A Comparative Study Of Learning Methodology Between Cognitive And Psychomotor For Non-Dyslexia Person Via Electroencephalogram (EEG)

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Abstract: Every action and decision makes by a person comes from the brain. This organ is the central processing unit (CPU) for a human. Electricity is used by the neurons which is the brain cells for communication between each other. From this activity, the presences of a few types of subbands are detected. The subbands are Delta, Theta, Alpha and Beta. Each of the subbands has its own characteristic and when these subbands will be dominant depends on the action made by the person. One type of action is learning and there are three types of learning methods which are cognitive, psychomotor and affective. Cognitive is a type of learning style where the student uses his or her reading, understanding and memorising skills. Psychomotor domain is a type of learning method where the student needs to learn by using his or her physical skills. For this project, ten engineering students from Universiti Tun Hussein Onn Malaysia are asked to become the subjects for data collection. Cognitive domain is tested by giving the subjects a set of question which contains fifteen questions of various types. The questions need to be answered in 5 minutes. Psychomotor domain is tested by asking the subjects to design a building or statue using legos and the subjects need to follow the conditions given with duration of 5 minutes as well. From the experiment conducted, for cognitive and psychomotor domain, the dominant subbands are delta and beta. Alpha subband is dominant when the person feels calm**.**

Index Terms: Electroencephalogram (EEG), Cognitive, Psychomotor, Alpha band, Beta band

1. INTRODUCTION

Brain is an organ which is located in the head that is protected by the skull. This is the organ that controls everything of a human or an animal. This is where all the activities such as analyzing, memorizing, solving a problem and even controlling the movement of a body happen. Humans use their brain even more than animals as they live their lives not only in survival mode as the animals, but they use their brain for processing information as well. A human body without a brain will not be able to do anything. There are four main parts in a human brain [1-2]. The biggest part of human brain is called cerebrum [1-2]. Cerebrum lies in two hemispheres. Brainstem is located underneath the cerebrum and limbic system lies inside it while cerebellum is positioned behind the brainstem [2,8]. Billions of brain cells called neurons are the cells that formed this organ where it uses electricity to communicate with each other [1-2]. This can be detected using sensitive medical equipment such as EEG by measuring electricity levels over areas of the scalp [3]. This activity is called brainwave pattern. Every human managed to do everything in his or her life such as managing stress matter, focusing on tasks in his life as well as getting a good night sleep. This matter could happen due to our brain's capability on becoming adaptable through various brain wave frequencies. The balance of all the brain frequencies produced is vital as it could affect the health of the person. There are five brain waves produced by a brain, Theta, Delta, Alpha, Beta and Gamma. However the most common brainwaves discussed are Theta, Delta, Alpha and Beta [2-4] [6]. Delta wave has the lowest frequency range which is from 0 to 4 Hz [2,4,6]. Delta waves help human to aggrandize the immune system of a body. Delta waves also help the body during natural healing and falling into deep sleep as well as giving continuous attention while doing a task. Be that as it may, too much of delta wave will cause brain injuries, learning problems, severe Attention Deficit Hyperactivity Disorder (ADHD) and inadequate of thinking [7]. Theta wave has a low frequency range which is from 4 to 8 Hz [2,4]. This type of brain wave is involved in daydreaming and sleep. Theta waves help one to enhance his creativity side, helping him in terms of emotional connection, intuition and relaxation [7]. Having too little of Theta wave in once brain will also create complication such as anxiety, stress building up and poor emotional awareness. Alpha waves has arrange of frequency from 8 to 14 Hz [2,4]. This type of brain wave helps the body to calm down when necessary and promotes feelings of deep relaxation. When Alpha wave is emitted by the brain, diminution level of focus does not happen. Beta wave has a range of frequency from 15 until 30 Hz [2,4]. This signal is present when the mind is in focus state, active thinking, trying to solve a problem and anxious. Gamma wave has the highest frequency which is more than 30Hz [7]. Gamma band is present when the brain needs to process information and memorizing. In this twenty first century, the education level is growing at high speed rate. In order for the students not be left behind in terms of education, learning methods that can be used as to be diverse. By doing so, students will be able to learn and understand more knowledge.

2. MOTIVATION

Bloom's Taxonomy had stated that there are three types of educational domains which are cognitive, affective and psychomotor [10,12]. Since the early age of civilization, cognitive domain had been the primary method of learning. Nowadays,

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psychomotor domain is more popular and more educational institutes are conducting classes using psychomotor learning method. Cognitive domain is when a student is learning using mental skill. This is where the student learns new knowledge by reading, understanding and memorizing. In other word, the student learns new things in theoretical form. Cognitive domain has six levels which start with knowledge, then comprehension, application, analysis, synthesis and lastly evaluation [10]. Using cognitive domain can help a student to understand the esoteric knowledge. Psychomotor domain uses physical or manual skills for learning. Psychomotor domains also have certain levels of physical dexterity which starts with imitation, manipulation, precision, articulation and lastly naturalization [11]. These two learning methodologies are affiliated with brain wave for thinking. Currently there is no scientific proof for cognitive and psychomotor learning methodology in terms of EEG. Thus, this is the intervention for this research to see how does EEG is related to learning methodology. For this research, the signals that will be focused on are Delta, Alpha and Beta bands [9]. Gamma waves will not be included for this research. The pattern of the graph for Delta, Alpha and Beta waves will be analysed in order to categorise the subject.

3. METHODOLOGY

The data will be collected from 10 subjects which are the students from Universiti Tun Hussein Onn Malaysia (UTHM). From Fig 3.1, the methodology of the project is divided into three categories which are the process of data collection, distribution of data evaluation and data analysis. The data collection will be done by using Emotiv equipment. The raw data collected by the Emotiv then will be downloaded from cloud file and will be transferred into Microsoft Excel for obtaining the distribution and the average. Then, the data will be transferred into SPSS to find the standard deviation and Q-Q plot of the data. In order to complete the research, collection of data regarding the topic has to be done. For this research, the experiment that is conducted in Artificial Intelligence Laboratory (E-MSP) under the Faculty of Electrical and Electronic Engineering in Universiti Tun Hussein Onn Malaysia (UTHM). The equipment that will be used for the data collection is Emotiv. Emotiv is a device that provides in- depth data regarding the brain activity [13]. One of the software used for the data collection is the software from Emotiv. The software for Emotiv also can be used for various cases including scientific and academic resarch, advertising and media, education and training for students, mobility, communication system automotive and development for Internet of Things (IoT) [13]. For the project, EMotiv Insight is used for data collection. Emotiv Insight is a sleek, wireless EEG headset with 2 reference sensors and 5 channels that record and translated the brainwaves into understandable data [13]. The contact quality when a person wears the Emotiv can be seen from the colours shown in the software. Green colour is when the connection is really good, orange is when the connection is good, red when it is bad and black is when there is no connection [13]. Table 1 shows the channels used in Emotiv Insight.

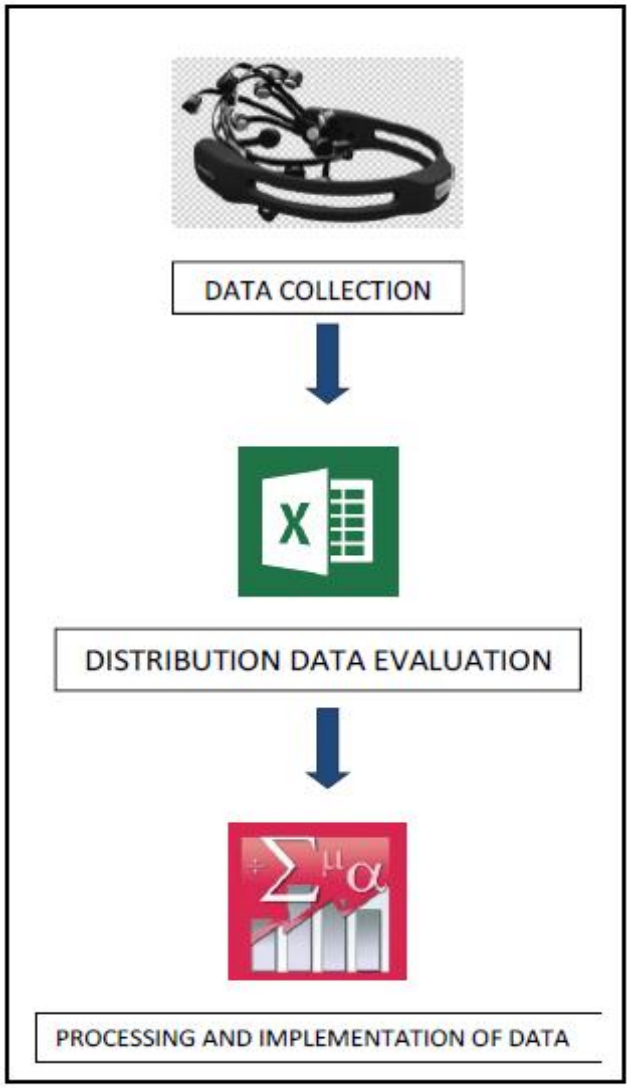

Fig 1. Flow diagram of methodology

TABLE 1:
CHANNELS IN EMOTIV INSIGHT

Channels	Description
AF3	Attention
AF4	Judgement
T7	Verbal memory
T8	Emotional memory
PZ	Balancing

3.1 Data Collection

There are two parts of the experiment, which are the cognitive activities and psychomotor activities. The experiment starts with cognitive activity where the subject is given a set of questions that needs to be answered in a given time. Firstly, the subject is asked to wear the Emotiv Insight on his head. Once the quality contact is good which is in green colour, the subject is given a set of question to be answered in 5 minutes. The activity starts once the record button is clicked. The questions are a variety of mathematics, general knowledge, world history, visual knowledge as well as English language. The

time given for the subject to answer the questions is five minutes. The data is recorded as soon as the subject started to answer the test. Fig 1 shows a subject is conducting the cognitive activity. The set consists of 15 questions in total. The questions come in various types. Once the time is finished, the subject is asked to stop answering the questions. The emotiv is able to record a set of data for 5 minutes duration. Fig 3.8 shows the flowchart of cognitive activity.

Fig 2: Cognitive activity

For the second activity which psychomotor activity, the subject is given a box of legos where he or she has to create a building using the lego parts given as ahown in Fig 3. The activity will be conducted after a few minutes the first activity is complete. This is done so in order to give some time for the brainwave to go back to its normal state and for the subject to feel calm again. For the psychomotor activity, the subject is given 5 minutes to build a building or a statue following a few conditions. The first condition is that the minimum height of the design must be 15 centimetres (cm). The second condition is the width of the design must be at least 5 centimetres (cm). The subject has to use all the legos parts provided and lastly, the shape of the building or statue is up to the subject's creativity. The experiment is started once the record button in Emotiv software is clicked. Once the time duration is up, the subject is asked to stop building the legos. Fig 3.9 shows the flowchart for psychomotor activity.

Fig 3: Psychomotor activity

3.2 Data Analysis

For the research, the data is collected using Emotiv before it is transferred into SPSS. The raw data collected will be kept in cloud. The raw data then will be downloaded from the cloud file. The data will be kept in Microsoft Excel. From Microsoft excel software, the raw data will be use to obtained distribution graph for each of the subjects. The significant of distribution graph is for identifying the pattern that is shown by the subjects. Another result from Microsoft excel is the average of the data for each of the subbands to be analysed. The pattern obtained from the average result will back up the distribution result. Another result that can be retrieved from SPSS is the standard deviation of the subbands. Theoretically, Beta subband will be higher than Alpha subband for both cognitive and psychomotor tests. The difference is the range of Beta subband between the two tests will determine whether the subject is focused or not. A bigger difference of the rage between Alpha and Beta shows that the person is more focus. Delta subband will show the subject is dominant in which domain. The higher Delta subband in one domain, the more dominant the subject in the specific domain. Alpha subband is used as the measuring line in this project. Some formulas are used in order to obtain the patterns from the raw data. A Power Spectral Density (PSD) is the measure of signal's power content versus frequency [15]. A PSD is typically used to characterize broadband random signals. The amplitude of the PSD is normalized by the spectral resolution employed to digitize the signal [15]. One of the purposes of PSD is to normalise the amplitudes by the frequency resolution to give the amplitudes a similar appearance [15]. The formula for Power Spectral Density (PSD) is shown by the following equation 1 [15].

$$P = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 \, dt \qquad \text{Equation 1}$$

where,
T = period
x(t) = value of amplitude

In order to find the average of subbands for Delta, Alpha and Beta, the statistical average formula is used. For this project, the average is calculated using Microsoft excel. The simplest Excel Average Formula for a set of values consists of the = sign, followed by (X), the sum of the values, all divided by the number of values in the group [16]. The equation for statistical average is shown in the following equation 2 [16].

$$A = \frac{1}{n} * \sum_{i=1}^{n} x_i$$

Equation 2

where,

A = average
n = the number of terms
x1 = the value of each individual item in the list of numbers being averaged

Standard deviation can be elucidated as the method of measuring how spread out or dispersed the data in a set are relative to the set's mean [17]. The standard deviation obtain for the result is obtained by using the SPSS software. The general formula for standard deviation is shown in the following 3.3 equation [17].

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Equation 3

where,

s = standard deviation
x = each value of the sample x' = mean value of the sample Σ= summation
n-1 = number of values in the sample minus 1

4. RESULTS AND DISCUSSION

4.1 Distribution Graph

Theoretically, Beta subband is present when the person is thinking or focusing on something, the Alpha subband is present when the person is calm and Delta subband is present when the person is doing an activity that requires continuous attention. Generally, cognitive domain and psychomotor domain would display Beta subband. Alpha subband is dominant when the subject is calm. The difference between Delta and Alpha subbands can be interpreted as the level of focus of the person. If the rate is huge, the person has a high focus level. Delta subband would be the pointer as which category does the subject fall into. The more dominant or high Delta subband during cognitive or psychomotor activity, it can be conclude as the subject is dominant in the specific domain. From the Distribution graph, there are three (3) categories that can be identified. The first category is dominant in cognitive. The second category is dominant in psychomotor and the third category is dominant in cognitive as and psychomotor. Table 2 shows the categories found from the distribution graph and the subjects in which category.

Table 2:
Categories of subject

Dominant in cognitive	Dominant in psychomotor	Dominant in cognitive as and psychomotor
S2, S4, S5, S6, S7	S3, S10	S1, S8, S9

4.1.1 Dominant in Cognitive

The activity for cognitive domain is answering a set of question which contains 15 questions of various types. From the analysis of result, the distribution shows that 5 out of 10 subjects are dominant in cognitive. The distribution graph shows three variables which are Delta, Alpha and Beta. From Table 3, it can be seen that Delta subband during cognitive activity is higher compared to Delta subband during psychomotor activity. Table 4 shows the comparison of Alpha subband during cognitive and psychomotor activity. All four subject which are dominant in cognitive has low reading for Alpha subband during cognitive activity. For psychomotor activity, subject number 7 (S7) has a higher Alpha subband during psychomotor activity. However, Delta Subband during cognitive activity is higher compared to Delta subband during psychomotor activity. Table 5 shows the comparison of Beta subband during cognitive and psychomotor activities. From the Table 4.4, all four subjects have low reading of Beta subband during psychomotor activity. For subject number 5 and 7 (S5 and S7), the Beta subband during cognitive activity is slightly higher compared to the Beta subband in psychomotor activity. S5 and S7 are categorised as dominant in cognitive because the Delta subband during cognitive activity is higher than Delta subband during psychomotor activity.

TABLE 3:
COMPARISON FOR DELTA SUBBAND DURING COGNITIVE AND PSYCHOMOTOR ACTIVITIES

Comparison for Delta subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S2	High	Low
S4	High	High
S5	High	Low
S6	High	Low
S7	High	Low

TABLE 4:
COMPARISON FOR ALPHA SUBBAND DURING COGNITIVE AND PSYCHOMOTOR ACTIVITIES

Comparison for Alpha subband during Cognitive and psychomotor activity.		
Subject	Cognitive	Psychomotor
S2	Low	Low
S4	Low	High
S5	Low	Low
S6	Low	Low
S7	Low	High

TABLE 5:
COMPARISON FOR BETA SUBBAND DURING COGNITIVE AND PSYCHOMOTOR ACTIVITIES

Comparison for Beta subband during Cognitive and psychomotor activity.		
Subject	Cognitive	Psychomotor
S2	High	Low
S4	High	Low
S5	Low	Low
S6	High	Low
S7	Low	Low

Fig 3 (a) and 3 (b) show the distribution graph for subject 2 during cognitive and psychomotor activities respectively. The delta subband during cognitive activity is high and generally maintains the value for one cycle. However, the delta subband for psychomotor activity started at high value and dropped before generally maintains the value. The beta subband for cognitive activity is higher than beta subband during psychomotor activity. From the graph, it can be determined that subject 2 is dominant in cognitive as the presence delta and beta subbands during cognitive activity are more dominant compared to psychomotor activity.

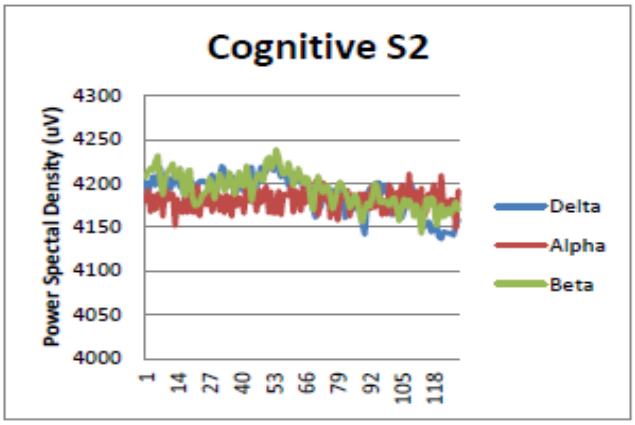

Fig 3(a): Distribution graph for cognitive activity

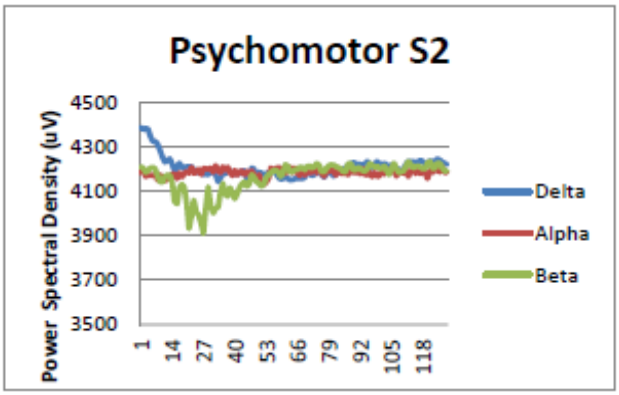

Fig 3(b): Distribution graph for psychomotor activity

Fig 4 (a) and 4 (b) show the distribution graphs for subject 4 during cognitive activity and psychomotor activity respectively. From the Figures, delta subband during cognitive activity is obviously higher compared to delta subband during psychomotor activity. The beta subband for cognitive activity is also more dominant compared to beta subband during psychomotor activity. From the graphs, the subject can be categorised as dominant in cognitive.

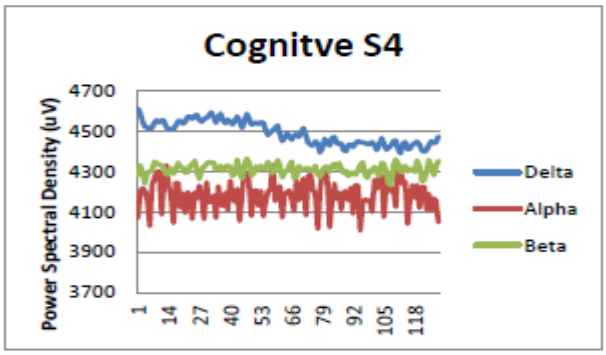

Fig 4(a): Distribution graph for cognitive activity

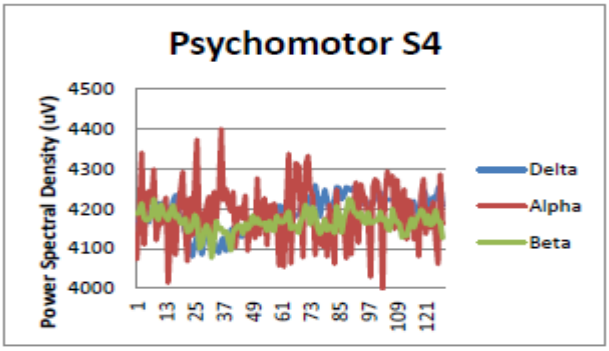

Fig 4(b): Distribution graph for psychomotor activity

Fig 5 (a) shows the distribution graph of subject 5 during cognitive activity and Fig 5 (b) shows the distribution graph of subject 5 during psychomotor activity. The beta subbands during cognitive and psychomotor activities are high. The range values for beta subband during both activities are almost the same. During cognitive activity, the delta subband of subject 5 is higher than delta subband during psychomotor activity. From this, it can be said that the subject is dominant in cognitive as the delta subband is more dominant during cognitive activity.

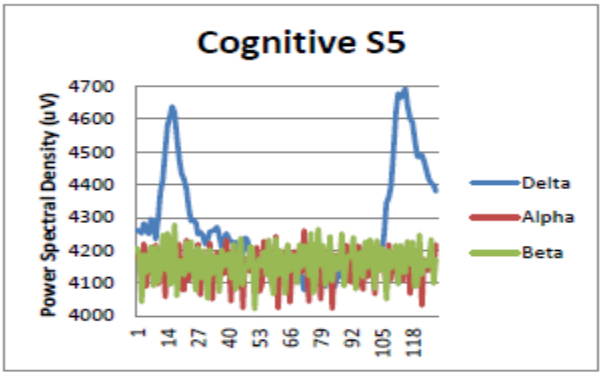

Fig 5(a): Distribution graph for cognitive activity

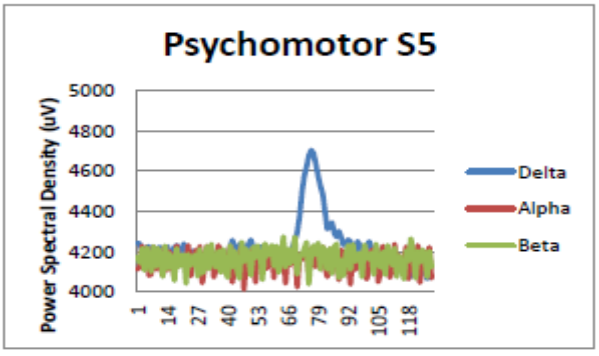

Fig 5(b): Distribution graph for psychomotor activity

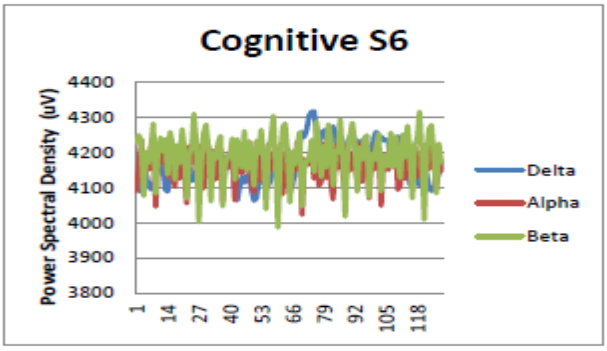

Fig 6(a): Distribution graph for cognitive activity

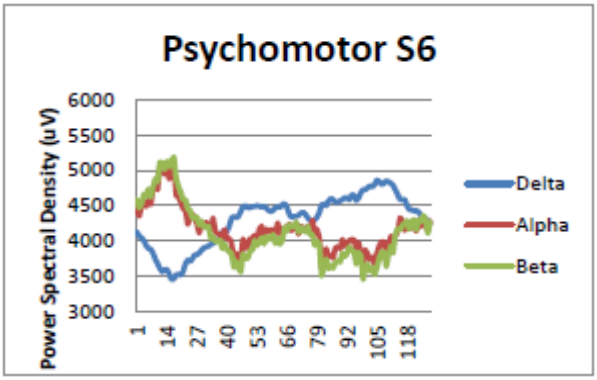

Fig 6(b): Distribution graph for psychomotor activity

Fig 7(a) shows the distribution graph for subject 7 during cognitive activity. From the graph, the delta subband started at high before dropped and started to increase once again on the second half of the cycle. The values of beta and alpha subbands of this subject are almost the same. Fig 7(b) shows the distribution graph for subject 7 during psychomotor activity. From the graph, it can be seen that delta subband is lower than alpha subband. Alpha subband is also a little bit higher than beta subband. Alpha subband is dominant when the person is in calm state. From here it can said that that subject can be categorised as dominat in cognitive domain.

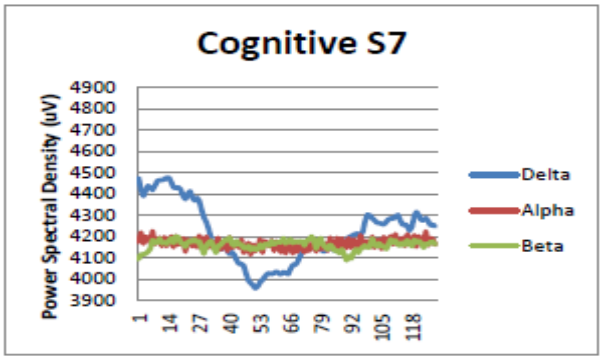

Fig 7(a): Distribution graph for cognitive activity

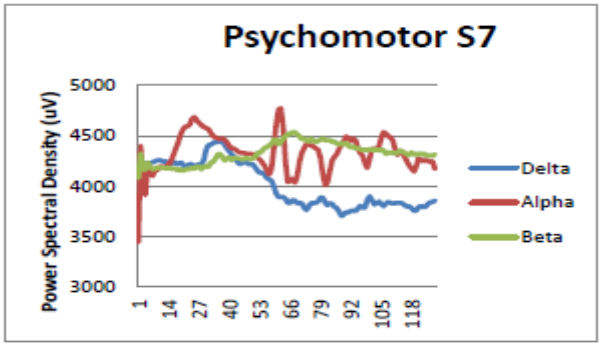

Fig 7(b): Distribution graph for psychomotor activity

4.1.2 Dominant in Psychomotor

Dominant in psychomotor can generally be defined as the Beta subband and Delta subband are high when the subject is be engaged in psychomotor activity. From the experiment conducted, 2 out of 10 subjects are categorised as dominant in psychomotor. Table 6 shows the comparison of Delta subband during cognitive and psychomotor activities. Both subjects (S3 and S10) have low reading of Delta subband during cognitive activity and higher reading during psychomotor activity. Table 7 shows the comparison of Alpha subband during cognitive and psychomotor activities. Both subjects have low Alpha reading during psychomotor activity. Table 8 shows the comparison of Beta subband during cognitive and psychomotor activity. Both subjects have high reading during cognitive and psychomotor activities. However, the reading of Beta subband during psychomotor activity for S3 which is around 4300 (uV) is higher compared to Beta subband during cognitive activity which is around 4000 (uV). For S10, the Beta subbands during both activities are high. However, the difference lies at Beta subband where the value keeps on dropping during cognitive activity whereas during psychomotor activity, the reading of Beta subband drops and started to rise again. From here, it can be concluded that both S3 and S10 are more dominant in psychomotor.

TABLE 6:
COMPARISON OF DELTA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Delta subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S3	Low	High
S10	Low	High

TABLE 7:
COMPARISON OF ALPHA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Alpha subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S3	High	Low
S10	Low	Low

TABLE 8:
COMPARISON OF BETA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Beta subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S3	High	High
S10	High	High

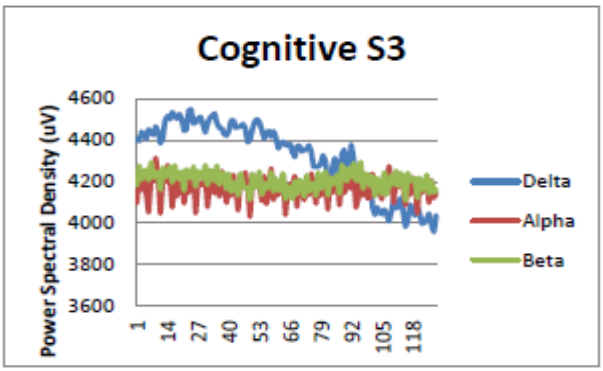

Fig 8(a): Distribution graph for cognitive

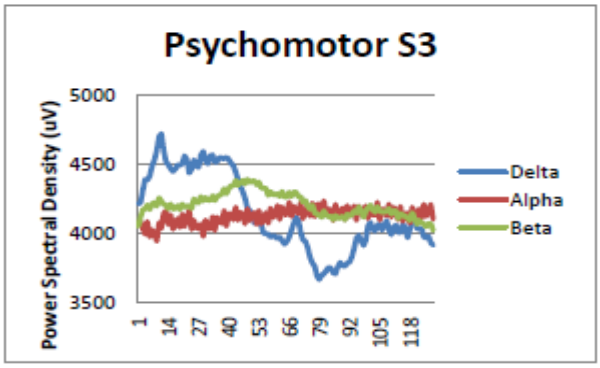

Fig 8(b): Distribution graph for psychomotor activity

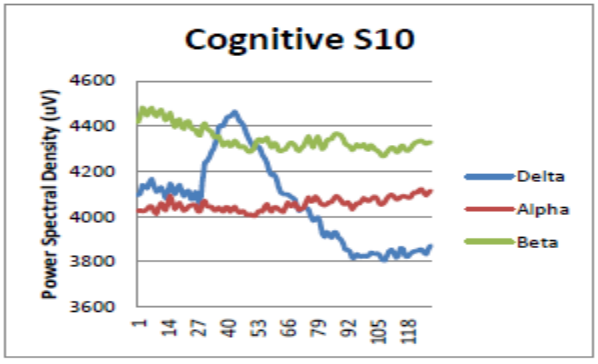

Fig 9(a): Distribution graph for cognitive activity

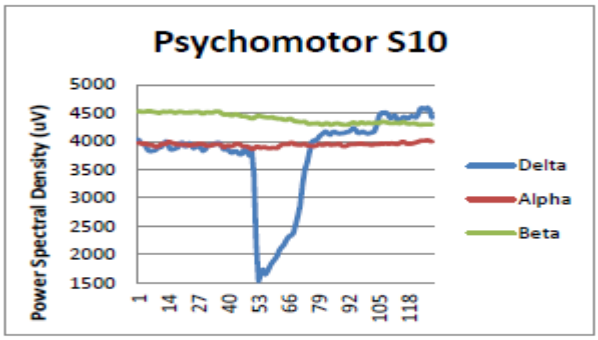

Fig 9(b): Distribution graph for psychomotor activity

4.1.3 Dominant in Cognitive and Psychomotor

Dominant in both cognitive and psychomotor domain is where the person has high focus level during performing kind of activities. In theory, both Delta and Beta subbands are higher compared to Alpha subband in cognitive and psychomotor activity. Form the experiment conducted, three out of ten subjects are categorised as dominant in cognitive and psychomotor domain. Table 9 shows the comparison of Delta subband between cognitive and psychomotor activities. All four subjects have high reading of Delta subband during both activities.

TABLE 9:
COMPARISON OF DELTA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Delta subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S1	High	High
S8	High	High
S9	High	High

TABLE 10:
COMPARISON OF ALPHA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Alpha subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S1	Low	Low
S8	Low	Low
S9	Low	Low

TABLE 11:
COMPARISON OF BETA SUBBAND IN COGNITIVE AND PSYCHOMOTOR

Comparison for Beta subband during Cognitive and psychomotor activities		
Subject	Cognitive	Psychomotor
S1	Low	High
S8	High	High
S9	High	High

Fig 10 (a) shows the distribution graph of subject 1 during cognitive activity. The graph shows that delta subband is dominant during the activity was conducted. The beta subband is

high at the early stage of the cycle and it dropped before rise again at the last part of the cycle. The alpha subband during cognitive activity is at almost the same for the whole cycle. Fig 10 (b) shows the distribution graph of subject 1 during psychomotor activity. From the graph, it can be seen that delta subband is dominant at the first half of the cycle before the value goes down until the cycle is completed. Beta subband is also dominant during the execution of the activity. From the graphs it can be concluded that subject 1 can be categorised as dominant in cognitive and psychomotor domains. Both beta and delta subbands are dominant during cognitive and psychomotor activities.

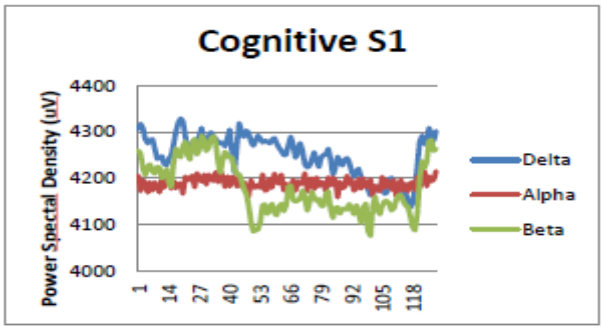

Fig 10(a): Distribution graph for cognitive activity

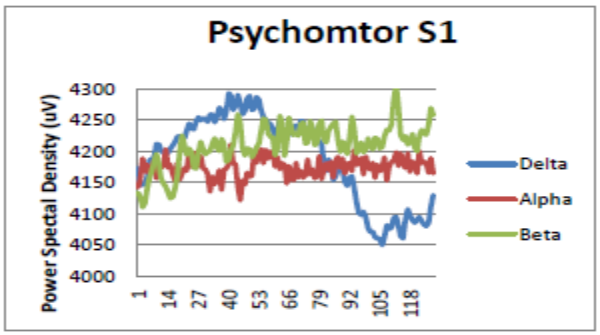

Fig 10(b): Distribution graph for psychomotor activity

Fig 11 (a) and 11 (b) show the distribution graph of subject 8 during cognitive and psychomotor activities respectively. From the Fig 11 (a), it can be seen obviously that delta and beta subbands are dominant when the activity was conducted. During the psychomotor activity, delta subband is dominant and this can be observed from the Fig 11 (b). From the observation, the subject 8 is dominant in both cognitive and psychomotor domains.

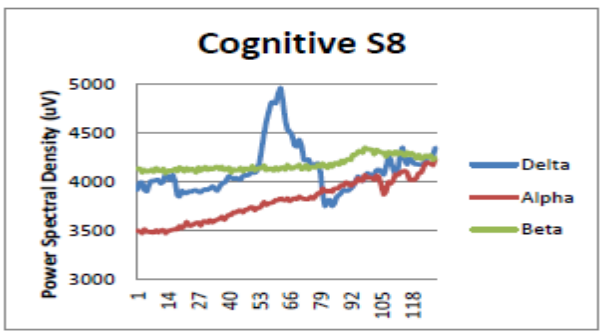

Fig 11(a): Distribution graph for cognitive activity

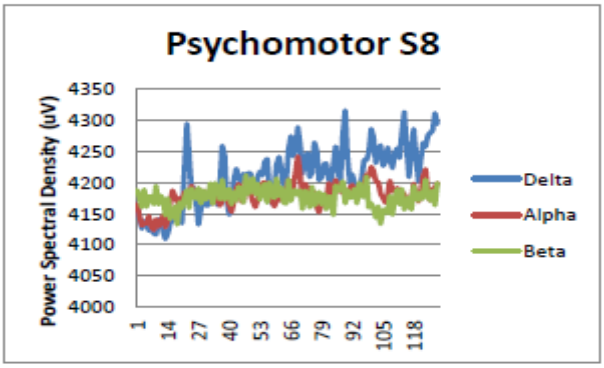

Fig 11(b): Distribution graph for psychomotor activity

Fig 12 (a) shows the distribution graph of subject 9 during cognitive activity. The delta subband appears to be dominant while the activity is conducted. The graph also shows that the beta subband is higher than alpha subband. Fig 12 (b) shows the distribution graph of subject 9 during psychomotor activity. From the graph, delta and beta subband are dominant when the activity is conducted. Even though the values for both subbands started dropping, they are still higher than the value of alpha subband. From the figures, subject 9 can be categorised as dominant in cognitive and psychomotor as both delta and beta subbands are dominant during cognitive and psychomotor activities.

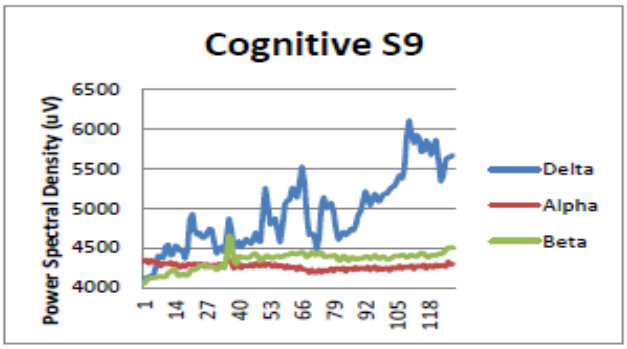

Fig 12(a): Distribution graph for cognitive activity

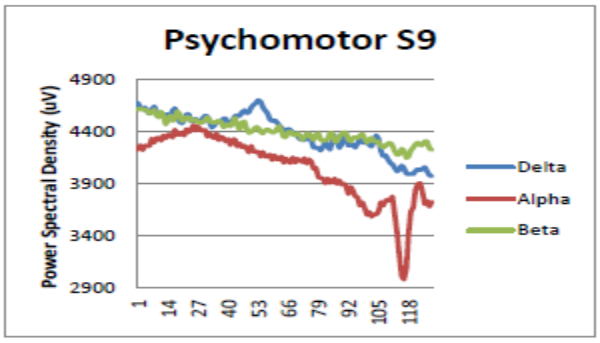

Fig 12(b): Distribution graph for psychomotor activity

4.2 Standard deviation

4.2.1 Cognitive

The significance of the result of standard deviation towards this project is to observe the minimum and the maximum size of the wave emitted by Delta, Alpha and Beta subbands. The bigger the range of standard deviation for one subband, the better it is. This is because the information in the wave is bigger in quantity as the range increase. The Fig 13 shows the bar graph standard deviation for cognitive activity. From the graph, the Delta subband is more dominant compared to Beta subband. This is obviously seen from subject 3, 5, 7, 8, 9 and 10. Table 4.11 shows the values of standard deviation for Delta, Alpha and Beta subbands during cognitive activity. Fig 4.27 shows the graph of standard deviation for cognitive activity.

TABLE 12:

VALUES OF STANDARD DEVIATION DURING COGNITIVE ACTIVITY.

Subject	Delta	Alpha	Beta
S1	48.03861	12.74396	57.655
S2	21.51943	12.68739	19.53792
S3	170.2692	59.2743	44.45265
S4	58.17869	74.0031	26.88669
S5	161.0404	57.14025	56.32565
S6	57.35038	51.70892	69.74733
S7	140.7715	24.62399	22.59573
S8	246.3168	211.3011	72.64448
S9	468.7039	35.34044	107.103
S10	195.3717	27.13968	53.43567

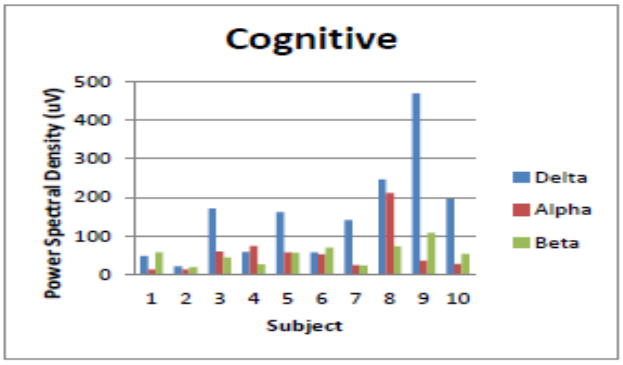

Fig 13: Standard deviation for Cognitive.

4.2.2 Psychomotor

The Fig 14 shows the bar graph of standard deviation for psychomotor activity In the early minute, it can be seen from the graph that Delta and Beta subbands are higher. Generally from the graph, the Beta subband is higher than Alpha subband. Table 13 shows the values of standard deviation during psychomotor activity.

TABLE 13:

VALUES OF STANDARD DEVIATION DURING PSYCHO-MOTOR ACTIVITY.

Subject	Delta	Alpha	Beta
S1	71.23779	15.94828	34.10139
S2	46.9491	16.13804	69.19856
S3	282.4913	60.33412	86.75955
S4	43.80473	77.10552	25.23369
S5	123.9483	58.64286	58.19477
S6	374.313	306.582	401.5849
S7	226.3021	184.3402	106.7611
S8	48.72033	20.72632	15.93805
S9	199.4569	319.3029	112.5781
S10	777.3328	30.09045	88.2447

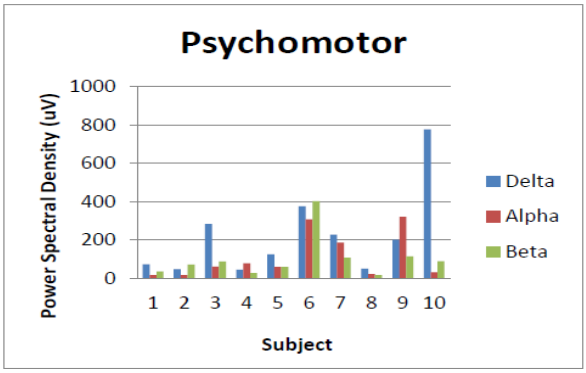

Fig 14: Standard deviation for Psychomotor

4.3 Average

4.3.1 Cognitive

Table 14 shows the values of average for Alpha, Beta and Delta subbands during cognitive activity. The Fig 15 shows the bar graph for average of cognitive activity. It can be said that a larger part of Beta subband in the graph is high. Delta and Beta subbands are higher compared to Alpha subband. This can be seen obviously from the graph. From here, it can be conclude that Beta and Delta subbands are higher than Alpha subband during cognitive activity.

TABLE 14:

AVERAGE VALUES FOR DELTA, ALPHA AND BETA SUB-BANDS DURING COGNITIVE ACTIVITY

Subject	Delta	Alpha	Beta
S1	4250.304	4189.615	4180.725
S2	4187.792	4180.481	4192.179
S3	4320.367	4173.002	4204.789
S4	4489.892	4183.357	4310.869
S5	4272.556	4155.381	4161.494
S6	4217.624	4167.111	4160.14
S7	4217.624	4167.111	4160.14
S8	4120.961	3804.291	4183.353
S9	4934.751	4265.272	4346.63
S10	4060.16	4053.413	4343.914

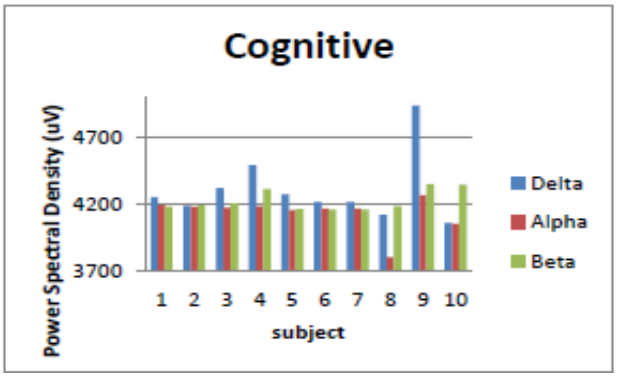

Fig 15: Average for cognitive

4.3.2 Psychomotor

Table 15 shows the average values of Delta, Alpha and Beta subbands during psychomotor activity. Fig 16 shows the graph of average for psychomotor activity. From the graph, Delta and Beta subbands are higher than Alpha subbands. This however is not very obvious.

TABLE 15:
AVERAGE VALUES FOR DELTA, ALPHA AND BETA SUB-BANDS DURING PSYCHOMOTOR ACTIVITY

Subject	Delta	Alpha	Beta
S1	4187.62	4174.407	4210.224
S2	4209.487	4184.836	4163.918
S3	4147.612	4122.544	4205.224
S4	4191.831	4187.957	4166.679
S5	4228.654	4152.047	4164.856
S6	4294.086	4169.515	4114.255
S7	4016.506	4335.569	4324.896
S8	4211.703	4179.463	4176.839
S9	4386.983	4050.465	4403.99
S10	3756.17	3939.127	4399.539

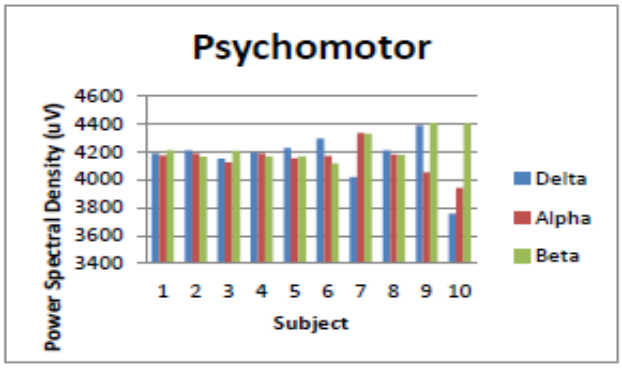

Fig 16: Average for psychomotor

5. CONCLUSION

This research is conducted to find out more about the EEG pattern when a person is studying using either cognitive or psychomotor learning methodology. For cognitive domain, theoretically, the band that will be mainly visible is Beta band. Both Alpha and Beta band would be present when a person is learning by using cognitive method. However, Beta band would be more dominant. The range of difference between Alpha and Beta band is the range level of focus of a person. If the difference between Beta and Alpha band of a subject is big, it can be conclude as the subject has a high focus level. The Alpha band is used as the measuring point in this experiment. From the experiment that was conducted to prove this theory, another band was present was well which is Delta band. The previous research regarding cognitive domain did not mention Delta band. Delta band is present when continuous attention task happens. For psychomotor domain, Delta, Alpha and Beta band would also be present. The Beta band would be more dominant as the person will be thinking actively in order to solve the task given. From the experiment conducted, Delta band is also present when psychomotor domain is used for learning. As more experiment is conducted, it is proven that Alpha and Beta band are not the only bands that are related to cognitive and psychomotor learning methodology. Delta band is also included in this matter. The distribution data shows the pattern and the categories existed. The result obtained from data collection has proven the hypothesis and it has achieved the objectives of the project.

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