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Research paper

Region of Interest (ROI) for EEG Activity in Depressed Young Adult

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Abstract

Several abnormal neural activities in regions such as dorsolateral prefrontal cortex (DLPFC) and prefrontal cortex (PFC) are known to be associated with depression. However most studies focused on major depression disorder and less on mild and moderate depression, moreover, these studies are mostly conducted in United State and European countries. This study uses data from 12 mild and moderately depressed and 12 healthy control young adult in Malaysia to examine the differences in brain activity via spectrum and coherence analysis in quantitative electroencephalography (qEEG). The study found that depressed group have higher beta on the anterior region that is found on people with depression and recurrent depression in previous studies, and higher theta on the prefrontal cortex may associate with deficits in attention and working memory in resting state compare to healthy control. Furthermore, left and right frontal showed low beta2 coherence that may indicate imbalance of functional processes.

Keywords: *prefrontal cortex; depression; qEEG; beta; theta.*

1. Introduction

Depression is the most common mental disorders occurred in Malaysia. The prevalence of depression in Malaysia is approximately between 3.9 to 46% [1]. This statistics is comparable of the prevalence that is occurring in developed countries and has become a concerning issue. Various brain imaging research has been done to understand the changes that occurs on brain activity of those suffering depression and these studies have found out several areas of the cerebral cortex reflected anomalies such as DLPFC, PFC and; bigger area such as the anterior and the posterior regions [2– 4].

A large amount of study on the brain activity of depression was done using Electroencephalography (EEG) because it is inexpensive, easy to use, high mobility and high temporal resolution. Therefore, EEG is commonly used to investigate brain activity. Previous findings using EEG has demonstrated the differences in brain activity of those suffering depression in comparison to a healthy person. Finding from Debener, and colleagues shows that in resting state, depressed group has higher alpha activity on the right than left anterior region of the brain [5]. While other studies have shown differences in other region like higher beta on the anterior region [6], higher delta on the posterior region [4], higher alpha on DLPFC and PFC, higher theta in anterior cingulate cortex (ACC) [7, 8], higher theta and alpha on parietal and occipital lobe [9] in depressed groups.

Most of the previous studies also focus heavily on major depression disorder, therefore leaving mild and moderately depressed group less explored. The present study examined the anomalies in brain activity of those suffering mild and moderate depression during resting state.

2. Methods

2.1 Subjects

Twenty six subjects were recruited from a local university in Malaysia to participate in this study. The criteria of participation are Malaysian with age range from 18 to 30 years old. The selection of participants for this study is based on their Beck Depression Inventory (BDI) scores. A BDI score of below 14 are considered non-depressed and will be group as healthy control and A BDI-II score between 14 to 28 are group as depressed. The depressed participants are recommended by university counsellors in the student affair counselling department before the process of grouping via BDI scores. 12 participants (2 male, 10 female) were grouped into depressed group and 12 participants (8 male, 4 female) were grouped into healthy control group. One participant was excluded from the study because her BDI scores indicated severe depression, while another subject from healthy control was removed due to technical faulty. All the participants were properly informed on the nature and procedure of this study and signed the informed consent form before participating.

2.2 Task and Experimental Procedure

The participants are properly briefed a day before the actual EEG sessions to abstain from caffeine, nicotine and alcohol at least 8 hours prior to the session. Besides that, they are informed to not apply any hair products before the sessions to ensure the precision of the data collection. The EEG session took place in a quiet, light-dimmed and air-conditioned room. The EEG was acquired with 25-channel Mitsar EEG-201 and the electrodes are positioned according to the International 10-20 system. (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2) with ref-

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erence from the earlobes (A1, A2). Impedances are kept below 5 kΩ and a bandpass filter of 0.3-50Hz was adjusted. The EEG data were subjected to a Fast Fourier Transform (FFT) algorithm for qunatification of absolute power (µV2), relative power (%) and mean frequency (Hz) in delta (1.5 – 4 Hz), theta (4 – 7.5 Hz), alpha (7.5 – 14 Hz), beta1 (14 – 20 Hz), beta2 (20 – 30 Hz), and gamma (30 – 40 Hz). Measures of coherence for each band were also computed for inter-hemisphere and intra-hemisphere.

2.3 EEG Acquisition

The EEG session includes two tasks, eyes open and eyes closed task with O – C – O sequence. Each task lasted for 3.5 minutes and the data were obtained using WinEEG software. In this study, Average montage was used throughout the data collection period. The participants are properly debriefed after EEG session. The absolute power was analysed using Mann Whitney U test due to the small sample size of the data that are not normally distributed.

3. Results

3.1. Demographic Data

Table 1 shows the mean age of the 24 participants from depressed 20.7 years old (SD = 2.27) and normal group 22.4 years old (SD = 1.08). The range of BDI scores in the depressed group was 14 – 28 with a mean of 17.5 (SD = 4.19) and the range of scores in the healthy control group was 0 – 13 with a mean of 7.00 (SD = 3.98) as shown at Table 3.2.

Table 1: Sociodemographic (N=24)

Variables	Depressed	Normal	*p*
N	12	12	-
Gender	M = 2,F = 10	M = 8,F = 4	-
Age	20.7±2.27	22.4±1.08	.002
BDI	17.5±4.19	7.00±3.98	.000

3.2. Absolute Power Activity

According to Table 2, different ROIs and frequency bands was tested according to previous studies to find significant difference between depressed and normal control participants. In theta band, no significant difference was found on parietal region (U = 57.0, p = .21, r = .18), occipital region (U = 68.0, p = .42, r = .047) and DLPFC (U = 71.0, p = .49, r = .012) but the results of Mann Whitney U test revealed depressed group has higher theta activity on prefrontal cortex (U = 41.0, p = .038, r = .37) during resting state. In alpha band, no significant difference was found on parietal region (U = 70.0, p = .47, r = .024), occipital region (U = 72.0, p = .51, r = .000), DLPFC (U = 66.0, p = .38, r = .072) and comparison of left and right hemisphere (U = 70.0, p = .47, r = .024). Furthermore, higher beta1 (U = 43.0, p = .050, r = .34) and beta2 (U = 43.0, p = .050, r = .34) activity on the anterior region of the brain.

Table 2: Mann Whitney U test for comparison between depressed and normal group

ROI	Variables		Mean Rank	Sum of Ranks	U	Z	*p*
Theta	Parietal	D	13.8	165	57.0	-.87	.21
		N	11.3	135			
	Occipital	D	12.8	154	68.0	-.23	.42
		N	12.2	146			
	DLPFC	D	12.6	151	71.0	-.058	.49
		N	12.4	149			
	PFC	D	15.1	181	41.0	-.1.79	.038*
		N	10.0	119			
Alpha	Parietal	D	12.3	148	70.0	-.12	.47
		N	12.7	152			
	Occipital	D	12.5	150	72.0	.000	.51
		N	12.5	150			
	DLPFC	D	13.0	156	66.0	-.35	.38
		N	12.0	144			
	L/R	D	12.3	148	70.0	-.12	.47
		N	12.7	152			
Beta1	Anterior	D	14.9	179	43.0	-1.67	.050*
		N	10.1	121			
Beta2	Anterior	D	14.9	179	43.0	-1.67	.050*
		N	10.1	121			

3.3 Coherence Analysis

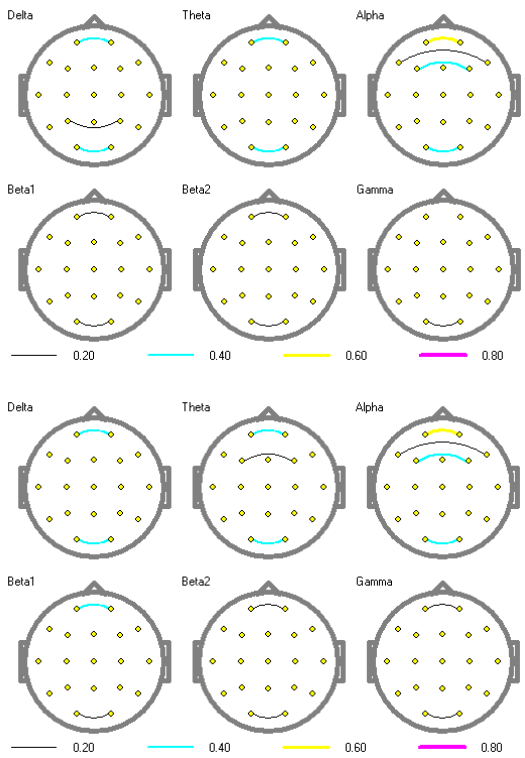

Fig 1: Diagram of qEEG inter-hemisphere coherence (top- depressed; bottom- normal)

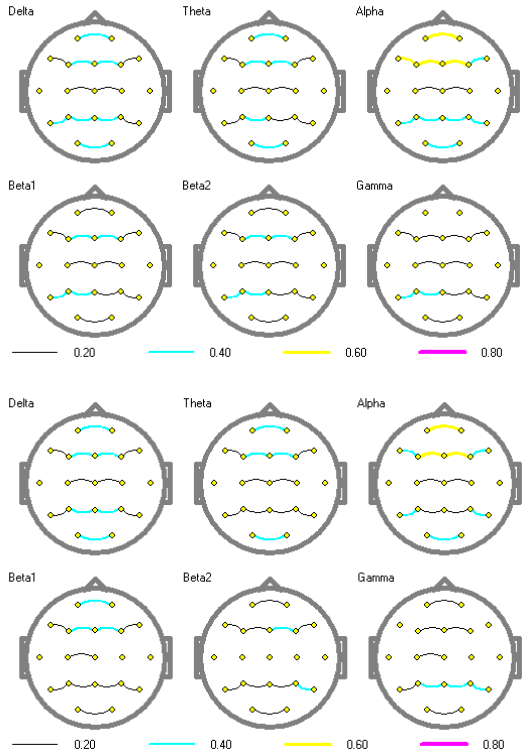

Fig 2: Diagram of qEEG coronal intra-hemisphere coherence (top- depressed; bottom- normal)

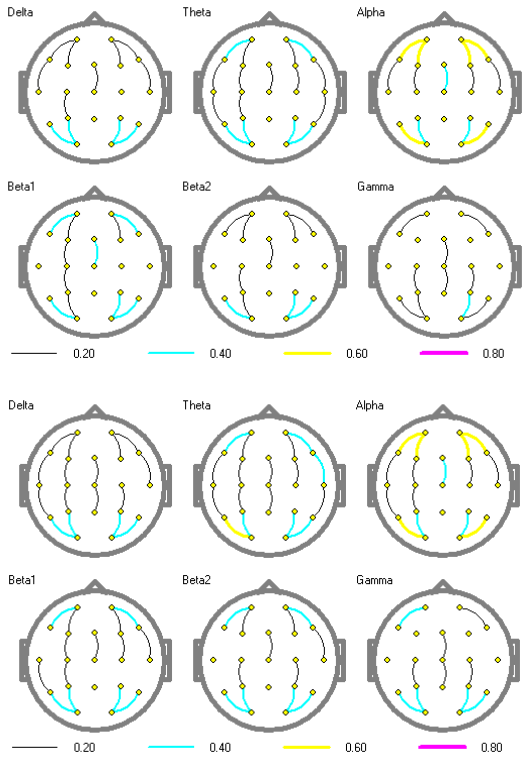

Fig 3: Diagram of qEEG sagittal intra-hemisphere coherence (top- depressed; bottom- normal)

Visually in Figure 1 and 2, 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. Discussion

4.1. Spectrum Analysis

Higher theta and alpha activity at parietal region was observed during eyes closed in Grin-Yatsenko, and colleagues [9] studies on participants with early depressive disorder but was not found to be significant in this study. This 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 [9]. Previous study by Ricardo-Garcell and colleagues 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 [4].

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 [5] and Ricardo-Garcell [4] 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' 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 [3]. 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's study in year 2001 [6].

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. Earlier study done by Ray and Cole [10] reported strong beta activation during positive and negative emotional tasks, and cognitive tasks. In Nystrom, Matousek and Hallstrom [11] study also shows positive correlation of beta dominated pattern qEEG and depression, although not much explanation was provided with such findings. John and colleagues' [12] 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 [13] 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.

Study by Matousek 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 [14]. Increased beta activity is also negatively correlated with psychomotor retardation that is core symptom of major depression [15]. 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 [16].

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 [3] but similar to previous studies by Goldberg and Gold [17] 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 [18].

Another study by Drevets and colleagues results suggested that hypoactivity on the prefrontal region distrupted the frontal-limbic circuitry that connects prefrontal cortex and amygdala that is involves in modulation emotion [19]. This decrease in prefrontal cortex was also duplicated in a later study by Mayberg and colleagues 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 [20].

4.2. qEEG Coherence

The significant findings from the coherence analysis that seems to associate with previous finding are on the area of left frontal (Fp1-F7) and right frontal (Fp2-F8) in beta2 band. The significantly lower left and right frontal intra-hemisphere coherences are associated with the reduced inter-hemisphere synaptic connection that causes imbalance in functional processes [6]. How low intra-hemisphere coherence can affect inter-hemisphere synaptic connection is still unknown.

5. Conclusion

In summary, the results suggest that individuals that are mild and moderately depressed exhibit significantly higher beta activity on the anterior region and higher theta activity on PFC of the brain. These results also served as a confirmation of previous studies as it has consistently exhibited by more severe depressed patients and indication of impairment on higher order functions. Besides that, this study also shows significantly lower intra-hemisphere coherence of the left and right frontal region in beta2 activity.

There are limitations that must be addresses such as the problem of generalization since the sample size is small. The reason for a small sample size is due to the nature of the study design which is a cross-sectional study; hence, there is shorter time for data collection. Therefore, the recommendation that can be greatly benefiting this study in the future is to be able to conduct a longitudinal study that enable a gathering of larger sample size.

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