Can Power Spectral Density (PSD) be used to Measure Reading Concentration?

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Abstract: This study aims to measure the concentration power on reading activity based on electroencephalography (EEG) recording. The concentration is in the beta wave, precisely at the frequency of 15-18Hz. This research used a qualitative approach. Data were collected using Open Brain Computer Interface and involved 16 respondents consisting of 8 men and 8 women. The recordings used 4 EEG channels with a maximum impedance of 15Ω. Data processing used MATLAB based application, EEGLab. Power concentration measurements used power spectral density (PSD) analysis. PSD can show power spectrum activity at any frequency. The results of this study indicate the average power spectrum activity in male respondents showed a higher concentration compared with female respondents and describe differences in concentration and non-concentration conditions based on brain map patterns. Besides the result, PSD can also be the alternative method to determine the power of a person's reading concentration more efficiently. Thus, the opportunity to conduct experiments related to the factors that affect the power of reading concentration.

1 INTRODUCTION

Reading is an activity that is easy to do, but not a simple thing. Some experts argue that reading activity is a very complex and complicated (McGinnis and Smith, 1982; Soedarso, 2002; Nurhadi, 2005). It is said complex because the reading activity involves many factors that are interconnected with each other. Of the many factors, concentration power is a factor that is generally recognized very influential in the process of reading. Complaints are often conveyed by readers regarding the difficulty of understanding the reading material due to the decreasing concentration power during the reading process. This lack of concentration certainly affects the reader in understanding the reading material, so the reading process becomes ineffective. In fact, the higher the concentration power the more information is captured from the reading material.

Accordingly, reading concentration plays an important role in the whole of the reading process itself, as well as on the absorption of information received by the reader from his reading. Measurement of reading concentration power can be used as an evaluation material to measure how long it takes a person to stay in optimal condition while reading.

One way that can be done to measure the power of concentration is to look at patterns of changes in brainwaves that are monitored through electroencephalograph (EEG) sensors. Tatum (2014) states that the EEG is a unique and valuable measurement of brain electrical function that displays graphics of voltage difference from within two brain function locations recorded over time. EEG involves the study of recording these electrical signals generated by the brain.

EEG is commonly used to detect problems in brain electrical activity that may be associated with certain brain disorders, for example, including seizures (such as epilepsy), head injury, encephalitis, brain tumors, encephalopathy memory problems, sleep disturbances, and dementia. However, this is not possible if the EEG is used to measure and record the electrical activity of the brain outside of such things, for example in reading activity.

EEG recording is expected to identify the power of concentration when a person performs reading activity. This concentration power is determined based on recorded brain waves, such as delta, theta, alpha, beta, and gamma. One analysis that might be

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an alternative in the EEG data processing is to perform an analysis of the Power Spectral Density (PSD). PSD is a very useful tool to know frequencies and amplitudes of oscillatory signals in the time series data. In line with it, Kusmaryanto (2013) stated that the PSD to show the amount of energy per unit based on the frequency and output-frequency components of different outcomes.

Power spectral density function (PSD) shows the strength of the variations (energy) as a function of frequency. In other words, it shows at which frequencies variations are strong and at which frequencies variations are weak. The unit of PSD is energy (variance) per frequency (width) and you can obtain energy within a specific frequency range by integrating PSD within that frequency range Cygnus Research International (2017).

Based on that, this paper will explain how the use of PSD to measure the concentration of reading through the data recorded using EEG. Through this analysis also expected to be found data related to the measurement result of reading concentration.

Studies on EEG have been widely practiced. However, a particular study of reading power concentration has not been done. EEG research focuses mainly on two things: time scale and Fourier transform.

The analysis performed to measure EEG data primarily to measure the strength of electrical signals at a particular frequency is to use power spectral density (PSD) analysis. The PSD analysis uses Fourier transforms rather than time series. Valipour, Shaligram, and Kulkarni (2014) state that "the power spectral density (PSD), explain how the power or energy of a signal is distributed across frequency". This term related to Fourier transform. Hence PSD is frequency domain analysis.

Any physical signal in Fourier transform can be decomposed into a number of discrete frequencies, or a spectrum of frequencies over a continuous range. Xizheng, Ling, and Weixiong (2011) state that "Fourier transformation have been used to analyze the pattern of EEG characteristics and non-transient EEG activity".

To describe and interpret the results of recording and measurement of reading concentration power in this study used two main theories, namely: neurolinguistics theory and brain wave interpretation theory. Neurolinguistics theory adapted from Caplan (1987) and Ingram (2007). Meanwhile, the brain wave theory was adapted from Stern and Engel, (2005), and Tatum (2014).

2 METHODOLOGIES

This research uses descriptive method. The elements described are interpretations of EEG recording results, including brain wave and brain mapping through neurolinguistics analysis. Data collection using Open Brain Computer Interface by utilizing 16 respondents consisting of 8 men and 8 women from Department of Indonesian Language and Literature Education.

The recordings use 4 EEG channels with a maximum impedance of 15Ω. Data processing using MATLAB based application, EEGLab. We record electrical signals in the brain through electrodes mounted under 10-20 International System, i.e. Frontal polar 1 (Fp1), Frontal polar 2 (Fp2), Occipital 1 (O1), Occipital 2 (O2), Ear 1 (A1) and Ear 2 (A2) (see figure 1).

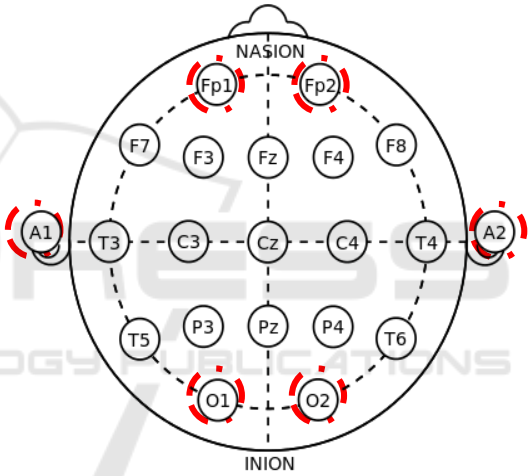

Figure 1: 10-20 international system.

The EEG data collection procedure for describing students' concentration on reading activity is done through the following steps.

- EEG data recording at the time of reading activity;
- Numbering on the respondents' EEG recordings by sex, data collection sequence, respondent code number, and
- Re-examination of EEG data recording results.

After the recording process is done, the EEG data is then interpreted. Raw EEG data is processed through EEGLab. EEGLab is a toolbox and graphic user interface running under the cross-platform MATLAB environment for processing of EEG data of any number of channels. Raw data is filtered at 15-18Hz, and analyzed through Power Spectral Density (PSD).

3 RESULTS AND DISCUSSION

Measurements of reading concentration power based on PSD are outlined in three ways: (1) Average PSD in Reading Activities, (2) Average PSD between Men and Women, and (3) Correlation between PSD and Time scale.

3.1 Average PSD in Reading Activities

The recapitulation of power spectrum density activity calculation at concentration condition during reading activity is presented in the table 1.

Table 1: Power spectral in reading activities.

Subject	Concentration Freq.			
	15Hz	16Hz	17Hz	18Hz
L1	2,25	0,90	0,40	-0,10
L2	0,30	-0,10	-0,55	-0,56
L3	4,70	4,40	3,90	3,70
L4	6,60	6,30	5,80	4,25
L5	1,20	0,96	1,03	1,08
L6	11,40	10,30	9,80	8,60
L7	4,90	5,30	5,25	4,25
L8	1,60	2,10	2,50	3,00
P1	-1,15	-1,28	-0,84	-1,00
P2	0,15	-0,40	-0,80	-1,30
P3	1,85	1,30	0,75	0,60
P4	3,70	3,30	2,45	2,80
P5	3,52	3,25	3,15	2,95
P6	-0,15	-0,81	-0,71	-0,65
P7	12,55	12,60	12,10	12,35
P8	5,50	4,95	4,80	4,50
Average	3,68	3,32	3,06	2,78

Based on the table 1, it can be described that based on the result of the measurement of the average power spectral density (PSD) in the frequency range of concentration condition (15-18Hz) is 3.68 at the frequency of 15Hz, 3.32 at the frequency of 16Hz, 3.06 at 17Hz frequency and 2.78 at 18Hz frequency. The highest number of PSD in the range of 15-18Hz is in the subject of P7, respectively with values of 12.55, 12.60, 12.10, and 12.35. Meanwhile, the lowest number of PSDs in the range 15-18Hz, is in the subject of P1, which respectively values -1.15, -1.28, -0.84, and -1.00. If the PSD value is related to the concentration duration, it can be shown that the subject with the highest PSD (subject P7) has the highest concentration duration. Meanwhile, subjects with the lowest PSD (subject P1) had the lowest concentration duration as well.

3.2 Average PSD Comparison between Men and Women

The power spectral activity on reading activity performed for 15 minutes between male and female subjects is shown in Figure 2 below.

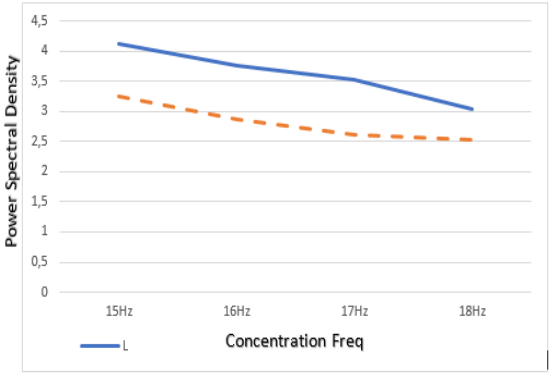

Figure 2: Average PSD comparison concentration conditions (15-18Hz) in reading activity between men and women.

Based on the results of the analysis can be seen that the average ability of reading concentration in men is higher than the reading concentration in women.

3.3 Correlation between PSD and Time Scale

In understanding the relationship between PSD with measurement of concentration duration, we can perform correlation measurement. Here is the measurement of the correlation between PSD and time scale. This measurement uses Pearson Correlation. The results of these calculations are presented in the table 2.

Table 2: Correlation between PSD and time scale.

		PSD	Opt.	Low	Total
PSD	Pearson Correlation	1	0,874	0,145	0,715
	Sig. (1-tailed)		0,000	0,296	0,001
	N	16	16	16	16
*Correlation is significant at the 0.01 level (1-tailed).					

Based on table 2, it can be described that the PSD analysis on the reading concentration measurements is positively correlated with the time scale measurement of the optimal reading concentration of 0.874. However, the correlation is low with the measurement of low read time scale concentrations of only 0.145. Meanwhile, it has a positive correlation with time scale measurement of total concentration of 0.715. This shows that the

measurement of PSD is very appropriate to know the condition of optimal concentration in reading activity.

4 CONCLUSIONS

Based on the analysis that has been done, it can be shown that the power spectral density (PSD) analysis can be an alternative for measuring the reading concentration, as well as other measurements based on a certain frequency or frequency range. In terms of reading concentration measurements, the PSD is more appropriate for measuring the optimal concentration and total concentration during reading activity. Because it is suitable for stationary signal measurements, the PSD will make the duration of EEG measurements more efficient especially in the measurement of EEG in bulk quantities.

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