Verification of Brainwave Balancing Index (BBI) Using EEG

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Abstract - **This paper presents on verification of brain wave balancing index system using Electroencephalography (EEG). In this research, both left and right side of human brainwave was recorded using non-invasive techniques called EEG. The brainwave signal was analyzed via intelligent signal processing method to determine the correlation between the left and right brain hemisphere resulting in brainwave balancing index. The index results involved in five categories that are Highly Balanced, Balanced, Moderately Balanced, Less Balanced and Un-Balanced. This research involves 53 samples. A set of brainwave dominance questionnaire were given to the samples. Then the samples were test via EEG. The data collected were analyzed using three methods that are RAW data, Power Spectrum Density (PSD) and Artifact removed. Finally, all the result were compared and it is shown that PSD give the best result with 82% accuracy which is greater than the RAW data and Artifact Removed that give 75% accuracy.**

Keywords: EEG, brainwave, BBI and PSD.

1.0 INTRODUCTION

1.1 Brainwave

The brainwave is defined as a rhythmic fluctuation of electric potential between parts of brain as seen on electroencephalogram. This brainwave can determine a person's behavior and also their personality because different types of brainwave can be associated with certain types of personality [1]. Brainwaves have been grouped according to their frequencies and labelled with Greek letters. Their most common frequencies include beta, alpha, theta and delta. All this frequency have their different range with 13Hz to 40Hz for beta(β), 8Hz to 12Hz for alpha(α), 4Hz to 7Hz for theta(θ) and 0Hz to 3Hz for delta(δ). These brainwave patterns commonly form sinusoidal wave shapes.

1.2 Electroencephalograph (EEG)

Electroencephalography is a medical imaging technique that reads scalp electrical activity generated by brain structures. The electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media [2]. EEG measures the brain waves of different frequencies within the brain. Electrodes are placed on specific sites on the scalp to detect and record the electrical impulses within the brain.

As the EEG procedure is non-invasive and painless, it is being widely used to study the brain organization of cognitive processes such as perception, memory, attention, language, and emotion in normal adults and children.

EEG also allows researchers to follow electrical impulses across the surface of the brain and observe changes over split seconds of time. An EEG can show what state a person is in such as asleep, awake, or anaesthetized because the characteristic patterns of the wave differ from each of these states.

1.3 Left and Right Brain Hemispheres

A person might either use the right or left, or even both of their brain most of the time. Even though the right and left brain are interconnected, they possess their own characteristics. The right side tends to function intuitively by recognizing relationship, integrating and synthesizing information while the left side tends to function in an analytical, rational, logical and sequential way [3]. The right and left dominance of a brain can indicate a stress occurring since there is an unbalanced brainwave pattern between right and left [4].

1.4 Brainwave Balancing index (BBI)

BBI is classified in different index between 1 to 5 as shown in table 1. BBI is measured using the EEG signal which using intelligent signal processing method and specific algorithm. Consequently, the signals were statistically correlated with established psychoanalysis techniques to produce BBI system.

Table 1: Brainwave Balancing Index

Category	Index
Highly balanced	5
Balanced	4
Moderately balanced	3
Less balanced	2
Unbalanced	1

1.5 Power Spectrum Density (PSD) and Artifact Removed

Power spectrum density (PSD) is a positive real function of a frequency variable associated with a stationary stochastic process, or a deterministic function of time, which has dimensions of power per Hz. The spectral density of the wave, when multiplied by an appropriate factor, will give the power carried by the wave, per unit frequency, known as the power spectral density (PSD) of the signal. PSD is commonly expressed in watts per hertz (W/Hz) [5] or dBm/Hz.

Artifact Removed is a system to remove the unwanted data that is greater than 100μV because the data which is greater than it is considered as error

1.6 Problem Statement

There is increasing concern that some people are confusing about themselves because do not know which side of brain they are using whether left or right hemispheres. In this study, we sought to determine the verification of brainwave balancing index using EEG system. Therefore, this project is design to answer some of the unresolved question about the balancing index and verify it using EEG.

1.7 Objective

The main objective is to record and analyse human brainwave's signal before and after specific mental activities using EEG. Then, it is use to analyse brain wave balancing index system using EEG and compare with the given questionnaire and lastly is to investigate the correlation between left and right brain wave for brainwave balancing index.

1.8 Significance Of Study

The study has gone thru some ways towards enhancing our understanding of the brainwave index. The significant of the study is to verify the brainwave balancing index using EEG. It is use to find the correlation between index from the questionnaire and the brainwave balancing index.

1.9 Scope And Limitation Of Project

They are four types of brainwave which are beta, alpha, theta and delta that can be use to read the signal processing in brain. However this research only takes the data until 100μV and the data that more than that is considered as artifact.

2.0 METHODOLOGY

The research was mainly performed at the biomedical and Development Laboratory for Human Potential, Faculty of Electrical Engineering, University Teknologi MARA, Malaysia. The objective is to verify the brainwave balancing index using EEG. A total of 53 samples were taken to test on their brainwave and data will be record.

2.1 Psychoanalysis Tests

Psychoanalysis Tests were carried out immediately after completion of EEG test recording to all 53 participants. The test consists of existing 15 item Brain Dominance Questionnaires [6].

2.2 Procedure

For each sample of students, their brainwave recorded is focusing on alpha, beta, theta and delta and from this data, the correlation of the brainwave index can be found. Figure 1 show the flowchart of the main step how the project is developed.

Firstly, some literature review and initial preparation has to be done. The information of frequency of brain waves and EEG are obtained from various sources such as websites and the review of books and article related to this research. This project needs 53 subjects to be tested to verify the brain wave balancing index system using EEG. The test takes three minutes for each sample. Before the start of the test, samples have to answer questionnaire which consist of related question brainwave balancing and all the information about the subjects will keep private and confidential. Then, their brainwave will be analyzed by using EEG. During the test, the sample needs to close their eyes to make the system to perform well without any artifact. Graphs will be plotted to show the correlation between the brain balancing index and residency of the students and lastly the conclusion will be made based on the analyzed data from EEG and the questionnaires.

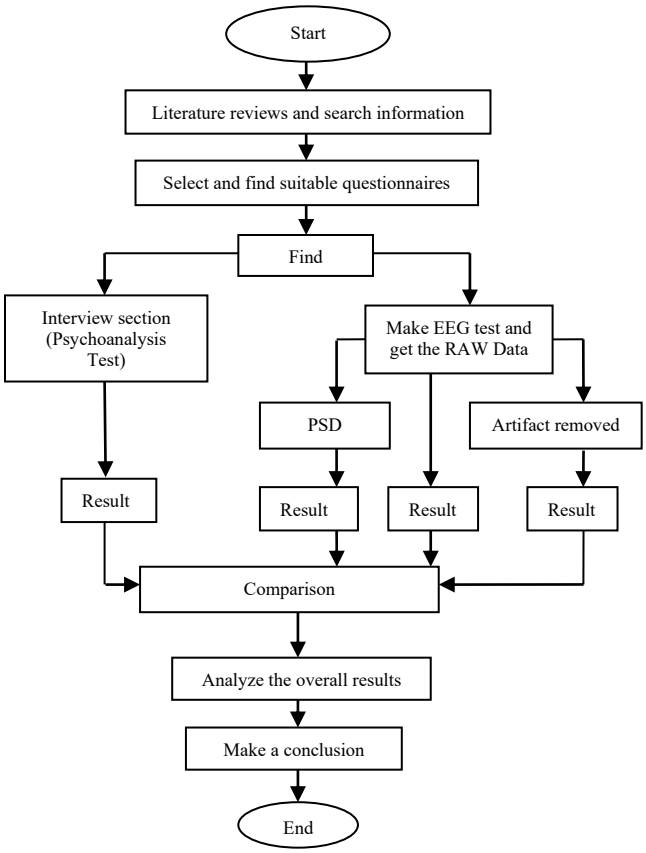

Figure 1: Research Procedure

2.3 Data Collecting

Figure 2 show the experimental step using the EEG system. The EEG system consists of five electrodes, EEG equipment and system and the computer. All the work on the computer was carried out using MATLAB R2007b and index will be shown as in the figure below as brainwave balancing index. The signal is measure by placing electrodes at both ears and three were place at the forehead with the ground at the center.

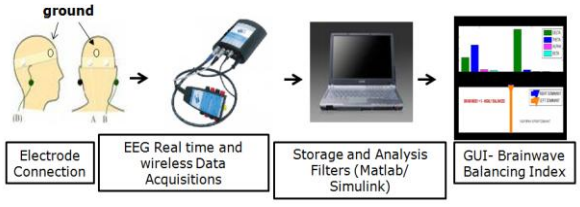

Figure 2: Data collecting process.

3.0 RESULT AND DISCUSSION

This paper has been divided into three parts. The first parts deal with questionnaire analysis. The second parts begin by lying out the brain signal analysis for the raw data and the last part is by doing the PDA and the artifact remover getting from the raw data.

3.1 Analysis of Interview

Sample was being interviewed with that related to brain balancing index with respect to left, right and balanced dominance.

A total sample of 53 students was taken and two of them that are sample number 34 and 50 were discarded due to the corruption data. Out of 51, 28 are male and 23 are female and their average age is 21.7. 100% of the sample were in the healthy condition and also do not taking any medicine or drug during the test. So this is an advantage for the research that the data might not be having any interruption or unwanted error.

From the questionnaire, some questions have been picked out to show the brain dominance through the answer that have been chosen from 'a' to 'c'. The questions that were use are Question 1, 2 and 14 that give the difference dominance.

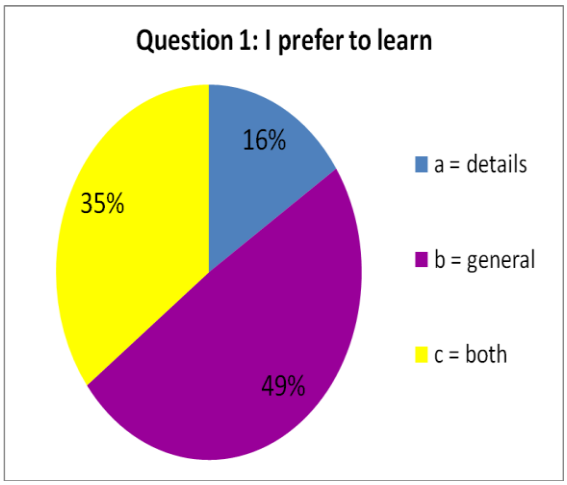

Figure 3: Comparison of first question of preference in learning.

Figure 3 show the result obtained from the question 1 of which learning style is prefer. It shown that 49% give the answer 'b' which they prefer to learn from a general overview of things and by looking at the whole picture. Then 35% answer 'c' while 16% answer 'a'. The finding shown to be most of the sample to be in right balanced condition since majority gives the 'b' answer.

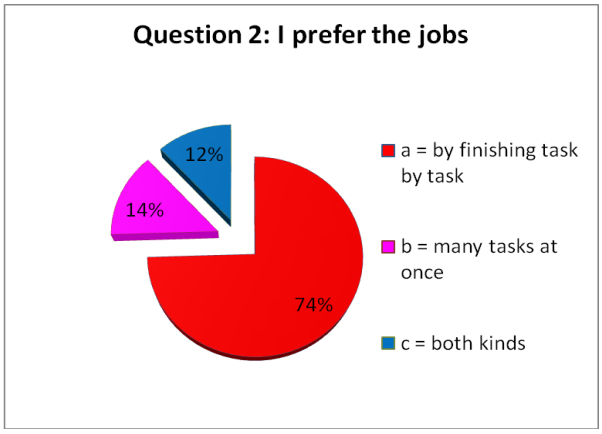

Figure 4: Comparison of second question of preference in doing jobs.

In figure 4, there is a clear trend of dominance to the 'a' answer with 74% saying they prefer the jobs which consist of one task at a time and can complete it before beginning the next one. It follows with 14% for answer 'b' and 12% give answer 'c'. This result show that the majority were in left condition.

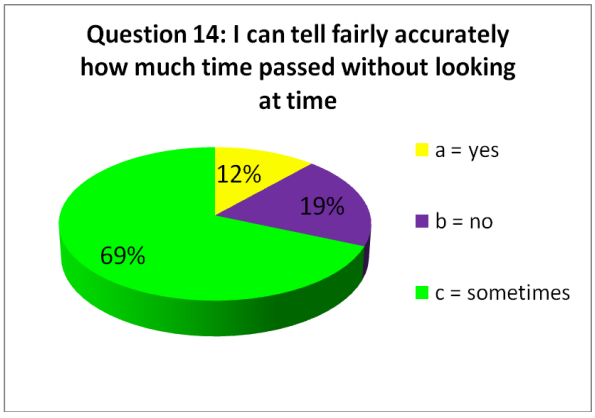

Figure 5: Comparison of how accurate the sample can tell about the time passed without looking.

In response of question 14 in figure 5, most of those samples indicated that they can tell fairly accurately how much time has passed without looking at a clock is sometimes. It shows when 69% have chose the 'c' answer while others choose 19% for 'b' answer and 12% to 'a' answer. It can be conclude that most of the sample was in the balance condition looking at this question.

Table 2: The overall of sample's answer for each questions and overall balance dominance.

Questions	Answers			Major Answer
	a	b	c	
1	8	25	18	b
2	38	7	6	a
3	11	3	37	c
4	24	10	17	a
5	13	33	5	b
6	7	20	24	c
7	15	6	30	c
8	27	5	19	a
9	22	18	11	a
10	34	10	7	a
11	25	4	22	a
12	30	16	5	a
13	6	17	28	c
14	6	10	35	c
15	17	18	16	b
		Overall Dominance		Index 4 and Left Balanced

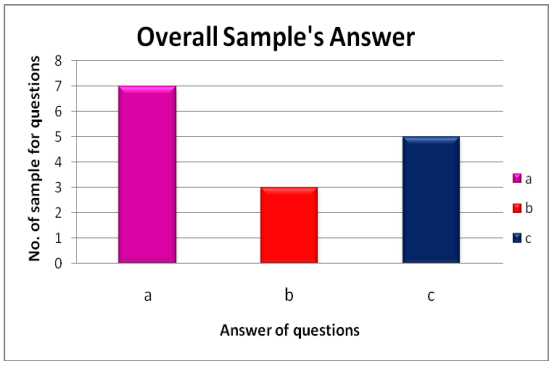

Figure 6: The overall number of sample's answer for each question.

Table 2 and figure 6 show the overall number of sample's answer for each question that have been choosen during the questionnaire section. It shown that the most striking result to emerge from the data is that most of them give the 'a' answer that is 7 out of 15. Others respone give 3 out of 15 to 'b' answer while for the 'c' answer give the total 5 out of 15. From the calculation of the result show that most of them have the significant towards the left dominance with index 4. The left side of the brain is the seat of language and processes in a logical and sequential order [7].

3.2 Analysis of EEG Data

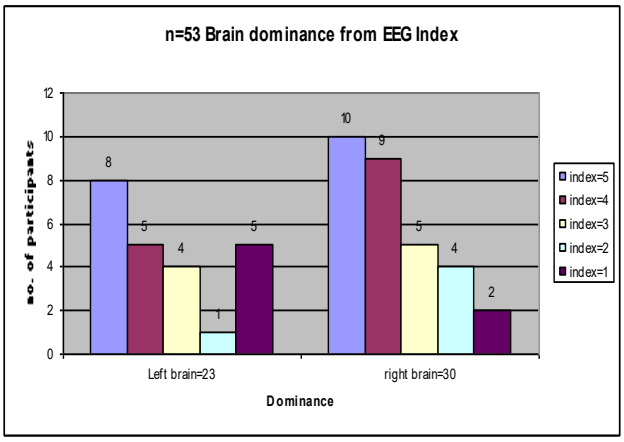

Figure 7: Brain dominance from EEG index.

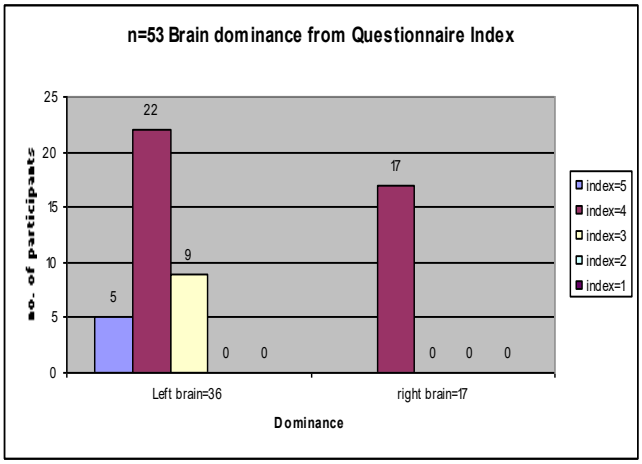

Figure 8: Brain dominance from Questionnaire.

From the figure 7 and 8, it shown that the index from the EEG shows more distribution compare to the index from questionnaire. The most striking result to emerge from the both figure is

that most participants have higher index either 5 or 4 which mean they have highly balanced and balanced.

Table 3: Result for Brainwave Balancing Index from EEG raw data and Questionnaires.

SAMPLE	EEG		QUESTIONNAIRE		CON-FORMITY
	INDEX	DOMINANCE	INDEX	DOMINANCE	
1	5	L	4	L	Y
2	4	L	4	L	Y
3	4	R	4	L	Y
4	5	R	4	L	Y
5	2	R	4	L	N
6	4	L	4	L	Y
7	5	R	3	L	N
8	5	L	4	L	Y
9	1	R	4	L	N
10	3	R	4	L	Y
11	5	R	4	R	Y
12	2	R	4	L	N
13	1	L	4	R	N
14	5	R	4	R	Y
15	3	L	4	L	Y
16	5	R	4	R	Y
17	4	R	4	R	Y
18	3	R	4	L	Y
19	5	L	3	L	N
20	3	L	3	L	Y
21	4	L	4	L	Y
22	2	R	4	L	N
23	4	L	4	R	Y
24	4	R	3	L	Y
25	4	R	4	R	Y
26	5	L	4	L	Y
27	5	R	4	L	Y
28	4	R	3	L	Y
29	5	R	4	R	Y
30	5	L	4	L	Y
31	5	R	5	B	Y
32	4	R	3	L	Y
33	4	R	4	R	Y
34	4	R	4	R	Y
35	5	L	4	R	Y
36	5	R	5	B	Y
37	5	R	4	L	Y
38	3	R	4	R	Y
39	1	L	4	L	N
40	1	L	4	R	N
41	3	L	3	L	Y
42	3	R	4	R	Y
43	1	L	5	B	N
44	4	L	5	B	Y
45	2	R	5	B	N
46	5	L	3	L	N
47	3	L	4	L	Y
48	1	R	4	L	N
49	2	L	3	L	Y
50	1	L	4	R	N
51	5	L	4	R	Y
52	4	R	4	R	Y
53	3	R	4	L	Y

From table 3, the yellow columns show the results that give the exact match between EEG index and questionnaire. It gives 20% from the overall participants. However, the conformity that was says yes,(Y) from the table give 38 participants out of 51 and give the percentage to 75% increasing compare to 20% of exact match. The result of the conformity was taken by the calculation in different of ±1. If the different is ±1 between the EEG index and questionnaire index, so it is considered to be conform. Notice that, the results with the red columns were discarded due to corrupt data.

However, the result of 75% from the data cannot be considered as a satisfactory result. Perhaps, artifact remover process and analyzing using PSD process to the EEG raw data should be done to get the batter result within the range of 0 to 100μV.

3.3 Analysis using PSD and Artifact Removed

Table 4: Result from PSD and Artifact Removed.

PSD							ARTIFACT REMOVED						
				index							index		
	sumL	sumR	%	C	Q	Conformity		sumL	sumR	%	C	Q	Conformity
L	91	89	2	5	4	1	L	81	74	9	5	4	1
R	82	87	6	5	4	1	L	74	68	8	5	4	1
L	180	136	28	4	4	1	R	147	157	6	5	4	1
R	95	98	4	5	4	1	R	85	90	6	5	4	1
R	122	131	7	5	4	1	L	78	73	6	4	4	1
L	157	145	8	5	4	1	L	125	100	23	4	4	1
L	145	144	1	5	3	0	L	142	137	4	5	3	0
L	144	139	4	5	4	1	R	123	132	6	5	4	1
R	139	149	7	5	4	1	R	110	116	5	5	4	1
R	98	100	2	5	4	1	L	89	83	7	5	4	1
R	106	107	1	5	4	1	R	108	114	6	5	4	1
R	128	135	6	5	4	1	R	89	99	10	5	4	1
L	126	108	16	5	4	1	L	121	104	15	5	4	1
L	147	140	5	5	4	1	L	109	104	5	5	4	1
R	136	146	7	5	4	1	R	108	119	10	5	4	1
R	105	122	15	5	4	1	R	100	116	15	5	4	1
R	95	103	9	5	4	1	R	76	80	6	5	4	1
R	95	105	10	5	4	1	L	74	62	18	5	4	1
L	110	106	4	5	3	0	L	131	120	9	5	3	0
L	196	169	15	5	3	0	L	107	96	11	5	3	0
L	103	100	3	5	4	1	L	105	100	5	5	4	1
R	112	133	17	5	4	1	R	118	153	26	5	4	1
L	126	124	1	5	4	1	R	149	151	1	5	4	1
L	84	83	1	5	3	0	R	66	73	10	5	3	0
R	107	108	1	5	4	1	R	80	90	11	5	4	1
R	141	146	3	5	4	1	L	173	164	5	5	4	1
R	120	126	4	5	4	1	R	112	122	8	5	4	1
R	98	99	1	5	3	0	R	81	94	14	5	3	0
L	115	113	2	5	4	1	L	120	112	7	5	4	1
R	121	122	1	5	4	1	R	155	160	3	5	4	1
L	161	134	19	5	5	1	R	97	104	7	5	5	1
R	106	109	3	5	3	0	R	97	116	18	5	3	0
R	138	140	1	5	4	1	L	157	134	16	5	4	1
R	128	133	4	5	4	1	R	113	127	11	5	4	1
R	102	107	5	5	5	1	L	83	78	6	5	5	1
R	104	108	4	5	4	1		90	90	1	5	4	1
L	292	161	58	3	4	0	R	85	124	37	4	4	1
R	112	119	6	5	4	1	R	95	96	1	5	4	1
L	177	106	50	3	4	1	L	217	94	79	2	4	0
R	137	139	1	5	3	0	R	126	140	11	5	3	0
R	113	124	10	5	4	1	R	112	131	16	5	4	1
L	182	133	31	4	5	1	L	163	82	66	2	5	0
	116	116	0	5	5	1	L	114	108	5	5	5	1
L	159	128	22	4	5	1	L	151	80	62	2	5	0
L	140	101	32	4	3	1	R	81	87	7	5	3	0
L	111	102	9	5	4	1	L	101	89	12	5	4	1
R	87	127	37	4	4	1	R	66	137	70	2	4	0
L	144	125	15	5	3	0	L	148	132	12	5	3	0
L	192	189	2	5	4	1	R	169	204	19	5	4	1
R	109	123	12	5	4	1	R	111	125	11	5	4	1
R	243	269	10	5	4	1	R	95	98	3	5	4	1
					Tot	42						Tot	38
					%	82						%	75

From this data from table 4, we can see that analysis of PSD in the lowest of the table show the higher percentage compared to the artifact removed analysis. PSD give the resultant to 82% which is higher than 75% giving by artifact removed.

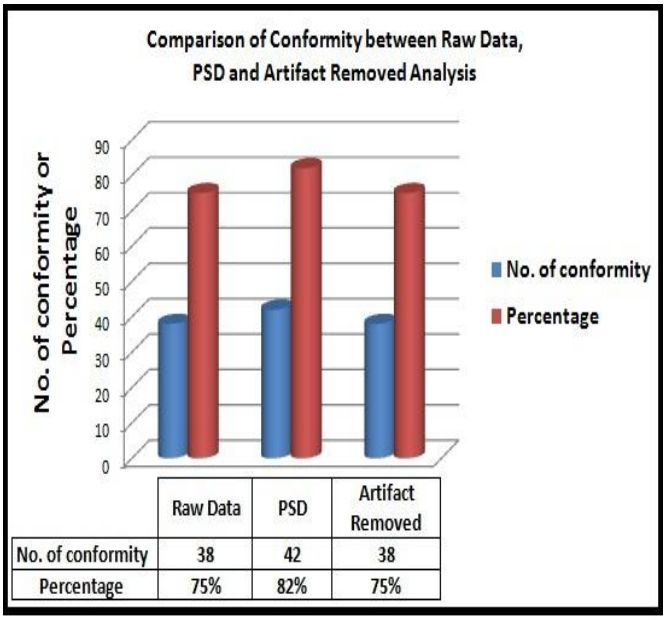

Figure 9: Comparison of Conformity between Raw Data, PSD Analysis and Artifact Removed Analysis.

The result obtained from the preliminary analysis between Raw Data, PSD and Artifact Remover is shown in figure 9. It shows that PSD gives the highest conformity with the percentage of 82% while Raw Data and Artifact Removed analysis give the same percentage of 75% that is less satisfactory.

4.0 CONCLUSION

This dissertation has investigated that through the research, we can verify the brainwave balancing index system using Electroencephalography (EEG) that had been involved in three paths and the best conformity is by using PSD analysis. The conformity was improved after PSD analysis give 82% which is much greater than the RAW data Artifact Removed analysis that give 75%. It shows that the finding was satisfactory since the conformity was greater than 80%.

The result shows from PSD suggest that EEG index should be considered as a truthful measurement to verify the brainwave balancing index system using EEG.

5.0 FUTURE DEVELOPMENT

This is an important issue for future research. Future studies on the current topic are therefore recommended to be done by including additional methods with increasing the number of sample to make the result become more accurate.

Then the existing electrode should be change with the electrode cap which electrodes place after 10 to 20 electrodes placement. Electrode caps are preferred for multichannel montages with number of electrodes installed on its surface [8] as shown in figure 10. Commonly used scalp electrodes consist of Ag-AgCl disks, 1 to 3 mm in diameter, with long flexible leads that can be plugged into the EEG [9].

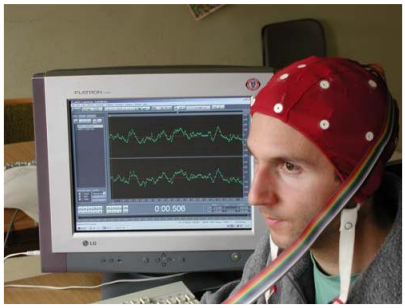

Figure 10: Electrode cap with electrodes placed after 10-20 electrode placement system.

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