THE INFLUENCE OF NOISE FACTORS ON CONCENTRATION BASED ON EEG SIGNAL

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Abstract. *The noise intensity with different levels can affect human cognitive abilities, performance, and brain activity. Human cognitive performance, especially concentration, is needed when doing work activities. However, there are still few studies related to the effect of continuous noise in the textile industry on cognitive performance as measured by electroencephalogram (EEG). This study aims to see the impact of noise caused by textile industry noise sources on concentration. In this study, an experiment was conducted to see the effect of noise on cognitive performance and attention with the variables used, namely sound intensity (45 dB, 75 dB, 85 dB, and 95 dB) and gender (female and male). The instruments used during the research, namely the trail-making test and the muse headband, were then analyzed using total response time and relative band power beta. The participants involved were 30 subjects, namely 15 men and 15 women aged 18-25 years. The two-way mixed ANOVA test results show the total response time with a significance value of 0.000 and the relative band power beta on the TP10 or right temporal channel with a significance value of 0.002. It can be concluded that the participants, when doing activities, are given noise disturbances with different sound intensities that affect concentration.*

Keywords: Noise, EEG, Concentration, Beta Signal, Total Response Time

1 Introduction

Humans need a cognitive function to work optimally (Maramis et al., 2021). Industrial noise influences several environmental factors that influence human actions (Feder et al., 2017). (Fanny, 2015). Noise exists in everyday life and can cause effects hearing and non-hearing health. The noise is generated from various sound sources, such as engine noise and activity noise which are considered sound sources in the industrial sector (Jinjing et al., 2021). Impaired concentration can cause work accidents due to decreased ability to focus while doing work. One of the causes of impaired concentration at work is physical factors in noise (Setiaji et al., 2021). The noise effect can be known by measuring the resulting brain wave activity. One of the methods used to view brain wave activity is the electroencephalogram (EEG) (Jafari et al., 2019). Many studies have discussed the effect of noise on cognitive performance as measured by EEG. Like Jinjing's (2021) study on evaluating the impact of noise on cognitive function with

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neurocognitive monitoring using EEG. Jafari's research (2019) on assessing mental workload and attention to noise exposure with different intensity levels using EEG signal analysis. Huda's research (2021) related to the effect of noise on cognitive performance, especially in decision making, which was analyzed using beta EEG signals. Hernandez's research (2017) states an increase in EEG signals, namely beta signals when given noise exposure treatment which is associated with the function of attention when participants perform the given task. Jafari's research (2019) showed that when participants were exposed to noise with an intensity of 95 dBA, they experienced a decrease in test results and beta signals. The beta signal is a signal that is dominated when the participant is in a normal state of consciousness, attentiveness, decision making, or focused activity. This study uses a noise level of 45 dB, 75 dB, 85 dB, and 95 dB. The conditions of 45 dB are normal or without noise, while conditions of 75 dB with additional noise are still below the maximum limit of 85 dB, and conditions of 95 dB with higher other noise. This study used muse headbands with 4 channels to measure brain wave activity and carry out the task trail making test. The urgency of this research is to identify the dangers of exposure to noise at different intensities on human performance.

2 Literature Review

2.1 Concentration

Concentration is the ability to focus each individual's attention on a particular object of activity, with concentration we can do work faster and with better results. Each individual has different stages of concentration levels according to several factors such as physical conditions, mental conditions, and various other conditions. Concentration can decrease due to work activities that are carried out regularly (Supyana et al., 2019).

2.2 Noise

Noise is one of the factors that can interfere with one's concentration. Any sound source that harms the quality of health is a form of noise. Noise can be interpreted as the unwanted sound from natural activities such as speech and artificial activities such as machines (Marisdayana et al., 2016).

2.3 Parts of the Human Brain

The brain is one of the most important organs that functions as the central controller of the human body. The human brain can be divided into three main parts: the cerebrum, cerebellum, and brain stem (medulla oblongata). Each piece of the brain has a different function. Generally, the brain is divided into several parts called lobes of the brain. There are four brain lobes, namely the frontal lobe, parietal lobe, temporal lobe, and occipital lobe. The frontal lobe is a part of the brain associated with higher executive functions such as emotional regulation, planning, reasoning, and problem-solving. The parietal lobe is the part of the brain responsible for integrating sensory information, including touch, temperature, pressure, and pain. The temporal lobe is the part of the brain responsible for processing sensory information, essential for hearing, recognizing language, and forming memories. The occipital lobe is the part of the brain responsible for the primary visual processing center in the brain.

2.4 Electroencephalography (EEG)

Electroencephalography (EEG) is a non-invasive medical imaging technique that records brain activity from the scalp's surface using conductive metal electrodes. The EEG signal between electrodes placed on the scalp comprises many different waves (Priyanka, 2016). According to Tatum (2014), EEG is a device that records the current electrical activity of the brain through electrodes placed on the scalp. The advantages of using an EEG device are sensitivity to stress conditions, awake, alertness, rest, and sleep. The disadvantages are that it is difficult to use, expensive, impractical, and difficult to process data and analyze.The following is a division of brain signals and the frequency range and mental conditions that occur.

1. Delta (0.5-4 Hz)
   Signals associated with meditation and dreamless sleep.
2. Theta (4-8 Hz)
   An increase in theta wave activity indicates a person experiences drowsiness (Rohit et al., 2017). Puma et al. (2018) explained that theta waves were used to measure mental workload.
3. Alpha (7.5-13 Hz)
   This frequency appears when a person is in a resting phase (calm, eyes closed). Decreased alpha wave activity also indicates a person experiences drowsiness and decreased alertness (Rohit et al., 2017).
4. Beta (13-30 Hz)
   This frequency indicates a person's attention is focused on a particular task. Beta wave frequency is associated with states of focus and alertness (Rohit et al., 2017).
5. Gamma (30-44 Hz)
   Demonstrates a high level of mental processing (Richer et al., 2018).

2.5 Muse Headband

The Muse headband uses four active electrodes and three reference electrodes. The main electrodes consist of the AF7 electrode, which is used to record brain waves on the left side of the forehead, the AF8 electrode to record brain waves on the right forehead, the TP9 electrode to record brain waves in the left ear, and TP10 electrode to record brain waves on the right ear. The reference electrode is a reference electrode that has a stable potential and is used as a controller for the primary electrode potential. One of the reference electrodes used in the muse headband is the Fpz electrode located in the middle of the forehead. The EEG signal obtained from the Muse headband has a continuous sampling rate between 220 Hz to 500 Hz. MUSE 1 is equipped with a Bluetooth system connected to Android or IOS devices and connected to the Mind-Monitor application to read and record EEG signals.

2.6 Trail Making Test

Trail Making Test A & B is one of the neuropsychological tests included in the batteries test to assess cognitive function in the form of concentration. Measurement of concentration levels with TMT is carried out in the following way, and respondents are given a paper (TMT A with a series of numbers 1-25 on a circle; TMT B a series of numbers combined).

3 Methods

This study employs experimental design research (experimental design), which is a method for determining the effect of a factor on specific variables. In this study, 30 participants were involved, with a balanced proportion of male and female subjects, namely 15 male subjects and 15 female subjects aged 18-25 years. The Total Response Time (TRT) and average beta signal are the parameters used to calculate concentration. The Trail Making Test is used to calculate Total Response Time (TRT). The Muse Headband device is used to measure the intermediate beta signal. The instruments used in this study were the Trail Mak-ing Test and the Muse Headband.

The total response time data that is processed is the average time data. The significance test was carried out on the sound intensity and gender using the Two-Way Mixed Analysis of Variance (ANOVA) test. Furthermore, if there are significant results, further analysis is carried out using a paired sample t-test to determine which factors are significantly different.

The data obtained from the muse EEG was recorded using the Muse Monitor application. The advantage of using an EEG device is that it is sensitive to stressful conditions, awake, alert, to rest and sleep. The results of the EEG recording are displayed in the form of a CSV file. The values shown are the absolute band power values for each delta, theta, alpha, beta, and gamma wave at the four-electrode points measured, namely TP9 (left temporal), AF7 (left frontal), AF8 (right frontal), TP10 (right temporal). EEG data processing is carried out through several stages, namely the pre-processing stage, the calculation of the relative band power, and the significance test.

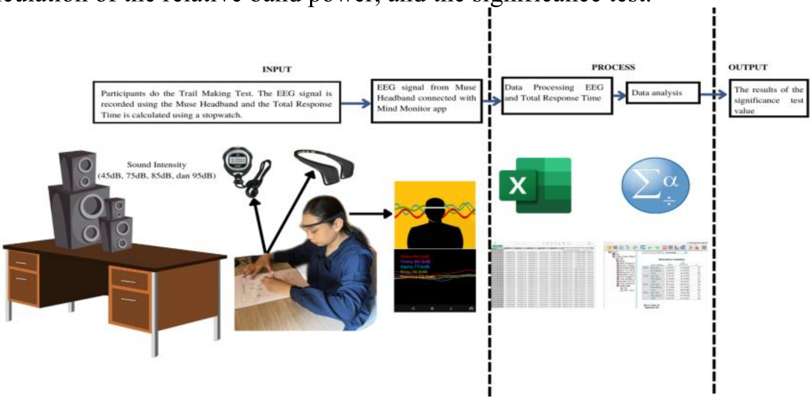

Fig. 1. Overview of Data Collection and Data Processing System

4 Results and Discussion

Raw signal has been processed using Matlab Signal Analyzer. Linear detrend processing is applied. High pass filtering is conducted with parameter Passband Frequency 0.45Hz, steepness 0.85 and stopband attenuation at 60dB. After that, the signal is smoothed using the moving average method.

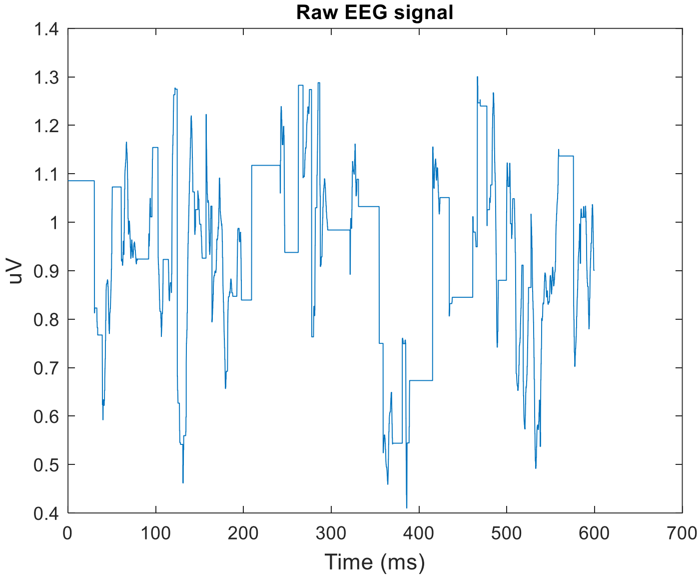

Fig. 2. Raw Signal TP9

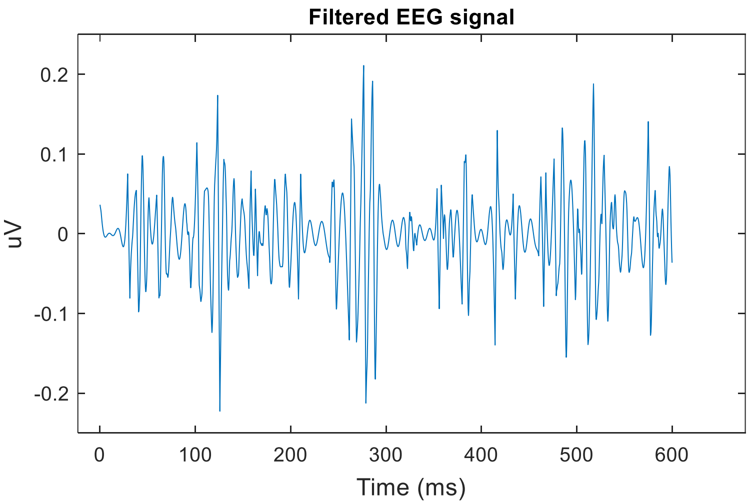

Fig. 3. Signal TP9 after processing linear detrend using Matlab Signal Analyzer

Table 1. Test Results Two Way Mixed Anova

Dependent Variable	Performance Measure	Factor	F	Sig.	Conclusion
Concentration	*Total Response Time*	Sound Intensity	196.46	0.00	Reject H0
		Gender	0.33	0.57	Accept H0
		Interaction	2.13	0.10	Accept H0
	Relative band power beta	Sound Intensity	0.15	0.93	Accept H0
		Gender	1.61	0.19	Accept H0
		Interaction	1.47	0.24	Accept H0
	Relative band power beta channel TP9	Sound Intensity	2.60	0.06	Accept H0
		Gender	0.95	0.42	Accept H0
		Interaction	0.74	0.40	Accept H0
	Relative band power beta channel TP10	Sound Intensity	5.50	0.00	Reject H0
		Gender	3.13	0.09	Accept H0
		Interaction	2.39	0.08	Accept H0
	Relative band power beta channel AF7	Sound Intensity	1.50	0.22	Accept H0
		Gender	1.10	0.30	Accept H0
		Interaction	2.05	0.11	Accept H0
	Relative band power beta channel AF8	Sound Intensity	2.23	0.09	Accept H0
		Gender	0.68	0.42	Accept H0
		Interaction	4.45	0.06	Accept H0

Based on Table 1 can answer the hypothesis that has been made; that is, H0 is accepted if the significance value is greater than 0.05; otherwise, H0 is rejected if the significance value is less than 0.05. According to the table, the significance value of sound intensity is 0.000 0.05, so H0 is rejected. As a result, the sound intensity factor significantly affects concentration. H0 was accepted if the significance value of gender and the interaction between sound intensity and gender were greater than 0.05. Gender and interaction factors have no significant effect on concentration. Because sound intensity has a significant impact, a paired sample t-test was performed to examine the difference in total response time when no noise (control) and noise treatment was applied.

Based on the results of the Two Way Mixed Anova Relative Band Power Beta, the hypothesis is that if the significance value is greater than 0.05, H0 is accepted; otherwise, if the significance value is less than 0.05, H0 is rejected. According to the table, the significance value of sound intensity is 0.927 > 0.05, indicating that H0 is acceptable. As a result, the sound intensity factor has no discernible effect on concentration. When the significance value of sex and the interaction between sound intensity and gender was greater than 0.05, H0 was accepted, indicating no significant effect of gender and interaction factors on concentration.

It is possible to answer the hypothesis that has been made based on the results of Two Way Mixed Anova Relative Band Power Beta Channel TP9; that is, if the significance value is greater than 0.05, then H0 is accepted; otherwise, if the significance value is less than 0.05, then H0 is rejected. According to the table, the significance value of sound intensity is 0.058 > 0.05, indicating that H0 is acceptable. As a result, the sound intensity factor has no discernible effect on concentration. When the gender significance value and the interaction between sound intensity and gender were greater than 0.05, H0 was accepted. As a result, there is no significant relationship between gender and interaction factors and concentration.

Based on the Two Way Mixed Anova Relative Band Power Beta Channel TP10 results, the hypothesis is that if the significance value is greater than 0.05, H0 is accepted; otherwise, if the significance value is less than 0.05, H0 is rejected. According to the table, the significance value of sound intensity is 0.002 0.05, so H0 is rejected. As a result, the sound intensity factor significantly influences concentration. When the sex significance value and the interaction between sound intensity and gender were greater than 0.05, H0 was accepted. As a result, there is no significant effect of gender or interaction factors on concentration. Because the sound intensity factor has a significant impact, a paired sample t-test was carried out to see further the difference in the relative value of the TP10 beta channel power band when there was no noise (control) and when given noise treatment.

Based on the Two Way Mixed Anova Relative Band Power Beta Channel AF7 results, the hypothesis is that if the significance value is greater than 0.05, H0 is accepted; otherwise, if the significance value is less than 0.05, H0 is rejected. According to the table, the significance value of sound intensity is 0.220 > 0.05, indicating that H0 is acceptable. As a result, the sound intensity factor has no discernible effect on concentration. When the sex significance value and the interaction between sound intensity and gender were greater than 0.05, H0 was accepted. As a result, there is no significant relationship between gender and interaction factors and concentration.

The hypothesis can be answered based on Two Way Mixed Anova Relative Band Power Beta Channel AF8 results. H0 is accepted if the significance value is greater than 0.05; otherwise, H0 is rejected if the significance value is less than 0.05. According to the table, the significance value of sound intensity is 0.090 > 0.05, indicating that H0 is acceptable. As a result, the sound intensity factor has no discernible effect on concentration. When the gender significance value and the interaction between sound intensity and gender were greater than 0.05, H0 was accepted. As a result, there is no significant relationship between gender and interaction factors and concentration.

Tabel 2. Test Result *Paired Sample T-Test*

Dependent Variable	***Performance measure***	**Pair**	**t**	**Sig.**	**Conclusion**
Concentration	*Total Response Time*	45dB - 75dB	-6.287	0	Reject H0
		45dB - 85dB	-13.843	0	Reject H0

		45dB - 95dB	-22.07	0	Reject H0
Concentra-tion	*Relative band power beta channel TP10*	45dB - 75dB	-2.555	0.016	Reject H0
		45dB - 85dB	-1.915	0.065	Accept H0
		45dB - 95dB	-2.76	0.01	Reject H0

According to Table 2, the paired sample t-test reveals that each pair has a significance value of 0.05, indicating that H0 is rejected. This suggests that the differences between the pairs are significant.

5 Conclusion

The sound intensity factor significantly affects the participant's total response time during the trail making test. Meanwhile, gender and interaction factors do not impact Total Response Time. The sound intensity factor, gender factor, and interaction factor on the relative band power beta did not have a significant difference. At the same time, the relative value of the beta band power seen from each channel shows that the sound intensity factor significantly influences the relative band power of the beta signal on the channel TP10 or right temporal.

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