The Analysis of EEG Distribution for Human Brainwave due to Mobile Phone Usage

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Abstract. Brain is the most amazing thing that god create, without brain humans are just like living zombies. Brain generate electrical impulse that create brainwave. Therefore, from the brainwave there are four type of spectrum which are Delta, Theta, Alpha and Beta. Each spectrum has their own special meaning. For instance, there will be slight change in the brainwave pattern if that person answers a phone call. With the references of previous research, there is radiation in mobile phone that can cause headache. This headache can occur during the phone call. Thus, an experiment based on the different type of phone is conducted. In this research project, the different pattern of brainwave between answering phone call through GSM phone and smartphone are needed. This is to find out which phone give more radiation to the user. This experiment will take placed at one of the laboratories in the Faculty of Electrical and Electronic Engineering. Other than that, 20 subjects are needed for this experiment. The first step of this experiment is to collect data using EMOTIV Insight equipment. Next, the data is process in the SPSS and then, it will transfer to Microsoft Excel for better understanding of the result. In addition, the result obtain from this research project is that GSM phone cause more effect to the subject rather than smartphone. This is why nowadays, most of the people use smartphone compared to GSM phone. This because smartphone is user friendly and have less radiation.

1. Introduction

Brain is the essential part of each living thing in this world, especially human. Without brain, nothing can be done by us human. It is like a computer without a processor. Brain is the most important organ in our body and it sends signal to our body part. For example, if our hands touch a hot plate, brain will send a signal to our hands, so that the hands could lift up from the hot plate. Other than that, the human brain consists of several lobes, which is frontal lobe, temporal lobe, occipital lobe and parietal lobe [1-3]. The frontal lobe is in charge for or problem solving, judgment and motor function. Next,
the temporal lobe is implying memory and hearing while the function of occipital lobe is processing
the brain's visual system. The last lobe which is parietal lobe where it controls sensation, handwriting, and body position [1-2].

Brainwaves is an electrical impulse in the brain. In the scientific word it is actually when the neurons which is the brain cells, interact with one and other through trains of signal pulses that produce brainwaves [2, 5, 8]. The brain has 4 types of spectrums which are Delta (δ), Theta (θ), Alpha (α) and Beta (β). The Delta waves (δ) is in range of 0.5-4 Hz, usually the wave is presented when the human body is in deep sleep and may be pre-sent in the waking state. Besides that, Theta waves (θ) is in range 4-8 Hz and the wave is presented during the unconscious state or drowsy, creative inspiration and deep meditation [10]. Next, the Alpha waves (α) is in between range of 8-13 Hz and presented in state of re-laxed or reflecting without any attention or concentration while Beta waves (β) is in range of 14-26 Hz and it is presented in the state of human brain, when it is thinking, active attention, focus on the outside world, or solving concrete problems [3, 7, 9].

Nowadays people tend to forget that mobile phone has radiations that can affect to brainwaves and can interrupt in the daily life activity. The excessive usage of mobile phone can also lead to cancer, depression, cell division and induction to epilepsy. This is why a re-search have to be conducted to prevent awful thing happen to the body [4, 10].

2. Motivation
The human brainwave is hard to see with our naked eyes. Thus, Electroencephalogram (EEG) pattern is to be uses as the result. In order to get the result, power spectral density (PSD) have to be analyses. All the analysis in needed to see the different when a person is answering the phone between two type of mobile phone which is GSM phone and smartphone [5]. There are a lot of problem refer to head sickness for example migraine, sinus, and etc. By referring previous research, some of effect for above head sickness are Radio Frequency (RF) implementation which is through mobile phone. By that circumstances, it become invention for this re-search [9].

3. Methodology
The Figure 1 shows the block diagram of the whole research process. The first step in this research project is to collected data from the subjects for five minutes. This must be done in order to get the result. The Next step is to transfer the data that is downloaded from the cloud storage to the SPSS software. In the SPSS software the data is analyzed. Lastly, the analyzed data will be transfer to the Microsoft Excel to produce a bar and line graph.

![Figure 1. Flow diagram of methodology](image)

Form the Figure 2, Emotiv Insight is used on a male test subject using a smartphone to make a phone call. While in Figure 3 a female test subject is using a GSM phone to make a phone call. The different type of mobile phone is used to see whether there is different in the radiation to the brain and how it effects the human brainwave.

3.1. Subjects and Data Collection
In this research, raw data are requiring to be collect and assemble to fulfill the experimental requirement. This experiment will be recorded in the Artificial Intelligence Laboratory (E-MSP) under the Faculty of Electrical and Electronic Engineering in University Tun Hussien Onn Malaysia (UTHM) [7]. Thus, to collect the raw data EMOTIV Insight equipment is used based on the Figure 4. The raw data are to be collect from volunteer consist of male and female not less than 20 subjects [6]. The sub-jects involve in this experiment need to be in a healthy condition and are not on any medication [6]. The smartphone that are used in this research project is Huawei P8lite shown in the Figure 5. For the GSM phone, a Nokia 105 is chosen to be used in this research project and the picture is also shown in the Figure 5. The software that are used for the data collection is the EMOTIV Pure•EEG™ Raw EEG Software shown in Figure 6.

![Figure 2. Using EMOTIV Insight on test subject by using smartphone](image1)

![Figure 3. Using EMOTIV Insight on test subject by using GSM phone](image2)

![Figure 4. EMOTIV Insight equipment [15]](image3)

![Figure 5. Smartphone and GSM phone [13-14]](image4)

![Figure 6. EMOTIV Pure•EEG™ Raw EEG Software](image5)

3.2. Analysis of Result
Statistical Package for the Social Sciences (SPSS) is used in order to evaluate and testing the data. The SPSS software is used after an excel file is downloaded from the EMOTIV Pure•EEG™ Raw EEG cloud storage. The next step is all the Alpha bands from 20 subjects are to be transferred to the SPSS software. Only the perfect data will be selected from the download file which is zero until 128. In the Microsoft Excel software, a bar graph for each subject are produced. This is to see the pattern between all of them. Each graph consists of the Alpha, Beta, Delta and Theta of each subject. Next, a line graph of standard deviation is also produced in this software. Lastly, an average bar graph for Alpha wave for all 20 subjects are produced. The other waves such Beta, Delta and Theta are also produced. This step is also repeated for both GSM and Smartphone EEG wave [12].

3.3. Theoretical Statistical Analysis

3.3.1. Descriptive Analysis. The meaning of descriptive analysis is that it summarizes the data set which can represent the whole data. In addition, the descriptive analysis can summarize the minimum and maximum value of the data set. It also can calculate the mean or the average value of the data. Last but not least, standard deviation and variance of the data also can be summarizing. This descriptive analysis on SPSS really helps the user to do their analysis of data if they have larger data since it helps to minimize the calculation error if doing it manually. The standard deviation, σ and variance, σ² can be calculated by using formula (1) and (2).

\[
\sigma = \sqrt{\frac{\sum(x-x)^2}{n-1}}
\]

(1)

\[
\sigma^2 = \frac{\sum(x-x)^2}{n-1}
\]

(2)

Where,
- \(\Sigma\) means the sum across the values
- \(x\) = each data in the data set
- \(x\) = the mean or average of data
- \(n\) = the number of the data set

3.3.2. Descriptive Statistic. Descriptive statistics are brief descriptive coefficients that summarize a given data set, which can be either a representation of the entire population or a sample of it. Descriptive statistics are broken down into measures of central tendency and measures of variability, or spread. Measures of central tendency include the mean, median and mode, while measures of variability include the standard deviation or variance, the minimum and maximum variables, and the kurtosis and skewness. All descriptive statistics, whether they be the mean, median, mode, standard deviation, kurtosis or skewness, are either measures of central tendency or measures of variability. These two measures use graphs, tables and general discussions to help people understand the meaning of the data being analyzed.

3.3.3. Spectral Analysis. Spectral analysis or Spectrum analysis is analysis in terms of a spectrum of frequencies or related quantities such as energies and eigenvalues. Spectral analysis is a means of investigating signal’s spectral content. It is used in: optics, speech, sonar, radar, medicine, seismology, chemistry and radio astronomy. There are two types of the spectral analysis which are nonparametric this is the classic one and parametric which is the modern one. Among the most popular and versatile of all measurement tools, the spectrum analyzer measures the magnitude of an input signal versus frequency. Its primary use is to measure the power of the spectrum of known and unknown signals. By comparison, the vector signal analyzer measures the magnitude and phase of an input signal within the analyzer’s intermediate-frequency (IF) bandwidth. It is typically used to make in-channel
measurements, such as error vector magnitude, code domain power, and spectral flatness, on known signals. Frequency-domain measurements (spectrum analysis) are made with either a fast-Fourier transform (FFT) analyzer or a swept-tuned receiver. The FFT analyzer takes a time-domain signal, digitizes it using digital sampling, and then applies the mathematics required to convert it to the frequency domain. The result is displayed as a spectrum. With its real-time signal analysis capability, the analyzer can capture periodic, random, and transient events and can measure phase and magnitude.

**Figure 7.** Subject individual graph for Smartphone
4. Results and Discussion

4.1. Graph Analysis

4.1.1. Graph Analysis. Figure 7 shows the Power Spectral Density (PSD) for each subject that used smartphone during the experiment. While Figure 8 is the PSD for each subject that used GSM phone during the experiment. These PSD shows all the sub band for each subject individually. Each subject has their own unique pattern of brainwave. But there is some similarity of the brainwave pattern during the phone call.

4.1.2. Percentage of Highest Sub Band. Based on the Figure 7, a highest sub band for smartphone is concluded. The bar graph above is based on the five minutes of the subject talking time on the smartphone. Thus, from the Figure 9, 40 percent of the highest sub band is Theta. This conclude that talking on the phone do have side effect on the brainwave. Next, 30 percent of the highest sub band is Alpha. 20 percent is Delta while another 10 percent is Beta.
As shown in the Figure 8, a highest or dominant sub band in GSM Phone is concluded. The bar graph above is the result from the five minutes’ call using a GSM phone. From the Figure 10, 60 percent of the highest sub band is Theta. This show that Theta in GSM phone is higher than smartphone. Other than that, 20 percent of the highest sub band is Delta. While 10 percent of the highest sub band is Alpha and Beta.

So, from the comparison dominant sub band GSM phone and smartphone the Theta for GSM phone high because of the radiation it produces. Based on the Figure 11, GSM phone produce more radiation compared to smartphone. This is because the Theta produce in GSM phone is 20 percent higher than the Theta produce in smartphone. Other than that, the Alpha in GSM phone are also higher than smartphone which is also 20 percent higher. The Beta and Delta of both mobile phones are the same which is 10 percent and 20 percent respectively.

4.1.3. Standard Deviation for Smartphone. From the Figure 12 (a) standard deviation of Alpha wave is shown. While Figure 12 (b) shows the standard deviation of Beta for all subject. Next, Figure 12 (c) shows the standard deviation of Delta. Figure 12 (d) shows the standard deviation of Theta. Based on the Figure 12, subject number three maybe have a severe headache during the phone call session. This is because all of the waves are very high compared to the others.
4.1.4. Standard Deviation for GSM Phone. From the Figure 13 (a) standard deviation of Alpha wave is shown. While Figure 13 (b) shows the standard deviation of Beta for all subject. Next, Figure 13 (c) shows the standard deviation of Delta. Figure 13 (d) shows the standard deviation of Theta. From all of the graph shown in Figure 13, subject number nine have high reading for Alpha and Delta compared to the other subject. The subject also has slightly higher Beta and Theta. This is because the subject has headache during the phone call experiment. Subject number six also have higher Alpha, Beta, Delta and Theta compared to the other subject. This is due to headache that the subject has during the phone call experiment. This prove that mobile phone emits radiation and effect the brainwave. Based on Figure 20 and Figure 13, GSM phone effect more people compared to smartphone. Only one person is affected by the radiation emits from the smartphone.

4.2. Positive Distribution comparison between GSM phone and Smartphone

Figure 14 show the positive distribution of GSM phone while Figure 15 shown positive distribution of smartphone. As can be seen, positive distribution of Delta in GSM phone and smartphone are the same with the percentage of 60. Meanwhile positive distribution of Theta in GSM phone is slightly lower than smartphone by 10 percent. Theta in GSM phone and smartphone are 70 percent and 80 percent.
respectively. Next, the positive distribution for Alpha in GSM phone is 40 percent while in smartphone is 50 percent. This means Alpha in GSM phone is lower by 10 percent. The Beta in smartphone is 70 percent while in GSM phone is 60 percent. In other words, Beta in smartphone is higher than in GSM phone. As can be seen through these both graphs, the positive distribution is more produced by the smartphone compare to GSM phone. This is believed to occur due to less radiation to the brainwave.

![Figure 14. Positive distribution of GSM phone](image)

![Figure 15. Positive distribution of Smartphone](image)

5. Conclusion
As a Conclusion, this research project is about how the radiation of two difference type of mobile phone will affect the user. The two types of phone are smartphone and GSM phone. Thus, the experiment conducted on 20 subjects which consist of 9 males and 11 females. The experiment lasted for five minutes on each subject. And the subject is required to answer the phone call on the right side of their ears. This is because the right side of the ears have much more effect rather than the left side of the ears [4], [11]. In addition, answering phone call do affect EEG pattern of the subject. From this research project, it is acknowledged that GSM phone emits more radiation compared to smartphone. Lastly, smartphone produced more positive distribution compared to GSM phone.

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