RESTING-STATE EEG CURRENT SOURCE-DENSITY OF NEURAL OSCILLATIONS: A GENDER COMPARISON STUDY

NUR AFIFAH BINTI RAHIMI

This Report Is Submitted In Partial Fulfillment of Requirements For The Bachelor Degree of Electronic Engineering (Industrial Electronic) With Honours

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2017

ii

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek	:	**RESTING-STATE EEG CURRENT SOURCE DENSITY OF NEURAL OSCILLATIONS: A GENDER COMPARISON STUDY**
Sesi Pengajian	:	1 6 / 1 7

Saya **NUR AFIFAH BINTI RAHIMI** mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Farah Shahnaz Binti Feroz
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Alamat Tetap: No.5, Jalan Rusa 10, Taman Scientex 81700 Pasir Gudang, Johor.

Tarikh: 2 Jun 2017

Tarikh: 2 Jun 2017

*CATATAN : Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya telah saya jelaskan sumbernya."

Tandatangan : ....

Nama Penulis : NUR AFIFAH BINTI RAHIMI

Tarikh : 2 JUN 2017

"Saya/kami akui bahawa saya telah membaca karya ini pada pandangan saya/kami karya ini adalah memadai dari skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Elektronik (Elektronik Industri)."

Tandatangan : ....

Nama Penyelia : FARAH SHAHNAZ BINTI FEROZ

Tarikh : 2 JUN 2017

This work is especially dedicayed to my parents, Rahimi Bin Mohd Raflis and Masni Binti Mohd Rashid, my siblings, Muhammad Aizat, Nur Atasya and Nur Alia, and dearest one, Syed Muhammad Danial, without whose caring supports it would not have been possible. Only Allah will return all your kindness.

ACKNOWLEDGEMENT

Praise to Allah S.W.T that with His blessings I'm able to finish this project in time successfully. Therefore, I consider myself as a very lucky individual as I was provided with an opportunity to be a part of it. Bearing in mind previous I would like to express my greatest gratitude to my supervisor Miss Farah Shahnaz Binti Feroz who in spite being extraordinary busy with her duties, took time out to hear, guide and keep me on the correct path during finishing this project. My next deepest appreciation is dedicated to my parents and family for their money and moral support. Thanks to my friend who had helped me a lot in completing this project. Last but not least to whom directly or indirectly contribute to this project.

ABSTRACT

Emerging research have concentrated on determining differences in brain oscillations in groups of subjects inclusive of patients with health and mental disorders. At the moment, very few of such studies focus on gender differences. Our attempt is to investigate gender differences in brain oscillations and the regions involved in healthy subjects. Using pre-recorded resting-state EEG, we sought to compare the similarities and differences of patterns of oscillations in male and female subjects. Thus far, we have 14 EEG resting state recordings for males and 15 females. First, pre-processing will be done on filtering which include high pass filter cut-off of 30 Hz and low pass filter cut-off of 0.3 Hz. The low pass filter is used to get rid of baseline drift while the high pass filter is to get rid of noise. For high pass filter, sodium chloride (electrolyte) from sweating reacting with metals of the electrodes may produce a slow baseline drift. After that, we down sample from 1000 to 250 Hz. Then, continued with manual rejection for muscle artifact and proceed using ICA in EEGLab to reject continuous data for eye/ocular artifacts. Next, the pre-processed data will be exported and analyzed using Loreta. Our objectives are to determine the EEG oscillations (frequency bands) that are significantly different between males and females and the brain regions that are responsible for the difference. All the objectives have been successfully achieved.

ABSTRAK

Penyelidikan baru muncul telah tertumpu pada menentukan perbezaan dalam ayunan otak dalam kumpulan mata pelajaran termasuk pesakit dengan kesihatan dan gangguan mental. Pada masa ini, sangat sedikit daripada kajian tersebut menumpukan kepada perbezaan jantina. Usaha kami adalah untuk menyiasat perbezaan jantina dalam jangka ukuran otak dan kawasan-kawasan yang terlibat dalam subjek yang sihat. Menggunakan pra-rakaman dalam keadaan rehat EEG, kami berusaha untuk membandingkan persamaan dan perbezaan corak ukuran dalam subjek lelaki dan perempuan. Setakat ini, kami mempunyai 14 EEG rakaman dalam keadaan rehat bagi lelaki dan 15 perempuan. Pertama, pra-pemprosesan akan dilakukan pada penurasan termasuk penurasan tinggi terhenti 30 Hz dan penurasan rendah terhenti 0.3 Hz. Penurasan rendah digunakan untuk menghilangkan sudut gelincir asas manakala penurasan tinggi adalah untuk menghilangkan bunyi bising. Untuk penurasan tinggi, natrium klorida (elektrolit) dari berpeluh bertindak balas dengan logam elektrod boleh menghasilkan sudut gelincir asas perlahan. Selepas itu, kami mengurangkan kadar sampel 1000-250 Hz. Kemudian, diteruskan dengan penolakan manual untuk artifak otot. Dan teruskan menggunakan ICA dalam EEGLab untuk menolak data berterusan untuk mata / artifak okular. Seterusnya, data pra-diproses akan dieksport dan dianalisis menggunakan Loreta. Objektif kami adalah untuk menentukan jangka ukur EEG (jalur frekuensi) yang jauh berbeza antara lelaki dan perempuan dan kawasan otak yang bertanggungjawab untuk perbezaan. Semua objektif telah berjaya dicapai.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

This chapter covers the introduction part of this Final Year Project which includes sub-chapters of objectives, problem statements, scopes, software and significant of the project.

2.1 Introduction of Project

Recently electroencephalogram (EEG) widely used in our world such as for medical purpose and further study on expanding human understanding of brain organization. History tells Hans Berger, a German psychiatrist was the first human developed EEG. Berger was interested in the study of the relationship between mental processes and the brain. Berger decided to measure the brain's electrical activity in belief the physiological record would provide insight into mental processes. At first reaction of Berger's work was one of disbelief. He did not achieve an international reputation. At the end, it was then Edgar Douglas Adrian, a renowned English neurophysiologist confirmed Berger's findings.

EEG is a graphic (vivid) of the electrical activity of the brain. By placing electrodes on the scalp of the subjects and connecting the electrode wires to a machine known as an electroencephalograph. The machine then records the patterns of brain waves (rhythmic changes in the electric pulse of the brain). EEGs are used to diagnose epilepsy, brain tumors, strokes and other neurological conditions. These conditions are categorized by abnormal patterns of brain waves. In addition, EEGs also used in investigating psychiatric disorders such as schizophrenia.

The EEG diagnose can be performed at any age of the subjects. But this project focused on resting-state EEG current source-density of neutral oscillation specifically in gender comparison between male and female. The diagnosis also can be conducted whether in resting-state opened-eyes or closed-eyes EEG. We are interested in closed-eyes EEG for this project. If the project success, it could be used in neurology fields in the future.

There are four types of brain waves frequencies to understand which each of them has a different frequency range such as delta (1.5Hz to 6Hz), theta (6Hz to 8Hz), alpha (8Hz to 12Hz) and beta (12Hz to 30Hz)

2.2 Objectives

1. To compare oscillatory activity in specific frequency bands (delta, theta, alpha, beta) between male and female subjects.
2. To identify the EEG oscillations (frequency bands) that are significantly different between male and female subjects.
3. To determine the brain regions that are responsible for the difference male and female subjects.

2.3 Motivation

This study is to describe the differences between male and female healthy subjects in oscillatory activity in brain oscillations and the region involved. Major motivation of this study is to know about the behavior of EEG during a resting state. Practically by doing this project, it shows the appropriate methods in conducting EEG experiments and pre-processing using Matlab and analyze data using LORETA software. It is also socially relevant since it can contribute to functional brain organization for study use.

2.4 Problem statement

Gender is presumed to be one of the factor causing inter-individual variability in the brain's electrophysiological parameters. Emerging research have concentrated on determining differences in brain oscillations in groups of subjects inclusive of patients with health and mental disorders. At the moment, very few of such studies focus on gender differences. Based on the previous specific studies in gender shown inconsistencies in report findings. The question arise on what is exactly the truth EEG oscillations and the brain regions between male and female. Thus, we attempt to investigate gender differences in brain oscillations and the regions involved in healthy subjects.

2.5 Scope of Project

The working principle of this project is to show differences EEG oscillations between male and female subjects and the regions involved. The main function of this project is to detect differences in brain oscillations between male and female groups. At the beginning, the project starts working on literature study by referring journals, articles and books. After doing some research, pre-processing is a next step. The pre-processing begins with filtering high pass and low pass and following with down sampling. Then, manual rejection of muscle artifacts caused by laughing, grinding teeth, head movement etc. This proceed with rejecting continuous data by eye/ ocular artifacts and heart rate using Independent Component Analysis (ICA). At the end of this project is doing analysis (oscillatory), obtain results and discussion regarding the current results and previous findings.

2.6 Software

As for the software used, the pre-processing is compatible with MATLAB software by Mathworks© and EEGLab. All the analysis for the project will be done by using LORETA.

2.7 Project Significance

The gender comparison study contributes to the ongoing research in brain function and oscillation by disentangling the effects of fundamental biological factor such as gender influence on the brain during a resting-state. Using pre-recorded resting-state EEG, we sought to compare the similarities and differences of patterns of oscillations in male and female subjects. Thus far, we have 14 EEG resting state recordings for males and 15 females. First, pre-processing will be done on filtering which include high pass filter cut-off of 30 Hz and low pass filter cut-off of 0.3 Hz. The low pass filter is used to get rid of baseline drift while the high pass filter is to get rid of noise. For high pass filter, sodium chloride (electrolyte) from sweating reacting with metals of the electrodes may produce a slow baseline drift. After that, we down sample from 1000 to 250 Hz. Then, continued with manual rejection for muscle artifact. And proceed using ICA in EEGLab to reject continuous data for eye/ocular artifacts. Next, the pre-processed data will be exported and analyzed using LORETA. This project is beneficial for our society on understanding of which gender consistently perform and for detection of mental activity to reliably identify.

2.8 Report Structure

The report consists of five chapters. Chapter 1 discusses the introduction of the project which includes the objectives of the project, problem statements; scope of the project, project significance and report structure.

Chapter 2 discuss about the Literature review. This chapter included literature review on Artifact Removal from EEG Signal by A.GuruvaReddy and Srilatha Narava, Resting brain activity: Differences between genders by Norbert Jauˇsovec and Ksenija Jauˇsovec, Brain oscillations are highly influenced by gender differences by Bahar Güntekin, Erol Başar, Network Analysis of Resting State EEG in the Developing Young Brain: Structure Comes With Maturation by Maria Boersma, Dirk J.A. Smit, Henrica M.A. de Bie, G. Caroline M. Van Baal, Dorret I. Boomsma, Eco J.C. de Geus, Henriette A. Delemarre-van deWaal, and Cornelis J. Stam and ADJUST: An automatic EEG artifact detector based on the joint use of spatial and temporal features by Andrea Mognon, Jorge Jovicich, Lorenzo Bruzzone and Marco Buiatti.

The next chapter discusses about methodology of the project. The methodology which includes project implementation, pre-processing and a flowchart.

Chapter 4 discusses about result and discussion of the project. It is full decision result after the completion of this project.

The final chapter is chapter 5 that explains about conclusion and recommendation for future work related to this project.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses the overview on the related topic and the background study related to this project. This chapter covers research studies in previous established works.

3.1 Artifact Removal from EEG Signal

By the artifacts itself not all the signals that display in the EEG record is coming from brain. A bad electrodes location, unclean hairy leather, electrodes impedance is caused the most common artifacts during the recording process. Furthermore, there is also a finding of physiological artifacts that is bioelectrical signals from other parts of the body (heart rate, muscle activity and eye movement) that are recorded in the EEG [2]. There are various types of independent sources in EEG recordings such as noise, muscle, eye activity and brain activity that should be rejected to get a clear data.

2.2 Resting Brain Activity: Differences Between Gender

The research is about electrophysiological (EEG) and hemodynamic (near infrared spectroscopy – NIRS) measures as a function of gender in healthy adult individuals. The EEG data analysis depending the resting eyes closed brain activity of 300 respondents (160 females) while the NIRS analysis is depending 155 respondents

(88 females) [3]. By referring the results, it shows a higher power values in females as compared with males in the gamma and beta bands [3].

Table 1: GLM F-test and p values for power measures significant main effects (gender) and interaction effects (gender x location). Only significant gender related differences are shown.

Frequency	Main effect – gender			Interaction effect – gender × location	
Lower-1 α	$F(1,298)=4.23$	$p<.043$	M<F	$F(2,596)=5.04$	$p<.015$
Lower-2 α		N.S.		$F(2,596)=5.13$	$p<.014$
Upper α		N.S.		$F(2,596)=5.36$	$p<.014$
β	$F(1,298)=49.46$	$p<1.4E-011$	M<F	$F(2,596)=38.01$	$p<2.0E-013$
γ	$F(1,298)=23.04$	$p<2.5E-006$	M<F	$F(2,596)=26.20$	$p<2.9E-009$

2.3 Brain Oscillations Are Highly Influenced by Gender Differences

Based on this paper, the EEG is recorded from F3, F4, Cz, C3, C4, T3, T4, T5, T6, P3, P4, O1 and O2 locations according to the 10–20 system and used EOG recordings. The data of 32 (16 males) healthy subjects is recorded from thirteen different scalp locations (F3, F4, Cz, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2). The analysis is included the delta (0.5–3.5 Hz), theta (5–8.5 Hz), alpha (9–13 Hz), beta (15–24 Hz), and gamma (28–48 Hz) frequency ranges [4]. The result shows that the maximum peak-to-peak delta response amplitudes for women were significantly higher than men over occipital, parietal, central and temporal electrode locations [4].

Table 2: For female and male subjects the mean, standard deviation and p values of the maximum peak-to-peak amplitude values are shown for the delta, beta and gamma frequency range at different locations.

Location–frequency	Female		Male		p value
	Mean value µv	Standard deviation	Mean value µv	Standard deviation	
C_z Delta	6.1936	±2.6156	4.4631	±1.7111	0.006
T_5 Delta	3.8313	±1.1303	2.9454	±1.4977	0.015
P_3 Delta	6.3035	±3.2922	3.8094	±1.8960	0.002
P_4 Delta	5.5824	±2.3954	4.2996	±2.2202	0.044
O_1 Delta	6.2502	±2.2661	3.7551	±2.3748	0.003
O_2 Delta	6.6248	±2.2345	4.5105	±3.1163	0.034
O_1 Beta	2.8032	±1.5162	1.7943	±0.6089	0.013
O_2 Beta	2.7716	±0.9632	2.1288	±0.5588	0.007
O_2 Gamma	1.397	±0.8319	0.9484	±0.3585	0.03

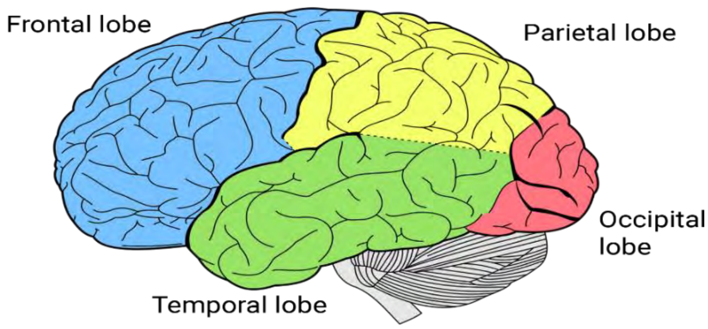

Figure 2.1: Brain lobes

2.4 Network Analysis of Resting State EEG in the Developing Young Brain: Structure Comes with Maturation

This paper mentioned the resting-state eyes-closed electroencephalography (EEG) is recorded (14 channels) from 227 children twice at 5 and7 years of age. Based on the result, girls show higher synchronization for all frequency bands and a higher mean clustering in alpha and beta bands [5].

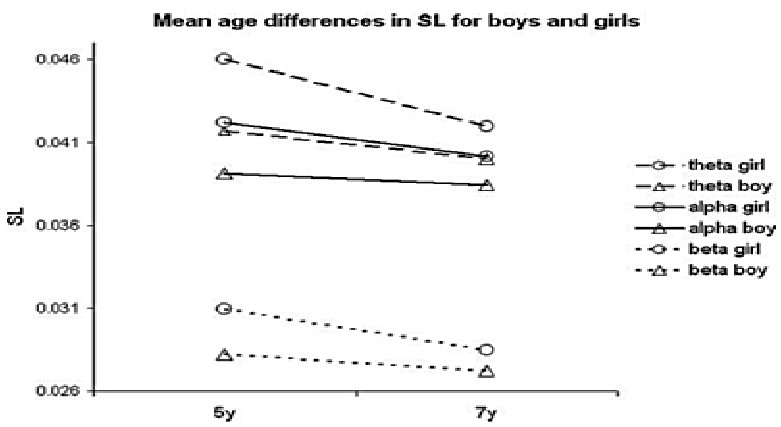

Figure 2.2: Mean SL over all epochs for boys and girls at 5 and 7 years of age in three frequency bands. The variance in SL was significantly lower in children at 7 years of age compared to that at 5 years of age in theta [F(1,225) ¼ 30.116, P < 0.001], alpha [F(1,225)¼ 8.330, P ¼ 0.004] and beta [F(1,225) ¼ 29.367, P < 0.001] band. Boys had significant lower SL in theta [F(1,225) ¼ 14.616, P < 0.001], alpha [F(1,225) ¼ 8.025, P ¼ 0.005] and beta [F(1,225) ¼ 16.796, P < 0.001] band. The beta frequency band showed a significant interaction effect between time and gender [F(1,225) ¼ 5.116, P ¼ 0.025].

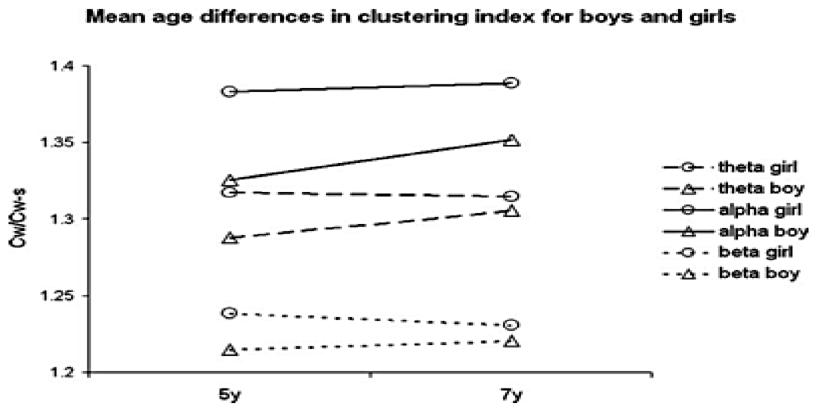

Figure 2.3: Mean normalized clustering index (Cw/Cw ? s) for boys and girls at 5 and 7 years of age in three frequency bands. The meanclustering index was significant higher in children of 7 years of age compared to children at 5 years of age in the alpha band (F¼ 7.087, P ¼ 0.008). Girls showed higher clustering in the alpha (F ¼ 10.966, P ¼ 0.001) and beta (F ¼ 9.207, P ¼ 0.003) bands.

2.5 ADJUST: An Automatic EEG Artifact Detector Based on The Joint Use of Spatial and Temporal Features.

Adjust is a successful method that can removed artifacts from electroencephalogram (EEG) recordings in Independent Component Analysis (ICA) [19]. Removal of the artifacted components detected by ADJUST leads to neat reconstruction of visual and auditory event-related potentials from massively artifacted data. Based on the results obtained, ADJUST provided a fast, efficient and automatic way to use ICA for artifact removal [19].

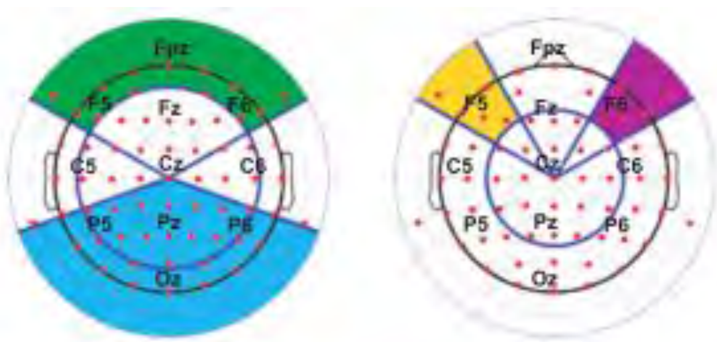

Figure 2.4: Scalp areas used in ADJUST spatial features computation. Left-hand panel: Frontal area (in green) and Posterior area (in blue); Right-hand panel: Left-eye area (in yellow) and Right-eye (in purple). Red dots indicate channel positions in the validation dataset.