SPEKTRA: Jurnal Fisika dan Aplikasinya
Volume 6, Issue 2, October 2021
Homepage: doi.org/10.21009/SPEKTRA

Check for updates

DOI: doi.org/10.21009/SPEKTRA.062.02

STUDY OF THE EFFECT OF MAGNETIC FIELDS ON ELECTROENCEPHALOGRAPHY MEASUREMENT IN FARADAY'S CAGE

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Received: 10 June 2021
Revised: 20 August 2021
Accepted: 30 August 2021
Online: 26 October 2021
Published: 30 October 2021

SPEKTRA: Jurnal Fisika dan Aplikasinya
p-ISSN: 2541-3384
e-ISSN: 2541-3392

ABSTRACT

Electroencephalography (EEG) is a method for recording the brain's electrical activity through electrodes placed on the scalp's surface. The amplitude of the EEG signal is in the 40–100 V range, with the five main frequencies in the 0 to 100 Hz range. The EEG is non-stationary and very susceptible to various disturbances, especially frequency disturbances, so eliminating troubles in the raw EEG data is essential to obtain helpful information reflecting brain activity. Interference in the EEG signal comes from muscles, eye movement and blinking, power lines, and interference with other devices. The distractions overlap. Shielding is required to perform an EEG without the risk of interference and ambient background noise. This study tested how the influence of magnetic field disturbances on EEG measurements was carried out in the Faraday cage and an unprotected room. The magnetic field was measured before, during, and after the EEG was operated. EEG measurements were performed on subjects who were conditioned to rest for 5 minutes. The EEG signals generated when EEG recordings were performed in the Faraday and the unprotected rooms were compared. It was found that the difference in the value of the magnetic field originating from electronic devices around the subject does not significantly affect the EEG measurement results.

Keywords: electroencephalography, power spectral density, Faraday's Cage, signal

INTRODUCTION

Electrical activity in the brain contains information related to the body's physical and mental disorders. Various recording and imaging techniques have been developed to study and understand the characteristics of the brain, both in structure and function. MRI (Magnetic Resonance Imaging), EIT (Electrical Impedance Tomography), CT (Computerized Tomography), and EEG (Electroencephalography) are some examples of recording and imaging techniques that have been developed [1].

EEG is a method for recording electrical activity in the brain through electrodes attached to the scalp. Research in the EEG field continues to be developed from various aspects such as theory [2], data inversion [3], signal analysis and processing [4], to hardware [5]. Behind the excellent ability of EEG to record electrical activity in the brain, the use of EEG has its challenges. One of the biggest challenges in using EEG is the emergence of signal interference or artifacts that can obscure the information to be obtained [6]. Signal interference or artifact is defined as any signal picked up by the sensor but not generated from the brain [7]. Sources of signal disturbances or artifacts on the EEG can be classified based on their origin, namely physiological signal disturbances, environmental signal disturbances, and motion artifacts [8].

Some sources of signal interference can be avoided, especially those from the environment, such as AC power lines, lighting, and various electronic equipment. The essential step in environmental signal interference is to remove any unnecessary electromagnetic sources from the measuring chamber. Another way is to isolate the measuring chamber from EM signal interference using a Faraday cage. In this study, we will compare the results of EEG measurements in two designed rooms, namely a room with a Faraday cage section and a room without a Faraday cage.

METHOD

The design of the EEG measurement room is the first thing to do. The measurement room is arranged so that all sources of electromagnetic fields can be a source of signal interference in the EEG. FIGURE 1 and FIGURE 2 show the layout of the EEG measurement room designed and used in this study.

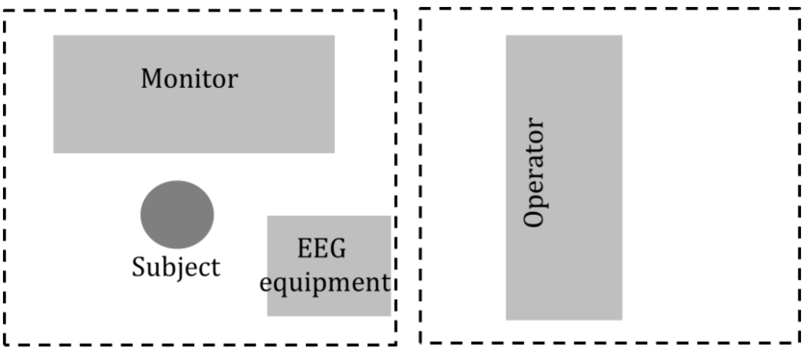

FIGURE 1. Measurement room plan without Faraday's cage (room A)

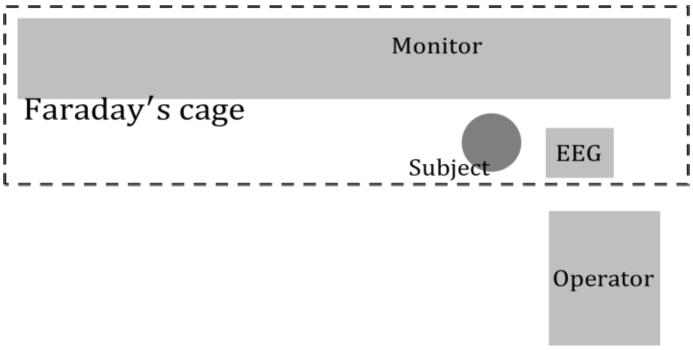

FIGURE 2. Measurement room plan with Faraday's cage (room B)

Magnetic field measurements were carried out to see if there were differences in the condition of the environmental EM wave source between the two spaces before, during, and after the EEG measurements took place. Measurements were made using the FW Bell 5170 tesla meter, which has a magnetic flux density range of 100 T - 3T and a resolution of 0.0001μT - 0.001T. Figure 3 shows the magnetic field measurement point located at a distance of 30 cm around the subject's head.

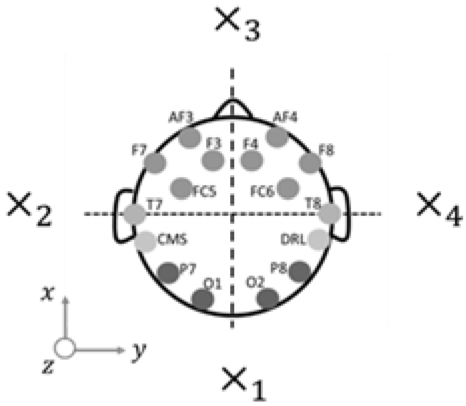

FIGURE 3. EEG electrode placement on the subject's head and the four magnetic field measurement positions around the subject (marked with a cross).

Measurements using EEG were performed on five subjects (male, age 25-30 years). All subjects did not have a history of severe illness and health problems related to nerves and were not taking medication. The recording was done using Neurosoft Neuron-Spectrum-63 EEG with 14 electrodes (AF3, F7, F3, FC5, T7, P7, O1, AF4, F8, F4, FC6, T8, P8, and O2) plus two reference electrodes (CMS) and DRL) whose installation followed international standards 10-20 as shown in FIGURE 3. Subjects were only instructed to open and close their eyes during the EEG recording process, as shown in FIGURE 4. All subjects have recorded a total of two times, each in a different room.

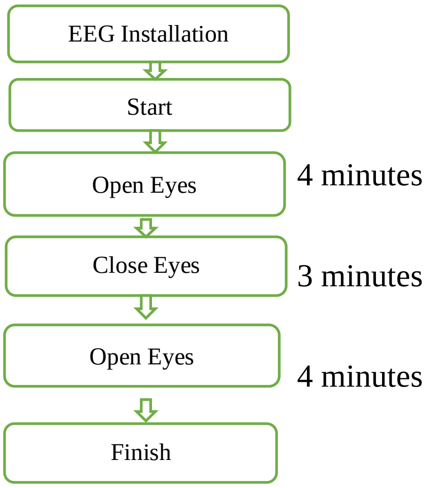

FIGURE 4. Flow chart of EEG measurement

The recorded data process through two stages to obtaining the desired information. The data from the EEG recording enters the signal pre-processing stage. At this stage, it contains a centering process that aims to reduce the increase in the amplitude value due to the built-in signal from the EEG device. After the centering process, the data is filtered using a bandpass filter. In this process, the signal is transformed from the time domain to the frequency domain using a Discrete Fourier transform (DFT) and then passes the signal with the selected frequency range. The selected frequency range is between 0.5-35 Hz. This frequency range is the brain wave frequency range. In the last stage, feature extraction is carried out using power spectral density (PSD) calculations using the Welch periodogram. Based on the PSD, the value of the peak frequency of the alpha wave is obtained.

RESULT AND DISCUSSION

TABLE 1 shows the results of magnetic field measurements before, during, and after the operation of the EEG device at each measurement position. Column A shows measurements taken in a room without a Faraday's cage, and column B shows measurements taken in a Faraday's cage.

TABLE 1. The average value of the magnetic field at the four points at three different times.

Measurement position	Magnetic fields (μT)					
	before		during		after	
	A	B	A	B	A	B
$\times_1$	0,092	0,089	0,144	0,128	0,122	0,119
$\times_2$	0,083	0,080	0,119	0,106	0,107	0,099
$\times_3$	0,085	0,086	0,143	0,124	0,101	0,099
$\times_4$	0,104	0,095	0,232	0,197	0,198	0,172

Based on the measurement results obtained, the measured magnetic field value varies with the measurement position and measurement time. The position $\times_4$ always has the most significant magnetic field value. This is because the position has the closest distance to the operator's computer equipment. The value of the magnetic field reinforces this at the position $\times_2$, which has the smallest value among other places because it has the furthest distance from the operator table.

There is a difference in the value of the magnetic field measured in the two rooms. The value of the magnetic field measured in A is always higher than in room B. The difference in the magnetic field value is in the percentage of 2% to 15%. The highest difference was seen when measurements were made at the $\times_4$ position when the EEG was operating.

TABLE 2. The average peak of alpha wave frequency during open and closed eyes.

Electrode	Average alpha wave peak frequency (Hz)			
	Room A		Room B	
	Open eyes	Closed eyes	Open eyes	Closed eyes
AF3	11,30	10,25	11,80	10,38
F7	11,00	10,25	8,75	10,25
F3	9,25	10,25	10,50	10,38
FC5	11,25	10,25	9,50	10,25
T7	11,38	10,25	11,75	10,13
P7	11,25	10,25	10,00	10,25
O1	11,50	10,25	10,13	10,38
O2	11,13	10,50	10,25	10,63
P8	11,13	10,38	10,25	10,63
T8	11,00	10,50	10,38	10,50
FC6	11,00	10,38	10,50	10,50
F4	11,63	10,25	12,00	10,50
F8	10,75	10,38	10,50	10,50
AF4	10,88	10,25	12,00	10,50

TABLE 2 shows the peak alpha frequency values for all subjects. Overall there is no significant difference from all conditions in the two rooms with values in the range of 8.75 Hz – 11.80 Hz. This shows that the external magnetic field from electronic devices around the EEG does not significantly affect the alpha frequency's peak value.

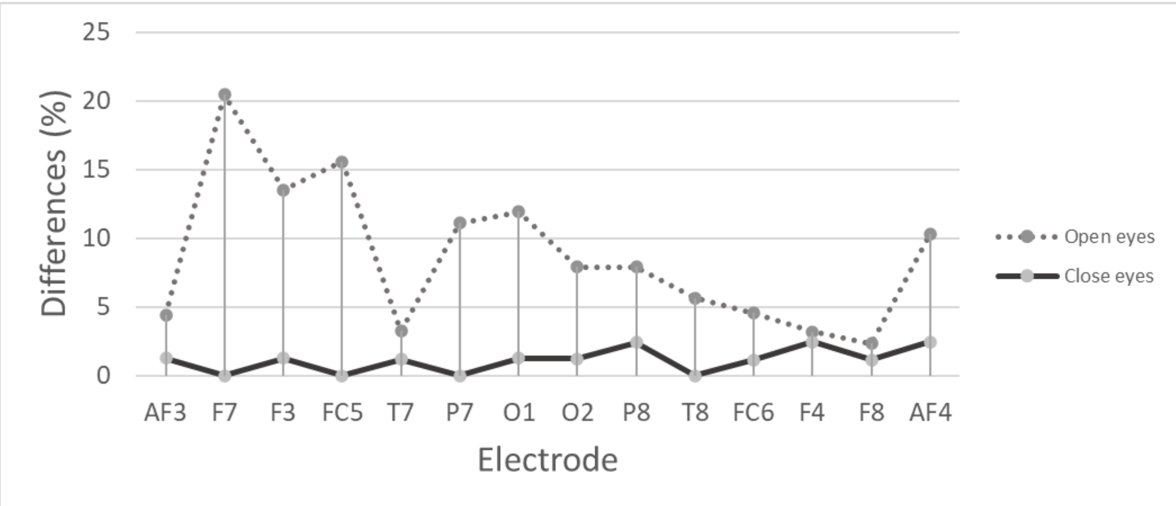

FIGURE 5. The difference in the average value of the alpha wave peak at each electrode

The average value of the peak alpha frequency in the open eyes condition in both rooms is shown on the dotted line. In comparison, the average value of the peak alpha frequency in the closed eyes condition in both rooms is shown on the solid line. In FIGURE 5, the average value of the peak alpha frequency in the open eyes condition has a significant difference compared to the closed eye condition. The highest difference was at the F7 electrode located in the left frontal area of 20,45% in the open eye condition. While in the closed eye condition, the highest percentage difference was at the F4 and AF4 electrodes with a value of 2.44%. In general, the electrodes in the brain's left hemisphere have a more significant difference than the electrodes in the right hemisphere.

CONCLUSION

The magnetic field value measured in a room with a Faraday cage is smaller than a room without a Faraday cage by a difference of 2% to 15%. However, the difference in the magnetic field value originating from electronic devices around the subject does not significantly affect the EEG measurement results. The difference in the average peak value of the alpha frequency obtained is only in the range of 0 – 20.45%.

ACKNOWLEDGMENTS

The author would like to thank the Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, the 2021 Research and Community Service Program (PPMI Lit) for funding this research.

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