Study & Analysis of Brainwave Asymmetry Influenced by Radio Frequency Waves Emitted by Mobile Phones at Different Charging levels of Battery using EEG

Anjali Pandey[1], Satyarth Tiwari[2], Suresh Gawande[3]
[1]*Research Scholar, RKDF College of Engineering, RGPV, Bhopal*
[2]*Assistant Professor, RKDF College of Engineering, RGPV, Bhopal*
[3]*Assistant Professor, Bhabha Engineering and Research Institute, RGPV, Bhopal*

Abstract- **A mobile phone, also known as cell phone or hand phone is among the most popular electrical devices used by people all over the world. During recent years, the use of mobile phones has increased substantially and longtime exposure to the electromagnetic fields produced by them and their base stations is a matter of concern. So it has become very important to study the effect of radiations emitted by mobile phone on human head. Brainwaves due to numerous neurons are a kind of electrical activity. This electrical activity of brain can be recorded with the help of polysomonography EEG (electroencephalogram) machine.**
EEG is used to acquire the brain signals. Brain signals are measured by placing electrodes on the scalp. These EEG signal give the micro voltage difference between different parts of brain in a non-invasive manner. The brain activity measured in this way is being currently analyzed for a possible diagnosis and psychiatric diseases. This research discussed on the analysis conducted to study the effect of mobile phone at different charging levels on human brain. The experiment was conducted in a laboratory using. This discusses the effect of EM radiations emitted from mobile phone (GSM GT S7392) at high battery level and at low battery towards human brain. Electroencephalogram machine is used to monitor and capture the brain signals at different stimuli. The signals were obtained under four conditions. 1. Mobile phone ringing at high battery level 2. Call ongoing at high battery level 3. Mobile phone ringing at low battery level 4. Call ongoing at low battery level The signals obtained under four different conditions are analyzed and processed using different signal processing techniques. The experimental findings show that the effect of mobile emitted EM radiations is more intense at low battery level especially during ringing mode P3-O1 and T5-O1 channels are more affected and when call is ongoing then P4-O2 and T6-O2 channels are severely affected.

1. INTRODUCTION

Wireless technologies are ubiquitous now days and people are heading more towards this technology. Earlier we were using only the wired devices but now there is a move away from the wired phones. The familiarization and dependency on mobile phone is increasing day by day. Cellular systems have experienced exponential growth over last decade and there are currently many billion users worldwide. Mobile phones have been an important tool and a part of everyday life not only in developed countries but its use and craze is also increasing in developing countries. A cellular phone is a low power, single-channel, two-way radio. EMFs emitted by cell phones are harmful for the human brain and it is more pronounced in children than adults, indicating that the children may be more vulnerable to the adverse health effects of mobile phones than adults, probably because absorption of microwaves is greatest in an object about the size of a child's head. The radiation can penetrate the thinner skull of an infant with greater ease. Cell phone frequencies vary according to the system used ranging around 900 or 1800 MHz and 2200 MHz [Universal Mobile Telecommunication System (UMTS)].While using mobile phone, electromagnetic wave is transferred to the body which causes health problems especially as the place near ear skull region where they are known to affect the neurons.

Neutrons are the cell in the brain through which information get transfer in the brain. There are

millions and millions of neurons present in the brain which is the most important part of the brain. The radiations interfere with the electrical impulses that two neurons connect each other with. The research done before shows that the effect of GSM technology on brain is more than CDMA technology and in GSM technology, the effect of 2G is more than3G.In this thesis, we have conducted a study to reduce the effect of electromagnetic radiation on human brain from mobile phone when we used Bluetooth headset and earphones. Bluetooth is a technology in today's tech world which easily allows you to communicate wirelessly anywhere & anytime. Earphone is a wired device which plug in to the mobile phone to provide mobile phone user talk hand-freely. Brain activity is studied in terms of biomedical signals acquired throughelectroencephalography.
Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain.

The method that is used here for EEG signal processing can be divided into two steps:

1) EEG signal acquisition 2) EEG signal analysis

1.1 MOBILE PHONE TECHNOLOGIES

1.1.1GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

GSM (Global System for Mobile Communications), is a standard set developed by the European Telecommunications Standard Institute (ETSI) to describe technologies for second generation (or "2G") digital cellular networks.

1.1.1.1 COMPONENTS AND PROCESSES OF GSM

- Basic Components of GSM - MS/SIM/ME/BTS/BSC - MSC/VLR/HLR/IN/AuC/EIN
- Basic Process of GSM - Handover - Paging - Location updating - Incoming/outgoing Call
- MS Mobile Station
- SIM Subscriber Identity Module
- BTS Base Transceiver Station
- BSC Base Station Controller
- HLR Home Location Register
- VLR Visitor Location Register
- AuC Authentication Centre
- IN Interrogating Node

1.1.1.2 The GSM System

1.1.1.3 GSM Processes

1) Handover: Handover is the means of maintaining a call when a user moves outside the coverage area of the serving BTS.
2) The call must be switched to an alternative BTS to provide service, automatically and without loss of service.
3) Handover is complex process requiring synchronization of events between the mobile station and the network.
4) Incoming Call: An incoming call is presented to the Gateway MSC- one containing the Interrogating Node. The IN determines the HLR from the Mobile Subscriber ISDN number and requests routing information from the HLR towards the MSC/VLR where the mobile was last located. The MSC/VLR pages the mobile and if this is in range it responds to the page and requests a radio channel. The MSC/VLR authenticates the MS and sets and ciphering. The bearer is now established and the alerting signal can be activated on the mobile.
5) Outgoing call: An outgoing call begins when the user dials a number and presses send. The MS then requests a radio channel. The Local MSC/VLR authenticates the MS and establishes a radio channel with ciphering. The call is routed in accordance with the dialed number and the MSC/VLR maintains the charging records.

1.2 INTRODUCTION TO EEG

1.2.1 EEG Characteristics

In this section we introduce the main characteristics of EEG signals. The EEG is a measure of voltage as a function of time. The voltage of the EEG determines its amplitude (measured from peak to peak). EEG amplitudes in the cortex range from 500-1500 μV, however, the amplitudes of the scalp EEG range between 10 and 100 μV . The attenuation is due to the poor electrical conductivity of brain tissues, skull and scalp. In general, EEG signals represent the combination of waveforms, and are generally classified according to their:
a) Frequency (speed);
b) Amplitude (power);

c) Wave morphology (shape);
d) Spatial distribution (topography);
e) Reactivity (behavioral state);

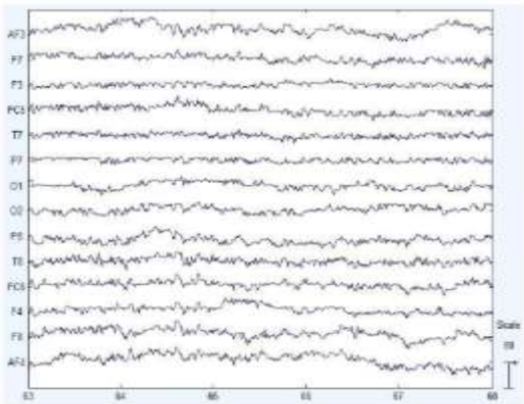

Figure 1: Raw EEG data without the baseline, amplitude scale is set to 80 µV.

1.2.2 EEG artefacts and their prevention

Unfortunately, EEG is often contaminated by signals that have non-cerebral origin and they are called artefacts, which are caused by eye movement, eye blink, electrode movement, and muscle activity, movements of the head, sweating, breathing, heartbeat, and electrical line noise and so on. This is one of the reasons why it takes considerable experience to interpret EEG clinically, because artefacts might mimic cognitive or pathological activity and therefore distort the analysis or completely overwhelm the EEG waves and make the analysis impossible. However, some artefacts can be informative as unique biometric identifiers.

All EEG artefacts can be divided in two main groups:
1. Physical world (technological) artefacts:

a. Movement of the EEG sensors
b. 50/60 Hz AC power sources
c. Fluctuations in electrical resistance
d. Contact and wire quality
e. Dirt
f. Low battery of the headset

2. Artefacts of a user's physiological origin:

a. User's heart rate and innervation (can be used as a biometric identifier)
b. Physical movements (can be used as a biometric identifier)
c. Eye movements (can be used as a biometric identifier)
d. Sweating

2. LITERATURE REVIEW

Dayang Azra, Awang Mat et al. (2009) had done the research work on "The effect of Bluetooth Headset and Earphone on Reducing Electromagnetic Radiation from Mobile phone towards Human Head". In this research work thermal imaging technique is used to detect the effect of electromagnetic radiations from mobile phone serving GSM 900 and GSM 1800 on human brain. This technique is used to measure and capture the temperature distribution during the experimental analysis for every 5 minutes interval. Bluetooth headset and earphone are used to study whether these devices are able to reduce effect of radiations on human brain. There are two types of mobile phone, one with internal antenna and other with external antenna. The result shows that at 900 MHz frequency, mobile phone serves highest thermal radiation with almost 38.3ºC. When using Bluetooth headset or earphone, it can be seen that the thermal radiation is reduced. Thermal radiation pattern operating at frequency 1800 MHz is shown. It is almost similar as of mobile phone operating at 900 MHz except the highest temperature is only 37.5 MHz. In this case too, when Bluetooth headset and earphone are used the effects of electromagnetic radiations are reduced. This shows that the radiation for mobile phone operating at 1800MHz is lower compare to mobile phone operating at 900 MHz.

Heow Pueh Lee*, Siak Piang Lim et al.(2014) conducted study on Comparative studies of perceived vibration strength for commercial mobile phones shows Among the five mobile phones for the survey, most of the student volunteers or participants felt that product E and product C had better vibration perception than the remaining phone models, be it holding in palms or putting in their pockets. Product A had the weakest vibration perception level when putting inside the pocket. Product E had the highest peak acceleration as well as inertial force among the five phone samples. This was probably the reason why it was consistently ranked as the phone which gave the strongest vibration alert. The student volunteers in general felt that mobile phone placed inside pocket would result in lesser vibration perception as compared to mobile phones held in palms. Both product A and product B had the lowest peak acceleration as well as inertia force values among the five mobile phone models. This was the reason why both of these mobile phones had the lowest vibration perception among all five mobile phones.

Christoph Augner, Timo Gnambs, Robert Winker, Alfred Barth et al (2012) study acute effects of electromagnetic fields emitted by GSM mobile phones on subjective wellbeing and physiological reactions: A meta-analysis gives provides evidence that short term exposure of RF-EMF emitted by mobile phones do not affect well-being and related parameters. We found no impact on headaches, nausea, fatigue, dizziness, skin irritation, blood pressure, heart rate, heart rate variability and skin resistance, or respiration. Additionally, there was no evidence that subjects were able to detect RF-EMFs under blind experimental conditions. The results of our meta-analysis are supported by previous reviews. Rubin et al. (2010) and Roosli (2008) identified 7 and 6 studies, respectively dealing with 'mobile phone handset experiments. All but one of these studies was included in our meta-analysis.

Although only one study (Hillert et al., 2008) found a significant effect for headaches it is intriguing that despite the small number of studies and the short exposure duration the overall meta-analytical effect for headaches was 0.08 with a standard error of 0.05.

V.I. Thajudin Ahamed, N.G. Karthick, Paul K. Joseph(2007) study Effect of mobile phone radiation on heart rate variability on Neurological effect of the electromagnetic field emitted from MP, using HRV measures is examined. The indices, namely sample entropy and scaling exponent, indicate an increase when MP is placed near the chest and a decrease when MP is placed near the head. It can be concluded that the variation is not significant as the 'p' value is high, compared to 'without MP condition'. This might be because MPs emit very low power to cause any detectable heart rate variation, when the user is not communicating. In order to get more insight into the neurological effect of radiation from MP, more studies may be conducted with more number of subjects.

3. EEG SIGNAL ACQUISITION & ANALYSIS

3.1 INTRODUCTION TO EEG SIGNAL ACQUISITION & ANALYSIS

The Electroencephalogram (EEG) is defined as a technique which provides measurement of the electric activity is the brain, translating the chemical currents into voltage recordings.In this technique, electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media. The medical imaging technique that reads scalp electrical activity generated by brain structures is called Electroencephalography. The EEG measured directly from the cortical surface is called Electrocardiogram while when using depth probes it is called Electro gram. It has high temporal resolution in that it is able to characterize fast changes in current flows, but poor spatial resolution because measurements are limited by the number of electrodes, their placement and properties of the head.

3.2 ANATOMY OF HUMAN BRAIN

The average human brain weights around 1400 grams. From the anatomical point of view, the brain can be divided into three sections: Cerebrum Cerebellum Brain Stem.

Parts of the Brain and Their Functions:

The human brain is a specialized organ that is ultimately responsible for all thought and movement that the body produces. Many different parts of the brain and their functions are shown in the article. Each part has a unique function that allows humans observe and interact with their environment effectively.

The main human brain part cerebrum is divided into the left and right hemispheres. They are linked by a central processing unit called the corpus callosum. Cerebellum is responsible for the balance and muscular co-ordination, but its activity cannot be measured by available EEG headsets. Each hemisphere is split into four more compartments:

1) Occipital lobe (back part of the brain) is responsible for the visual imagination and responds to visual stimuli. This part is the most efficient for biometric purposes. This part is recognized as the most effective in terms of extracting biometric data.

2) Temporal lobe is involved in the organization of sound, memory, speech, and emotional responses.
3) Parietal lobe handles sensations, such as touch, body awareness, pain, pressure, and body temperature, as well as processes spatial orientation tasks.
4) Frontal lobe is considered the home of our personality. The highest part of the frontal lobe is involved in solving problems, activating spontaneous responses, retrieving memories, applying judgment, and controlling impulses. It also controls our social and sexual behaviour.It has already been proved that some of the EEG parameters extracted from the frontal lobe are highly personal-dependent.

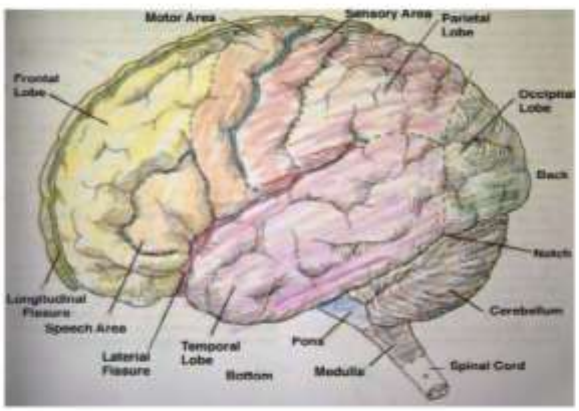

Figure 1: Structure of Brain

3.3 ELECTRIC ACTIVITY IN BRAIN

EEG is the recording of the potentials generated inside the brain. The generation of this potential comprises of a biomedical process. When brain cells (neurons) are activated, local current flows are produced. EEG measures mostly the currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. Differences of electrical potentials are caused by summed postsynaptic graded potential from pyramidal cells that create electrical dipoles between soma (body of neuron) and apical dendrites (neural branches). Brain electrical current consists mostly of Na+, K+, Ca ++, and C1- ions that are pumped through channels in neuron membranes in the direction governed by membrane types of synapses involving variety of neurotransmitters. Only large populations of active neurons can generate electrical activity recordable on the head surface. Between electrode and neuronal layers current penetrates through skin, skull and several other layers. Weak electrical signals detected by the scalp electrodes are massively amplified, and then displayed on paper or stored to computer memory. Due to capability to reflect both the normal and abnormal electrical activity of the brain, EEG has been found to be a very powerful tool in the field of neurology and clinical neurophysiology.

3.4 EEG RECORDING AND MEASUREMENT

EEG instruments used to acquire date are of two kinds: Analogue EEG instrument and digital EEG instruments. Conventional analogue instruments consist of an amplifier, a galvanometer and writing device The conversion from analogue to digital EEG is performed by means of multichannel analogue-to-digital converters (ADCs). Fortunately, the effective bandwidth for EEG signals is limited to approximately 100 Hz.

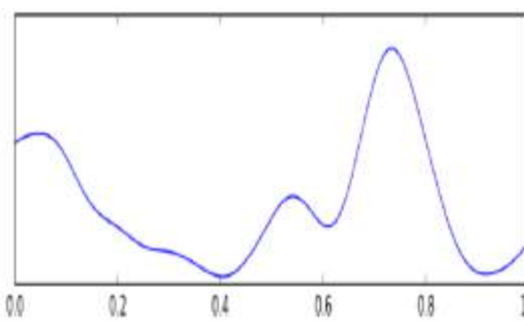

Figure 2Analogue waveform [30]

The EEG recording electrodes and their proper function are crucial for acquiring high quality date. Different types of electrodes are often used in the EEG recording systems as:

- Disposable (get-less, and pre-gelled types);
- Reusable disc electrodes (gold, silver, stainless steel, or tin);
- Headbands and electrode caps;
- Saline-based electrode;
- Needle electrodes.

Acquire is used to record the signals and BP LONGITUDINAL1(R) configuration for montage is set for conducting this study. The setting of montage used in this study for the signal acquisition has been shown in Figure 3. This configuration has 16 electrodes. Analysis Software is used to analyse the signals so acquired.

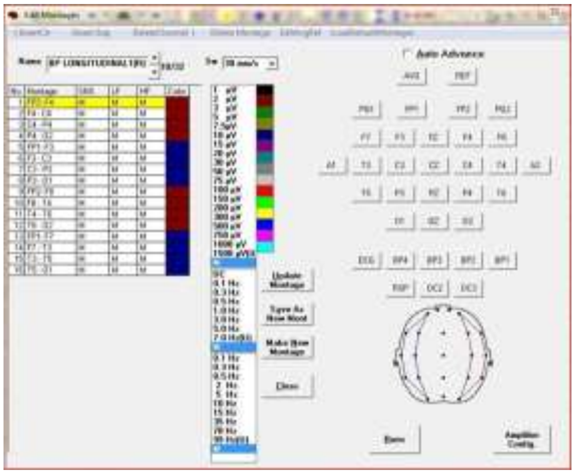

Figure 3.: Montage setting for EEG Signal Acquisition [28]

The channels with even numbers correspond to right hemisphere of brain and the one with odd numbers correspond to left hemisphere of brain. The letters F, P, T and O correspond to Frontal, parietal, Temporal and Occipital region of brain respectively. The regions of brain corresponding to channels on EEG montage are shown in Fig

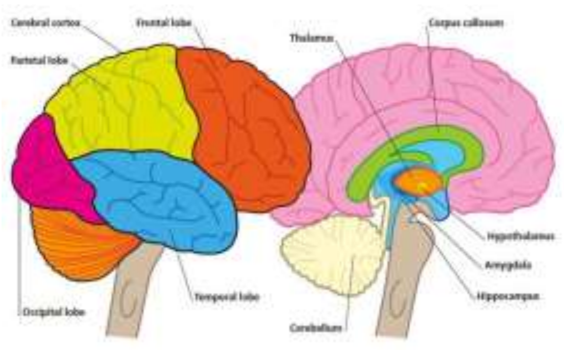

Fig 4 Regions of Brain

The EEG signals are time varying continuous signals as shown in Figure 5. These signals are recorded in Acquire software and are automatically stored in Analyses software where further analyses of the recorded signals can be done.

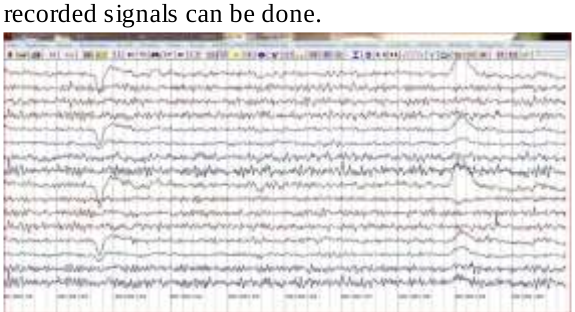

Figure 5: Recording of EEG Signal in Acquire Software.

3.5 ANALYSIS OF EEG SIGNAL

3.5.1 SELECTION OF CHANNELS FOR ANALYSIS BP LONGITUDINAL 1(R) setting of Montage has 16 channels. Out of 16 channels, the maximum effected 4 have been chosen for analyses after calculating the maximum PSD value for each channel and comparing it with all other channels which are:

1) P4-O2
2) P3-O1
3) T5-O1
4) T6-O2

The first two channels are between the parietal lobe and occipital lobe and second two channels are between temporal lobe and occipital lobe. Phone and Bluetooth headset are held on left ear by the subject for the various cases.

3.5.2 SAMPLE RATE the "Sample rate" value indicates how many samples the RMS 32 should acquire per second on each channel during data acquisition. The default Sample Rate is 121 Hz, but can be changed by clicking on the pull-down menu. In this work 128 is used as a sample rate. Depending on the nature of the data being acquired, the "best" choice for Sample Rate will vary.

3.5.3 ACQUISITION LENGTH There is no limit on how long a signal can be recorded. Clinical application require a recording time of 40 to 45 minutes. Even overnight recording is also desired sometimes while studying sleep stages. In this study duration of 10 minutes has been used as recording period.

3.5.4 SIGNAL PROCESSING EEG signal processing is of importance not only to the physiologist conducting research and the clinical treating patients but also to the biomedical engineer who is required to process and interpret the physiological signal by designing system and algorithms for their manipulations.

4. RESULTS AND DISCUSSIONS

4.1 SIGNAL PROCESSING TECHNIQUES

To examine the effect of electromagnetic radiations on human brain digital signal processing techniques are applied. The signals obtained are analysed using digital signal processing techniques like power spectral density, autocorrelation, Fast Fourier transform. Fast Fourier transform is calculated to obtain the power spectrum density of the acquired electrical signals originated in the brain in response to the stimuli impinged in the form of radiations emitted by the mobile phone at high battery level and at low battery level. Various signal processing techniques like autocorrelation, cross correlation, power spectral density, average, and max & min operations are used.

4.1.1 AUTOCORRELATION

Autocorrelation refers to the correlation of a time series with its own past and future values. Autocorrelation is also sometimes called "lagged correlation" or "serial correlation", which refers to the correlation between members of a series of numbers arranged in time. Positive autocorrelation might be considered a specific form of "persistence", a tendency for a system to remain in the same state from one observation to the next. Autocorrelation can be exploited for predictions: an auto correlated time series is predictable, probabilistically, because future values depend on current and past values. Autocorrelation is the similarity between observations as a function of the time lag between them.

4.1.1.1 Time series plot

Positively auto correlated series are sometimes called persistent because positive departures from the mean tend to be followed by positive departures from the mean, and negative departures from the mean tend to be followed by negative departures. In contrast, negative autocorrelation is characterized by a tendency for positive. Departures to follow negative departures, and vice versa. Positive autocorrelation might show up in a time series plot as unusually long runs, or stretches, of several consecutive observations above or below the mean. Negative autocorrelation might show up as an unusually low incidence of such runs.

4.1.1.2 Lagged scatter plot

The simplest graphical summary of autocorrelation in a time series is the lagged scatter plot, which is a scatter plot of the time series against itself offset in time by one to several time steps. Let the time series of length N be , where i= 1... N. The lagged scatter plot for lag k is a scatter plot of th the last N -k observations against the first N - k observations. For example, for lag 1, observations x2,x3,x4…….xN are plotted against observations x1,x2,x3,…..xN-1. A random scattering of points in the lagged scatter plot indicates a lack of autocorrelation. Such a series is also sometimes called "random", meaning that the value at time t is independent of the value at other times.

4.1.1.3 Autocorrelation function (correlogram)

An important guide to the persistence in a time series is given by the series of quantities called the sample autocorrelation coefficients, which measure the correlation between observations at different times. The set of autocorrelation coefficients arranged as a function of separation in time is the sample autocorrelation function, or the acf. An analogy can be drawn between the autocorrelation coefficient and the product moment correlation coefficient.

4.1.2 CROSS CORRELATION

The cross-correlation (CC) function represents the similarity of two signals as a function of a time-lag applied to one of them. It is also known as sliding dot product. Usually it is used to find occurrences of a known signal's sequence in an unknown one

4.1.3 POWER SPECTRAL DENSITY

Power Spectral Density (PSD) is the frequency response of a random or periodic signal. It tells us where the average power is distributed as a function of frequency. The PSD is deterministic, and for certain types of random signals is independent of time. This is useful because the Fourier transform of a random time signal is itself random, and therefore of little use calculating transfer relationships (i.e., finding the output of a filter when the input is random). The PSD of a random time signal x(t) can be expressed in one of two ways that are equivalent to each other:

4.1.4 MIN & MAX

This gives us the minimum and maximum values of the given data. PSD of continuous Analogue EEG signal is a set of approx. 1000 values. Min & Max function gives o/p out of large set of data.

4.1.5 COHERENCE

Coherence is a linear correlation measure between two signals represented as a frequency function. It uncovers the correlation between two signals at different frequencies and is often applied for the EEG signal analysis at hospitals.

In our case, the EEG feature is represented by a set of points of the coherence function. The values x and y are de-trended and filtered raw EEG values in microvolts (μ) from two different electrodes. This function should be applied to all pairs of the data from EEG electrodes. Thus, if the number of electrodes exceeds, the size of the feature table exceeds exponentially. So we must keep in mind that we have to limit the number of sensors for the coherence analysis.

TABLE 1 AUTOCORRELATION VALUES OF SUBJECT FOR P3-O1 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.845056528
SUB1	SUB3	0.705127255
SUB1	SUB4	0.868334929
SUB1	SUB5	0.859973398
SUB2	SUB3	0.649742631
SUB2	SUB4	0.831482316
SUB2	SUB5	0.876267703
SUB3	SUB4	0.818628465
SUB3	SUB5	0.595567117
SUB4	SUB5	0.776518764

TABLE 2 AUTOCORRELATION VALUES OF SUBJECT FOR P4-O2 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.746343014
SUB1	SUB3	0.664698088
SUB1	SUB4	0.88892281
SUB1	SUB5	0.886236502
SUB2	SUB3	0.345691453
SUB2	SUB4	0.603732296
SUB2	SUB5	0.58594325
SUB3	SUB4	0.826609856
SUB3	SUB5	0.76878633
SUB4	SUB5	0.918903109

TABLE 3 AUTOCORRELATION VALUES OF SUBJECT FOR T5-O1 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.846135378
SUB1	SUB3	0.700058003
SUB1	SUB4	0.789093562
SUB1	SUB5	0.913929733
SUB2	SUB3	0.636104592
SUB2	SUB4	0.709752419
SUB2	SUB5	0.881125885
SUB3	SUB4	0.868574938
SUB3	SUB5	0.700306259
SUB4	SUB5	0.799305084

TABLE 4 AUTOCORRELATION VALUES OF SUBJECT FOR T6-O2 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.892396041
SUB1	SUB3	0.497319256
SUB1	SUB4	0.919408069
SUB1	SUB5	0.881783776
SUB2	SUB3	0.540396923
SUB2	SUB4	0.82958905
SUB2	SUB5	0.868900271
SUB3	SUB4	0.616410643
SUB3	SUB5	0.737587585
SUB4	SUB5	0.887476509

TABLE 5 AVERAGE AUTOCORRELATION VALUES OF SUBJECT FOR THE FOUR CHANNELS HIGH BATTERY RINGING MODE

CHANNELS	AVERAGE CORRELATION(HIGH BATTERY RINGING)
P3-O1	0.782669911
P4-O2	0.723586671
T5-O1	0.784438585
T6-O2	0.767126812

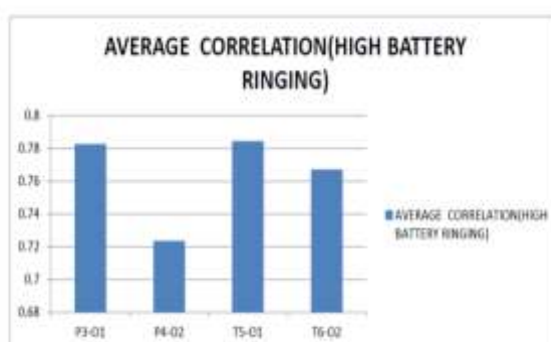

FIGURE 6 PLOT OF AVERAGE AUTOCORRELATION VALUES OF SUBJECT

FOR THE FOUR CHANNELS HIGH BATTERY RINGING MODE

4.3 RESULT OF ANALYSIS

EEG signals obtained under four different conditions are firstly analysed with digital signal processing techniques like autocorrelation, cross correlation, PSD and max & min operations.

The different parameters of EEG machine were set as follows: Low filter
1 Hz High filter
70 Hz Notch filter
50 Hz Sensitivity
7.5 µV/mm Sweep speed
30 mm/sec Number of channels
16 Impedance limit
50KOhms Montage BP Longitudinal
1(R).

The correlation coefficient for the Scatter plot summarizes the strength of the linear relationship between present and past values. The value of correlation coefficient lies between 0-1. A value close to 1 is desired. Autocorrelation of brain activity for different subjects for the same channel for four modes of communication shows the correlation values of channels of all subjects.

By observing autocorrelation values, we conclude that the impact of radiation is not same at all the areas of brain. This very fact indicates the variable impact of radiations on our brain cells. As we can see from the table's 1-4 that the value of autocorrelation is greater than 0.6 for most of the channels. In most of cases it lies between 0.7-0.9. This indicates a strong linear relationship between present and past values. It is concluded that it is more dangerous to use mobile phone when its battery is at low level. When it is in ringing mode, at low battery, P3-O1 and T5-O1 channels (back-left part of brain) are more affected. When call is on-going, at low battery, P4-O2 and T6-O2 channels (back-right portion of brain) are severely affected. Mobile phone has its own advantages and disadvantages. Every new technology comes with some shortcomings. In this era of technology it is impossible to avoid the use of mobile phone. But scientists should take into account the harmful effects caused by radiations emitted by mobile phone and try to improve the mobile circuitry and antenna so that ill-effects of radiations on human biological system could be minimized. This paper presents a novel work for the betterment of human being.

5. CONCLUSIONS

After completing this research work it can be concluded that the mobile phone adversely affects the human brain. , we conclude that the impact of radiation is not same at all the areas of brain. This very fact indicates the variable impact of radiations on our brain cells. As we can see from the table 4.2.1-4.2.5 and figures 4.2.1-4.2.5 that the value of autocorrelation is greater than 0.6 for most of the channels. In most of cases it lies between 0.7-o.9. This indicates a strong linear relationship between present and past values. It is concluded that it is more dangerous to use mobile phone when its battery is at low level. When it is in ringing mode, at low battery, P3-O1 and T5-O1 channels (back left part of brain) are more affected. When call is ongoing, at low battery, P4-O2 and T6O2 channels (back-right portion of brain) are severely affected. Mobile phone has its own advantages and disadvantages. Every new technology comes with some shortcomings. In this era of technology it is impossible to avoid the use of mobile phone. But scientists should take into account the harmful effects caused by radiations emitted by mobile phone and try to improve the mobile circuitry and antenna so that ill-effects of radiations on human biological system could be minimized.

Vast technology in communication world has made mobile phone an important gadget for 21st century. Now-a-days it is very rare to see people not having a mobile phone and it shows mobile phone playing a vital role in everyday life. Teenager starts using cellphone at school level. With this increased popularity and demand of mobile phone has raised concern about possible interaction between the electromagnetic field radiation and human being. This has been found that EM radiations emitted by mobile phone can cause genetic damage, tumors, memory loss, increased blood pressure and weakening of the immune system, headache problem, increased heart attack rate, skin cancer, sleep disorder etc. This paper discusses on the analysis conducted to study the effect of EM radiations emitted from mobile phone (GSM GT S7392) at high battery level and at low battery towards human brain.

Electroencephalogram machine is used to monitor and capture the brain signals at different stimuli. Electroencephalography (EEG) signals provide valuable information to study the brain function and neurobiological disorders. Digital signal processing gives the important tools for the analysis of EEG signals. The EEG signal was collected from the standard data base. These EEG signals were not distinguishable with human eyes. We used the signal processing tools to distinct them and provide the status of the individual.

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