

3.8 Challenges in Data Sample Selection 46

3.9 Data Collection Gantt chart 49

3.10 Ethical Consideration 49

3.11 Conclusion 51

CHAPTER 4: RESULTS 52

4.1 Demographic Data 52

4.2 Beck Depression Inventory 53

4.3 Ruminative Response Scale 53

4.4 Absolute Activity 54

4.4.1 Crosscorrelation Coherence 67

4.5 Conclusion 71

CHAPTER 5 CONCLUSION 72

5.1 Introduction 72

5.2 Discussion 72

5.2.1 Coherence Analysis 77

5.3 Conclusion 78

5.4 Contribution of Work 80

5.5 Limitation 81

5.6 Recommendation for Future Work 81

5.7 Concluding Remark 82

REFERENCES 83

APPENDICES 90

LIST OF TABLES

Page

Table 1.1 Comparison on the prevalence of depression in Malaysia and United State (%) 2

Table 1.2 Frequencies, normal occurrence and significance of each frequency bands 6

Table 1.3 ROIs from previous studies that will be investigated 11

Table 2.1 Previous studies on depression using PET/SPECT scan 22

Table 2.2 Previous studies on depression using fMRI 24

Table 2.3 Previous studies on depression using EEG 27

Table 2.4 Previous studies on depression using qEEG 32

Table 2.5 Previous studies on DMN using fMRI and qEEG 35

Table 3.1 Gantt chart for data collection 49

Table 4.1 Descriptive Statistics for the Age of Participants (N=24) 52

Table 4.2 Demographic Table for Participants' Race 53

Table 4.3 Descriptive Statistics for BDI scores of Participants (N=24) 53

Table 4.4 Descriptive Statistics for RRS scores of Participants (N=24) 53

Table 4.5 Mann Whitney Test for EC Task 55

Table 4.6 Mann Whitney Test for EO Task 56

Table 4.7 Mann Whitney Test for Comparison in Depressed and Normal Group (1) 58

Table 4.8 Mann Whitney Test for Comparison in Depressed and Normal Group (2) 58

Table 4.9 Mann Whitney Test for Comparison in Depressed and Normal Group (3) 59

Table 4.10 Mann Whitney Test for Comparison in Depressed and Normal Group (4) 59

Table 4.11 Mann Whitney Test for Comparison in Depressed and Normal Group (5) 60

Table 4.12 Mann Whitney Test for Comparison in Depressed and Normal Group (6) 60

Table 4.13 Mann Whitney Test for Comparison in Depressed and Normal Group (7) 61

Table 4.14 Mann Whitney Test for Comparison in Depressed and Normal Group (8) 61

Table 4.15 Mann Whitney Test for Comparison in Depressed and Normal Group (9) 62

Table 4.16 Mann Whitney Test for Comparison in Depressed and Normal Group (10) ... 62

Table 4.17 Mann Whitney Test for Comparison in Depressed and Normal Group (11) ... 63

Table 4.18 Mann Whitney Test for Comparison in Depressed and Normal Group (12) ... 63

Table 4.19 Descriptive Statistics for IPL Bands of Depressed Participants in EC Task 64

Table 4.20 Descriptive Statistics for IPL Bands of Normal Participants in EC Task 64

Table 4.21 Mann Whitney Test for Comparison on EC and EO Task 65

Table 4.22 Mann Whitney Test for Comparison in Depressed and Normal Group 66

Table 4.23 Spearman Correlation Matrix among RRS and Alpha Activity in EC Task 66

Table 5.1 Result from all Hypotheses Based on Previous Studies 73

LIST OF FIGURES

Page

Figure 1.1 Hubs and subsystems within DMN 8

Figure 1.2 Conceptual framework for current study 15

Figure 3.1 Data collection protocol for current study 40

Figure 3.2 Diagram of Average Montage (Av) in Mitsar WinEEG 45

Figure 3.3 Example of Coherence Diagram in Mitsar WinEEG program 48

Figure 4.1 Grand average maps of qEEG power spectra for Depressed Group 56

Figure 4.2 Grand average maps of qEEG power spectra for Normal Group 57

Figure 4.3 Grand average diagram of qEEG coronal intra-hemisphere coherence for Depressed Group 67

Figure 4.4 Grand average diagram of qEEG sagittal intra-hemisphere coherence for Depressed Group 68

Figure 4.5 Grand average diagram of qEEG inter-hemisphere coherence for Depressed Group 68

Figure 4.6 Grand average diagram of qEEG coronal intra-hemisphere coherence for Normal Group 69

Figure 4.7 Grand average diagram of qEEG sagittal intra-hemisphere coherence for Normal Group 69

Figure 4.8 Grand average diagram of qEEG inter-hemisphere coherence for Normal Group 70

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	Spearmen'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, pyscho-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 Fournier 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)