T.C.
FATIH UNIVERSITY
INSTITUTE OF BIOMEDICAL ENGINEERING

Assessment of Effect of the Alcohol on Brain Activity Using Electroencephalography

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MSc THESIS
BIOMEDICAL ENGINEERING PROGRAMME

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ASST. PROF. ŞÜKRÜ OKKESİM

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T.C.
FATİH ÜNİVESİTESİ
BİYOMEDİKAL MÜHENDİSLİK ENSTİTÜSÜ

Elektroensefalografı Kullanarak Alkolün Beyin Aktivitesi Üzerindeki Etkisinin Değerlendirilmesi

BURAK CEYLAN

YÜKSEK LİSANS
BİYOMEDİKAL MÜHENDİSLİĞİ PROGRAMI

DANIŞMAN
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İSTANBUL, JUNE / 2014

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Burak Ceylan, a **MSc** student of Fatih University **Institute of Biomedical Engineering** student ID **520112012**, successfully defended the **thesis** entitled "**Assessment of Effect of the Alcohol on Brain Activity Using Electroencephalography**", which he/she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To my Parents and Fiancee,

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May 2014 BURAK CEYLAN

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LIST OF SYMBOLS

α	Alpha
β	Beta
χ	Chi
δ	Delta
γ	Gamma
κ	Kappa
φ	Phi
σ	Sigma
τ	Tau
θ	Theta

ABBREVIATIONS

CNS : Central Nervous System
CT : Computerized Tomography
CWT : Continuous Wavelet Transform
DT : Decision Tree
DWT : Discrete Wavelet Transform
EEG : Electroencephalography
FMRI : Functional Magnetic Resonance İmaging
FSC : Fuzzy Sugeno Classifier
GMM : Gaussian Mixture Model
HCA : Hierarchical Cluster Analysis
HHT : Hilbert-Huang Transformation
IF : İnstantaneous Frequency
IMF : İntrinsic Mode Function
k- NN : k- Nearest neighbour
Mbps : Megabits per second
MF : Marginal Frequency
NBC : Naive Bayes Classification
PCA : Principle Compenent Analysis
PET : Positron Emission Tomography
PNN : Probabilistic Neural Network
PNS : Peripheral Nervous System
SPET : Single Photon Emission Tomography
St : Station
STFT : Short Time Fourier Transform
SWAT : Soil and Water Assessment Tool
UMN : University of Minnesota
VEP : Visual Evoked Potential
WPD : Wavelet Packet Decomposition

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SUMMARY

Assessment of Effect of the Alcohol on Brain Activity Using Electroencephalography

Burak CEYLAN

Biomedical Engineering Programme

MSc Thesis

Advisor: ASST. PROF. ŞÜKRÜ OKKESİM

EEG is a very useful signal in the field of neurology and clinical neurophysiology. Analyzing EEG signals scientist can evaluate the normal and abnormal electrical activity of the brain. In this thesis our aim is analyzing EEG signals to get new features which uses to evaluate the effect of alcohol on Brain activity. The frequency range involves 0,5-100 Hz. This range is divided into five because of various characteristics. EEG signal is evaluated according to frequency range not with shapes. There are five important brain wave with different frequency rates. These frequency ranges are alpha (α), beta (β), theta (θ), delta (δ) and gamma (γ) which have not a certain waveform.

Nowadays, alcohol is a substance that is consumed widely and makes people muddled up. It hinders the healthy thinking. Alcohol deranges the health physically. Besides, it affects negatively the mental health of the consumer of alcohol. It causes monetary loss and bad relationship with family and acquaintance. The order and serenity of society can get distorted. It promotes crime and increases crime rate. That is to say, the damages of alcohol can be held as physical and mental damages, damages to society and effects on family bounds, the increasing crime rate and traffic accidents with a broad perspective. We assessed the EEG marks of alcohol consumers with spectral analysis in this study. In control group with alcohol consumers, the analysis of EEG results is assessed by Fourier and Wavelet transform to understand whether the alcohol has effect or not. The effects of it on EEG signals are tried to be understood. Here, non-parametric Welch method is used to analyze and compare.

Keywords: EEG, Wavelet Transform, Fourier Transform, Matlab

ÖZET

Elektroensefalografı Kullanarak Alkolün Beyin Aktivitesi Üzerindeki Etkisinin Değerlendirilmesi

Burak CEYLAN

Biyomedikal Mühendisliği Programı

Yüksek Lisans

Danışman: YRD. DOÇ. DR. ŞÜKRÜ OKKESİM

EEG nöroloji ve klinik nörofizyoloji alanında çok yararlı bir sinyaldir. EEG sinyallerinin analizini bilim adamları beynin normal ve anormal elektriksel aktivitesini değerlendirebilir. Bu tezde amacımız EEG sinyallerini analiz ederek alkolün beyin üzerinde etkisi olup olmadığını değerlendirmekdir.

Frekans aralığı 0,5-100 Hz içerir. Bu aralık çeşitli özellikleri yüzünden beşe ayrılmıştır. EEG sinyallari şekillerinden ziyade frekans aralığına göre değerlendirilir. Bu frekans aralıkları alpha (α), beta (β), theta (θ), delta (δ) and gamma (γ) dır, bunlar belirli bir dalga formuna sahip değildir.

Günümüzde Alkol çok sık tüketilen, insanın zihnini bulandıran ve sağlıklı düşünmesine engel olan bir maddedir. İçen kişinin fiziksel sağlığını bozmasının yanında, ruhsal sağlığını da olumsuz yönde etkiler. Maddi olarak kayba uğratır. Ailesiyle ve sevdikleriyle sorunlar yaşamasına neden olur. Toplum yapısını ve huzurunu olumsuz etkiler. Yani, alkolün zararları fiziksel ve ruhsal zararlar, topluma zararları, aileye etkisi, suç oranlarını arttırması, trafik kazaları gibi çok geniş bir açıdan ele alınabilir.

Biz bu çalışmamızda alkol kullanan kişilerden alınan Elektroensefalogram (EEG) isaretleri, spektral analiz yöntemleri ile degerlendirilmistir. Alkollü ve kontrol grubumuzdaki kişilerde, EEG işaretlerinin Fourier ve Wavelet transform ile incelenmesi gercekleştirerek alkolün etkisinin olup olmayacağı ve EEG sinyallerinde ne gibi bir değişim etkisi yaptığı belirlenmeye çalışılmiştır. Burada parametrik olmayan Welch metodu kullanılarak analiz edilmiş ve karşılaştırılmıştır.

Anahtar kelimeler: EEG, Dalgacık Dönüşümü, Fourier Dönüşümü, Matlab

CHAPTER 1

INTRODUCTION

1.1 Literature Survey

For health and socioeconomic condition, alcohol consumption is among the most risky factors, especially for the ones having habit of drinking heavily [1].

Great number of researches have been carried out to point out relationship between alcholism and brain [2].

There are considerable amount of evidence to prove the relationship between epilepsy and alcoholism because of unprovoked epilepsy crisis [3].

Complexity and energy (power) analysis which were two distinctive methods were implemented to inspect the different EEGs of alcoholic and control subjects in this work by Tugce Balli et al [4].

Hayden et al. made use of EEG as a way of investigating the brain hemispheres'asymmetrical behaviours which was based on based on α-band (8-12Hz) showing differences conversely with cortical activity to find out infirmity to alcoholism in their study. In conclusion of that, they found that the subject with alcohol addiction showed less activeness in left anterior cortex than in the right [5-6].

The study conducted by Kok-Meng Ong, Kim-Han Thung, Chong-Yaw Wee and Raveendran Paramesran aims to classify alcoholics and non-alcoholics by using PCA in subset selection of EEG channels. A subset of channels is chosen to assess Visual Evoked Potentials (VEP). The study has revealed that long term alcohol use effects VEP. The estimation of VEP recording's power spectral density is accomplished by utilizing from Burg algorithm (parametric analysis). Furthermore, classification of the alcoholics and non-alcoholics was executed by and the extracted Gamma band power as traits to condition the neural network.

According to the authors of the study, the classification results of alcoholics and non-alcoholics have reached success with 97.50%. After presentation of single trial visual stimuli to the subjects, to classify alcoholics and non-alcoholics the electroencephalogram recordings were performed. In the end, the use of PCA to choose channels to classify the alcoholics and non-alcoholics as recommended method is justified with high certainty of classification results [7].

A study introduced by Kelly E. Courtney and John Polich to search about EEG of young adult humans experienced binge drinking. In the course of passive observation, assessment of 96 young adult in university experienced binge drinking on electroencephalography (EEG) recording was made. Male and female non-binge drinkers, low-binge drinkers and high-binge drinkers composed the groups for study. The aim of the study was to reflect the relationship between central nervous system (CNS) and binge drinking. As a result, in young adults electrical activities of brain, some certain patterns may be evidence for future development of alcoholism [8].

To classify EEG signals as alcoholic or normal, Oliver Faust Wenwei Yu Nahrizul Adib Kadri composed a computer-based identification system. Feature extraction and classification algorithms built up the system of identification. Wavelet packet decomposition (WPD) and energy measures create the feature extraction. To test and train a competitive 10-fold cross-validated analysis of six classification algorithms they were used. 95.8% certainty rate confirms that the k-nearest neighbour (k-NN) algorithm overcomes naïve Bayes classification (NBC), fuzzy Sugeno classifier (FSC), probabilistic neural network (PNN), Gaussian mixture model (GMM), and decision tree (DT). To sum up, alcoholic patients' diagnosis and treatment monitoring can be accomplished automatically thanks to EEG signals. Cost reduction may be succeeded with the automatization [9].

Chin-Feng Lin et al. applied a Hilbert-Huang Transformation (HHT) related with scheme of time frequency to the analysis of alcoholics and single electrode (FP1) EEG signals. The distinctive responses of the EEG signals of alcoholic and control groups were compared between the simulation outcomes of the clinical EEG signals as the intrinsic mode function (IMF), instantaneous frequency (IF), marginal frequency (MF), and the Hilbert spectrum. In the EEGs of the control groupwhich was stimulated by some visuals, there was no apparent rise in voltage when the EEG signals of the

alcoholic and control groups were compared. As a result, for diagnosis of the diseases incurred because of the alcohol consumption, an alcoholic and a normal subject's IMFs, IFs, Hilbert Marginal frequency, and Hilbert spectrum of EEG signals can be the biomarker [10].

The EEG signals were gathered from drinking testers and no-drinking subjects to analyse by Jihong Liu et al. In the study, wavelet transform, short-time Fourier transform, spectrum analysis and the Wigner distribution are the method utilized from. The results of the experiment revealed that there was relationship between chronic alcohol consumption and nervous system as a stimulator noticeably. Transient pulse signals were approximately 0.6s and the energy of EEG power spectrum was in the low frequency in the EEG data of subject with alcohol [11].

In this study, implementing Principal Component Analysis (PCA) recurrently to decrease background EEG markfrom VEP signal having multi-channel and multi-trial is suggested by Sharmilakanna P et al. To reduce the noise PCA was implemented twice as stages of multi-channel VEP signals and multi-trial VEP signals. There after distinctive features of N4 parameter between alcoholic and non-alcoholic subjects in EEG were investigated. T-test which enables to test the hypothesis revealed that non-alcoholics had remarkably stronger and faster N4 responses when they are compared to alcoholics who had weaker and slower N4 responses [12].

Many different researches about resting EEG proved that chronic alcoholics showed escalated level of power in θ-band (4-8Hz) and in β-band (12-30Hz) [13-15].

1.2 Purpose of the Thesis

The aim of this thesis is to assess maximum points of PSD results which are obtained by using EEG marks of control group and group with alcohol and observe the differences among the subjects of EEG data of control group with methods of spectral analysis - wavelet and Fourier transform. In the study, EEG data belongs to the control group and experiment group. It contains measurements from 64 electrodes placed on subject's scalps which were sampled at 256 Hz (3.9-msec epoch) for 1 second. The data consists of 3 versions. We use large data set in our study. The large data set consists of 10 subjects who used alcohol and 10 subjects of control group.

CHAPTER 2

BACKGROUND

2.1 Brain and Neuron

The Brain is the most important organ and complex creation which makes human life possible and it receives and operates the signals coming around and generates reactions to them. In order to understand how brain works, Electroencephalography (EEG) recordings are used. EGG is written transformation of electrical activities as brain waves made by neurons in the brain. EGG signal is non-invasive method which plays important role on diagnosis and investigation of various neurological diseases like epilepsy and it provides crucial information about brain activities [16-17].

2.1.1 Brain

Neural system is an organ system that regulates activities of muscles and organs. This system leads living beings to perceive their internal and external environment, obtains information and operates that information, enables the transfer of signals to different body parts with the help of cell web inside the body.It is composed of the central nervous system (CNS) and the peripheral nervous system (PNS). Central nervous system has a basic mission on controlling the behaviors with peripheral nervous system. On the other hand, brain is a management system of central nervous system. It means that brain is organ of central control that manages and supervises the functions of all the other organs. Nerves also run from spinal cord to various parts and the rest of the body. Human brain is composed of two main hemispheres as right and left which includes five main lobes each hemisphere.

1. Frontal lobe: It executes the process of conscious thinking. In case of any damage, there may be changes in psychological state and emotional situation.

2. Parietal lobe: It plays role on combining the data collected from different sense organs. Furthermore, the parts of parietal lobe are important for usage of objects and visuospatial processing.

3. Occipital lobe: It is the lobe of which the data of visual sense is operated. Even slight damage can cause hallucination.

4. Temporal lobe: Perception of sounds and smell and operation of complex stimuluses like places and faces is possible with this lobe.

5. Cerebellum: It links data from sense organs with action. This lobe plays role on providing balance, especially.

While our brain is accomplishing its missions, some electrical actions accompany with them. Electroencephalogram signal emerges fromcombination of these electrical actions.

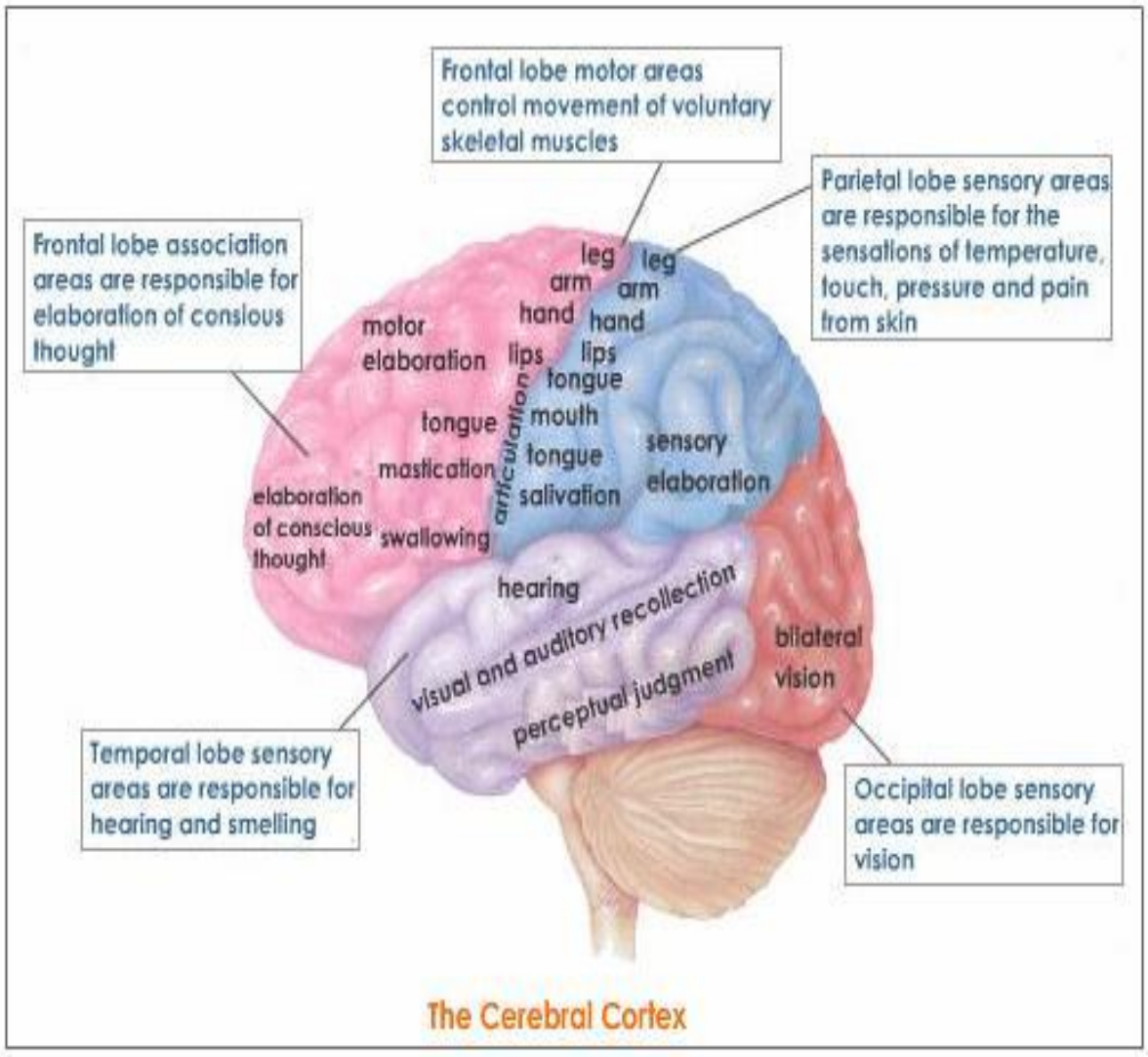


Figure 2.1 Cerebral cortex lobes and their functions [18]

2.1.2 Action Potential

The data conveyed via neurons is called action potential (figure 2.2). Action potential comes after the change of ion that goes through neuron membrane and the action potential is contemporary change in neuron membrane during the action It Usually starts in the body of cell and goes through a direction normally. The membrane becomes "depolarized" by generating longitudinal strike. This means that it becomes more positive. After the longitudinal strike, the membrane becomes "repolarized" - more negative. Action potential lasts 5-10 ms in many neurons. The speed of action potential shows variety between 1-100 ml. It can be started with so many different stimulus (chemical, optical, electrical, baric, tactual). For instance, the neurons in neural system are stimulated with chemical activities. To create an action potential, a stimulus must reach the specific level. Otherwise, it just causes local electrical disorder and it cannot create action potential. If the power of stimulus can reach the specific level, an action potential emerges and it starts moving from the neuron. Action potential generally occurs by opening the sharp point to channel of sodium Na). The sodium pump generates both sodium and potassium gradients. Both of them are used for the production of action potential. Sodium is less in the inside of the neuron but more outside of it. Stimulated neurons have special sodium and potassium channel doors that can be opened or closed according to membrane of neuron's voltage. The opening sodium channel's doors permit the flow of positively loaded sodium into the neuron. This creates depolarization and brings longitudinal strike.

Process:

I- When the dendrites of neurons are stimulated, the channels of Na are opened. If this opening can enhance the action potential -90 mV to -60, the process can goes on.

II- When the specific level is achieved, more Na channels are opened. The flow of Na raises the inside of membrane about -20 mV. This process is called depolarization.

III- After that, Na channels are closed and K channels are opened. The depolarization time is over because of the slow opening process of K channels. When both Na and K channels are opened at the same time, this makes the system neutral and hinders the production of action potential.

IV- When the K channels are opened, the membrane becomes repolarized through the relaxation potential

V- Repolarization usually makes the relaxation potential -90 mV. This is called hyperpolarization. Hyperpolarization hinders the any other stimulus of neutron or prevents the increasing to specific level. One another importance of hyperpolarization is to guarantee the directing the signal to a specific direction.

VI- After hyperpolarization, Na/K pumps turn he membrane to relaxation potential as -90 mV as a result.

To receive another stimulus, neuron needs about 2 ms. In this process, action potential is not generated.

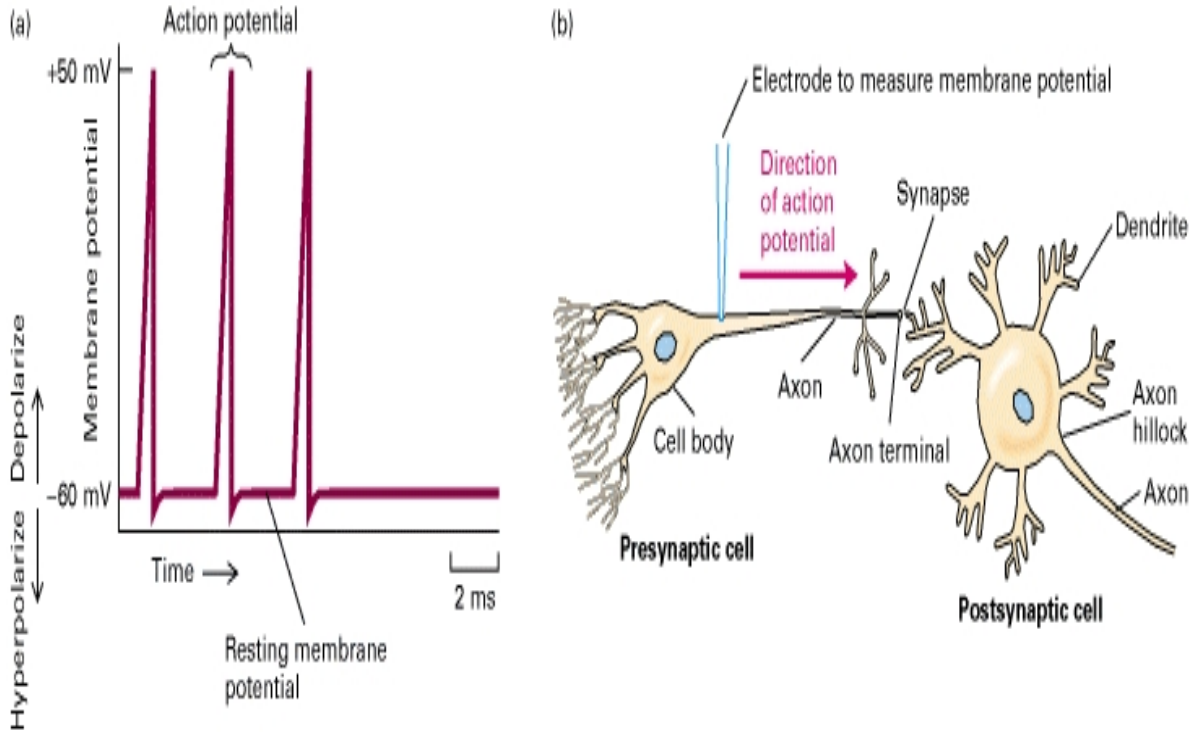


Figure 2.2 Action potential (a) Measured (b) Propagation [19]

2.2 Electroencephalogram (EEG)

Electroencephalogram or Electroencephalograph is a recording (“graph”) of electrical signals (“electro”) from the brain (“enchephalo”). Electroencephalography or EEG is

the recording of brain's electrical activity along the scalp over a period of time. EEG, a neurological test, provides measurement of fluctuation of voltage caused by ionic current flows in neurons of the brain [20]. Physicians and scientists utilize from EEG to work on functions of brain and diagnosis of neurological disorders. With recordings of EEG, brain electrical activity is among the most crucial means of diagnosing neurological diseases, like epilepsy, brain tumour, sleep disorder, head injury, dementia and controlling depth of anaesthesia in the course of surgery.

2.2.1 History

Carlo Matteucci (1811-1868) and Emil Du Bois-Reymond (1818-1896) are the first ones who created the concept of neurophysiology and recorded the electrical signals reflected from muscle neurons by using galvanometer [21-22]. However, Hermann Von Helmholz introduced the concept of action current and he clarified and justified the variation coming out during the contraction of muscles [23].

In 1975, Richard Caton (1842–1926) presented the findings about the electrical phenomena of apes and rabbits' brain hemispheres in the British Medical Journal. This can be regarded as discovery of EEG activities [24].

Polish physiologist Adolf Beck (1863–1939) searched about spontaneous activities in brains of dogs and rabbits. He was the first person who discovered rhythmic oscillation of electrical activities of brain in 1890 [25].

In 1912, Russian physiologist Vladimir Vladimirovich Pravdich-Neminsky published the first animal Electroencephalography (EEG) and the evoked potential of the mammalian (dog) [26].

With implementation of galvanometer with photographic insertion Napoleon Cybulski (1854– 1919) the collaborator of Adolf Beck and Jelenska Macieszyna put forward the graphical form of EEG in 1914. This was the first time to behold a dog's epileptic EEG activity detected via electric stimulation [27].

Hans Berger was the person who recorded the first electroencephalogram from the surface of the human scalp the surface of the human skull in 1924 [28-29]. By recording the EEG signals of a 17-year-old boy having trepanation during his surgery for tumour in his brainHans Berger was the first human electroencephalographer in 1929. Non-

polarizable clay cylinder electrodes and Edelmann's small size string galvanometer were put the use to record the electrical activity in the brain [30].

Figure 2.3 Berger's patient [31]

2.2.2 Uses of EEG

These are primarily used in the EEG signals.

1 Neurology: EMG, echocardiogram and determination of brain pathology in patients with neurologic controls.

2 Brain Surgery: abnormal pathological tissues, such as brain tumor surgically removed determining the optimal locations,

3 Anesthesia: a patient under anesthesia to determine the level of anesthesia,

4 Pediatrics: Average evoked potentials obtained with other test methods, determination of new-born children, hearing and vision problems,

5 Psychiatry: a mental disorder in order to determine more precisely is used to determine whether an organic brain disease

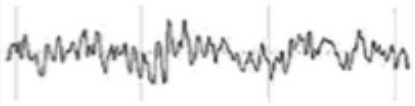
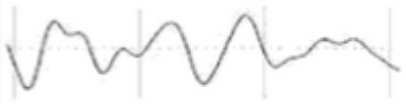
2.3 Emergence of EEG Signal

The functions in our bodies are accomplished with hormones and neural system. Hormones are created in endocrine tissues and sent to distant organs where they function. In neural system, commands regulate the actions of organs by being sent via neurons through peripheral nervous system and brain and spinal cord which create central nervous system. The main cell of neural system is called neuron. Neuron is composed of a stem of cell called soma, fibers called dendrites and long conveyer fibers called axon. The part of axons that is near the body of cell is called hillock and this point is where the action potential is generated. Axon, dendrites and neural dendrites and personal neural fibers bunches are also called neuron. Brain is intense combination of body of neurons and fibers in skull. The joining points between neurons are called synapses. All of the synapses are around the body of neurons. The neurons never contact with each other and the data exchange between them occur when the chemical substance is excreted on the synapses. When the data comes to the end of axon, one way data transfer is achieved when chemical data transmitter is excreted [16, 32].

2.4 The Features of EEG Signal

EEG signs are not static and periodical. Their magnitude, phases and frequency are different. For this reason, their interpretation has quite difficult morphology. Thus, to obtain meaningful data long time period measurement must be conducted. The studies about EEG point out that EEG frequency changes according to individual's mental activity. EEG signal is formed by total of many potentials coming from vast part of cerebral cortex. The frequency range involves 0,5 - 100 Hz. This range is divided into five because of various characteristics. EEG signal is evaluated according to frequency range not with shapes. There are five important brain waves with different frequency rates. These frequency ranges are alpha (α), beta (β), theta (θ), delta (δ) and gamma (γ).

Table 2.4 Common frequency band chart [33]

Frequency Band Name	Frequency Bandwidth	State Associated with Bandwidth	Example of Filtered Bandwidth
Raw EEG	0–45 Hz	Awake	
Delta	0.5–3.5 Hz	Deep Sleep	
Theta	4–7.5 Hz	Drowsy	
Alpha	8–12 Hz	Relaxed	
Beta	13–35 Hz	Engaged	

Clinical and physiological interest is intensified around 0,5 and 30 Hz although the range of EEG signal is quite broad. The magnitude of EEG signal fluctuate between 5 V and 400 V depending on mental activities [34]. Studies show that the synchronization of neurons is distorted when the mental activities are increased and thus creating declining magnitude and increasing EEG frequency. While sleeping, the synchronization of neurons is increased. For that reason, the frequency is decreased while the magnitude of EEG is increased. It cannot be determined any mental activity from a patient who has cerebral death.

Delta waves: It is less than 4 Hz. Their magnitude varies between 20-100. These waves can be seen in case of deep sleep, sometimes being awake and general anesthesia which may be called low activities of brain [35].

Theta waves: It is between 4-8 Hz. Their magnitude varies between 5-100. Especially, it is seen in the parietal and temporal area of children's brain. Adults experience that while dreaming in sleep, optimal level of anesthesia, starting stages of sleep, inspiration and deep thoughts, anxiety and disappointment [35].

Alpha waves: Their magnitude varies between. It is collected from the back of the head. It is usually located in occipital area and seems like sinus. Sometimes it has sharp corners. Normal and calm people experience it while they are awake, there is no concentration, external stimulus and they close their eyes- in relaxing times.

Beta waves: It is between 13-26 Hz. Their magnitude varies between 1-5. Beta waves occur in the situation of active thinking time of brain, focusing on something, concentrating on outer world or solving a hard problem. Normal adults experience these waves. High level of beta waves is seen on people having panic. Rhythmic beta condition generally is obtained from frontal and central area of brain. Above 30 Hz and mostly about 45 Hz frequencies are sometimes called beta but they are on gama range actually.

Gamma waves: It is used by some researchers. Their magnitudes are under 2. These are much more in the center of brain. They have the characteristics of sleep and this wave group is the only group which is in all parts of brain.

(a) Sharp signals with broad frequency. They are seen in body of temporal lobe.

(b) Contemporary (ERP) and (POST) signals

(c) Signals caused by damaged areas like brain lesions with tumors.

(d) Localized as spatial and taken into consideration as round but easily blocked with physical action like mu.Mu stands for motor and it is related with motor cortex.

(e) The little Phi (φ) rhythmless than 4 Hz that occurs when the eyes are closed found by Daly.

(f) The rhythm Kappa (κ) which is regarded as an artefact signal and believed that it is a result of separate oscillation sides of eyeballs.

(g) The rhythm between 11-15 Hz frequency range and called Sigma (σ) activity.

(h) Tau (τ) rhythm which makes alfa activities in temporal area.

(i) The signals that cause increasing front artefacts in alfa range with eyelicks' vibration when eyes are closed.

(j) Chi (χ) rhythm is like mu activity which even observed during yoga exercises 11-17 Hz.

EEG signals play important role on clinical diagnosis of many diseases depending on change of frequency and magnitude according to age and various conditions.

2.5 Recording and Measuring EEG signals

It is vital to get signals and images from human body to diagnose various diseases in advance. Like EKG taken from heart, EMG taken from muscles, EEG and MEG taken from brain and EEG taken from eye neurons, also computerized tomography(CT), magnetic resonance imaging MRI orFunctional magnetic resonance imaging (fMRI), positron emission tomography (PET), single photon emission tomography (SPET) have the form of such an ultrasound or radiograph.The physical and functional changes inside of the brain can be recorded via EEG, MEG or fMRI. However, EEG is widely used because of limited usage, expensive and low performance MEG and fMRI. In EEG systems, to obtain qualified data, the type and number of electrodes are important. There can be different types of electrode.

- The non-returnable electrodes without gel and previously with gel

- Reusable disc electrodes (gold, silver, tin, stainless steel)

- Ba ranges and electrode head

- Salt electrode

- Pin shaped electrode

The most widely use one among them is disc electrodes that are reusable. Electrode heads are generally used for multiple channels and great amount of electrodes' recordings.

2.6 The placement of electrodes

Electroencephalography and International Federation of Clinical Neurophysiology propose the order of 21 electrodes placement known as 10- 20 placement order. In measurements reusable disc electrodes are preferred generally. These electrodes are placed by pressing hat shaped rubber bands or pasting electrical conductive paste that is suitable for head skin. Their conductivity is preserved with special pastes or salt water. In this placement system, the head is marked with four points. These are: nasion: nose, union: the back of head, right and left preauricular: ears.

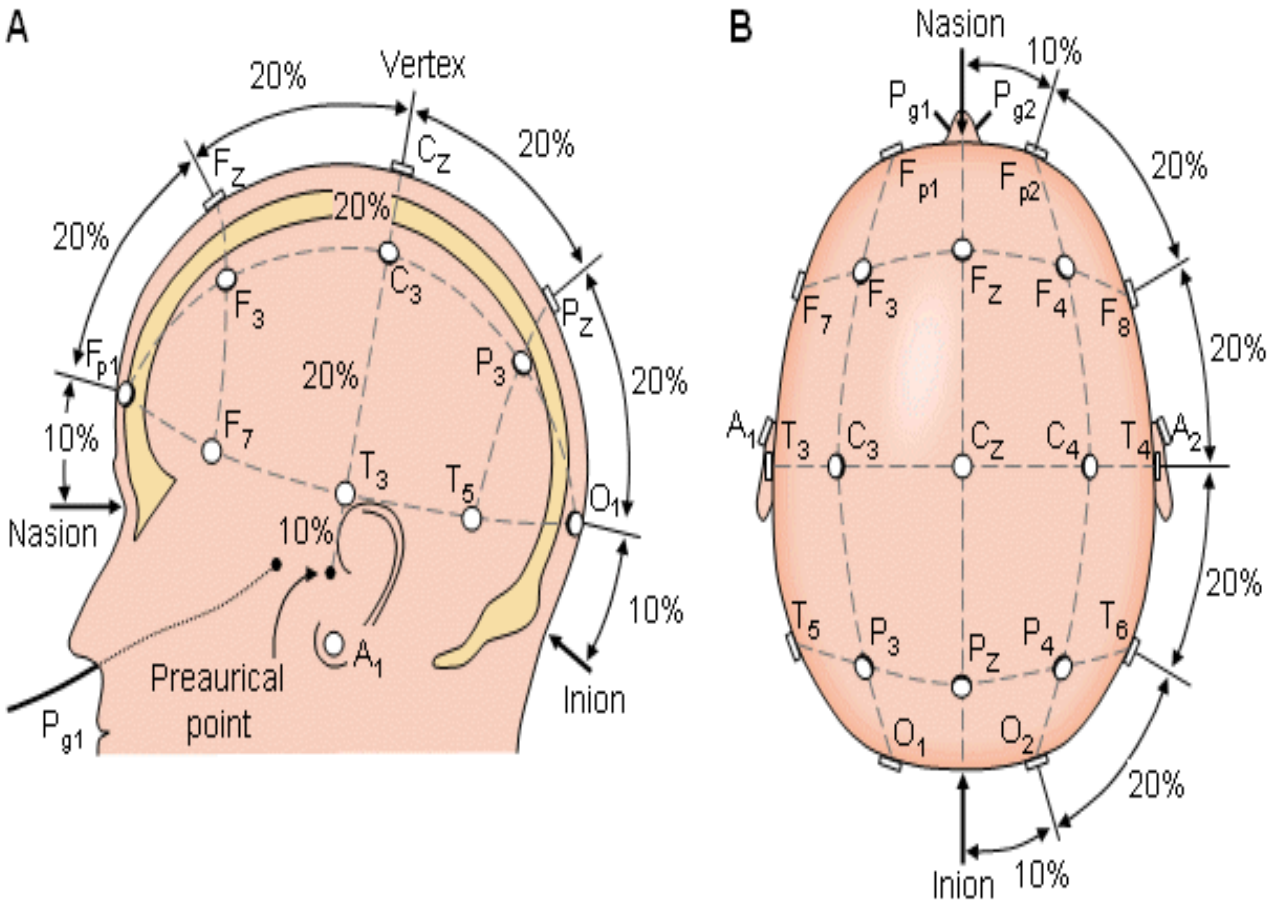


Figure 2.6 (A) and (B) International 10 – 20 System's Electrode measurement [36]

Usually EEG recordings last about 30 minutes. The stage of placement before recording is really vital stage. Electrodes must be placed symmetrical according to right and left lobes of brain. This is for healthy comparison of two hemispheres. The electrodes placed on lobes are named with the initial letter of lobe as odd number on left, even

number on right side. For instance, F7 is for left back frontal and F4 is for right front frontal lobe. Before EEG measurement, it is important that the patient has clean hairs. Moreover, for more efficient measurement, the patient should not be hungry. During the recording, the patient sits calm and eye-close. In all EEG recordings hyperventilation is applied. Furthermore, one another important application in EEG recordings is directing intermittent light.

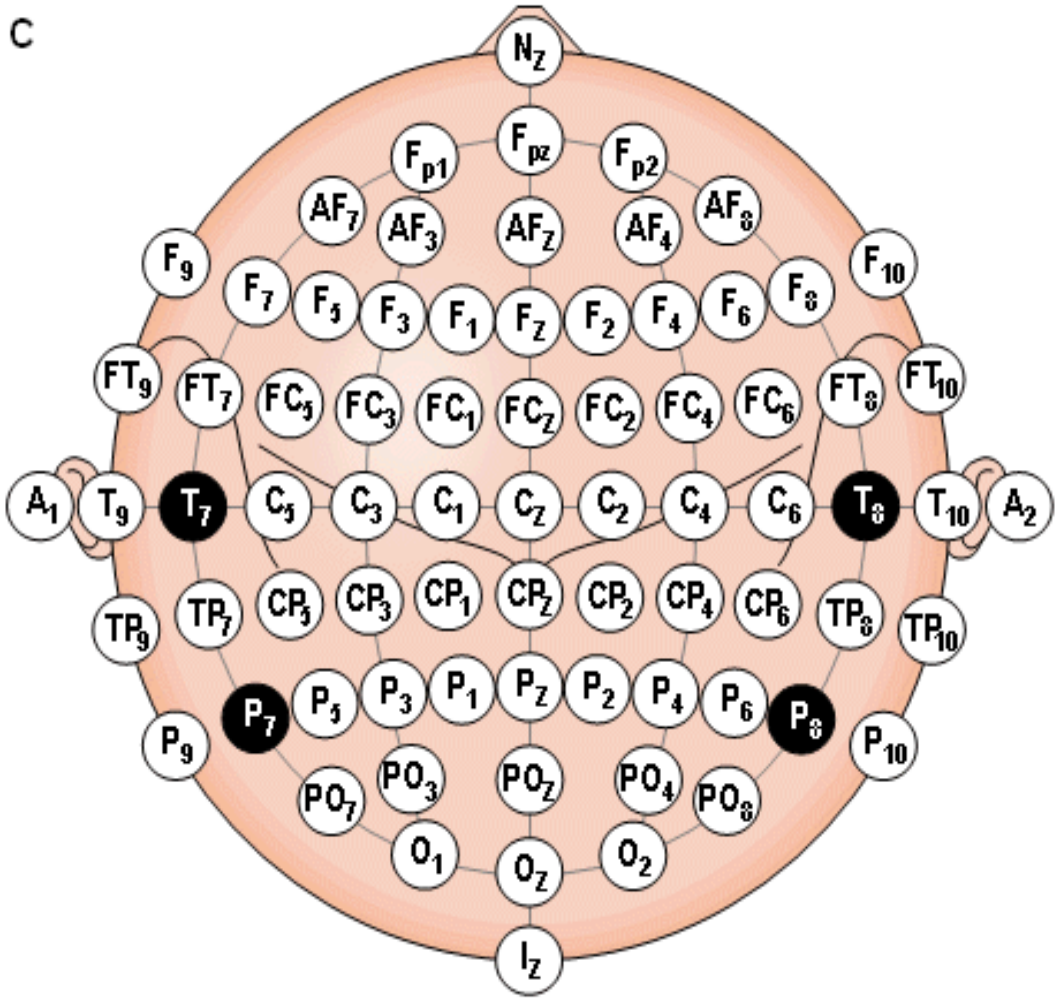


Figure 2.6.1 64 electrode system based on 10-20 International System [36]

CHAPTER 3

MATERIAL AND METHODS

Demographic Data

Fourier regarded as precursor of operation of signal for more than one hundred years proved that signal can be composed by linking sinus and cosines. Fourier gathered or separated magnitude, frequency and phase and obtained new data. The data did not disappear and he obtained new signals. Of course, it is possible to reach previous signal via new one. Figure 3 shows that a wave form is composed of composition of two sinus waves.

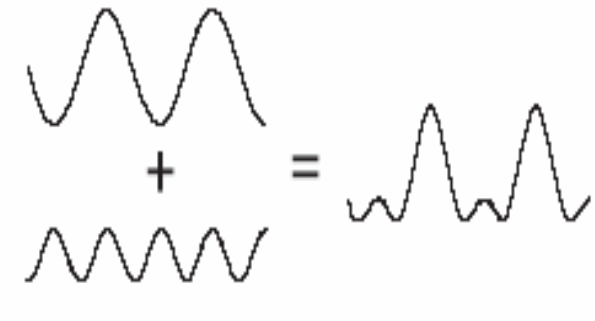


Figure 3 The combination of the two signals

As Fourier proved, data signal used widely can be obtained from the composition of magnitude, frequency and phase rate by choosing appropriately or data signal can be divided into more than one sinus. Signals can be showed on part of time- magnitude or time-frequency. Demonstration of signals on frequency part is called spectrum. Each line on spectrum is called component of signal. We use frequency spectrum while defining the term of signal. In fact, we can call frequency spectrum as graphic demonstration of signal frequency data.

3.1 Fourier Transform

French scientist Jean-Baptise Joseph Fourier (1768-1830) decomposed signals to sinusoidal components and Fourier analysis was placed in medicine history. Fourier managed to show a continuous signal as properly selected sinusoidal total signal form. In other words, it is proved that sum of periodic functions can be identified with infinite complex upper function. For this reason, stabile signals, it means continuous signals gives right results but desirable results could not be obtained from unstable signals.

In Fourier unrevised transform data signal is composed of many sinusoidal frequencies. Fourier transform turns a signal to frequency part from time part. In this transform, there is a disadvantage, also. It is loss of the time data of signal. That is to say, it is impossible to say that the event happens in a special part when the Fourier transform is considered [37].

Analysis of Fourier is studied under the series of Fourier. Periodic f(x) function is stated as sum of infinite number of sinus and cosines. Fourier series analyze a function and signal by using the orthogonal relation of sinus and cosines functions. A function can be stated by using Fourier series as following.

3.1.1 Short Time Fourier Transform(STFT)

Fourier transform giving great results for stabile signals gives terrible results for unstable signals, even it remains insufficient [38]. Denis Gabor plotted small part of mark in time range by using windowing technique. He stated the mark under two dimensions as function of time and frequency. This signal operation system, a specific part of the signal is windowed by considering it as stabile and with a local frequency parameter Fourier transform is applied. In STFT, the signal is divided into small pieces and the signal is regarded as stabile in the process of windowing. The stabile windows are obtained by multiplying the signal with a window function. This technique based on the idea of localization on Fourier transform can be done by choosing a window in a right place where the technique matters [39,40].

STFT is reproduced in two ways as frequency parameters and transferring to time part from a basic window function. The window function used here is stated with equality (3.1). Window function must have definite power and the integral must be measured. In

STFT method, windowed function's Fourier transform can be accomplished by placing a w(t) window function on the t point above the time part.

$$g_{w,\tau(t)} = e^{jwt}\, w(t-\tau) \tag{3.1}$$

After that, the window slides and the process goes on by taking the Fourier transfor again. The mathematical statement of this process is demonstrated in (3.2).

$$(\mathrm{w},\tau) \;=\; \int_{-\infty}^{\infty} \mathrm{f}\,(\mathrm{t})\,\overline{\mathrm{w}}(\mathrm{t}-\tau)\mathrm{e}^{-\mathrm{jwt}}\mathrm{dt} =< \mathrm{g}_{\mathrm{w},\tau}(\mathrm{t}),\mathrm{f}(\mathrm{t}) > \tag{3.2}$$

The transform known as Gabor is actually the STFT itself. One another window used by Gabor is Gaussian window [41]. To complete the timing Gabor (1946) proposed the idea of analysis of signal in time part as small windows. STFT provides compromise between time and frequency appearance of a signal. It means that it gives information about time and frequency. However, the information can be obtained in a limited accuracy. Because the accuracy is about the size of window. If the size of window is big the quality of frequency will be great and vice versa. Method is reproduced with the technique of classical Fourier transform by multiplying time signal f(t) and nearly one time window.

The most important issue of STFT is the stability of the size of window. STFT signal is crucial to have data of time and frequency. However, it is not a good analysis when the function remains stable during signal. Solubility, in other word details, must be much more than usual sometimes and in this case the size of window should be changeable. Many other marks require more flexible and changeable windowing technique to get more information about time and frequency [41].

3.2 Wavelet Transform

We encounter with wavelet transform as the composition of data signals and main wavelet signals. That is to say, the signal is reproduced from signal and stated by coding the signal in a way. In wavelet transformation data, main wavelet is linked and the obtained signal scale parameter is stated in time aspect. Here it exists the time we want and the data of frequency in parameter aspect in showed scale. So this provides us advantage and even superiority when it is compared with Fourier analysis. Because we

can inspect the signals both in frequency and time parts as well. This situation is desirable in medical electronics. In medicine sector, not seeing just as frequency but as magnitudes in time part is a really desirable situation. We encounter with it as signal operation method and it is taking the place of Fourier analysis slowly and it will take [38,40].

Wavelet transform is a technique of changeable sized windowing. Furthermore, it helps us determine the low and high frequency in short and long time periods. Unlike Fourier transform, it is used not only in time-frequency part but also time-parameter part. Signals can be analyzed better locally in wavelet transform End of the transformation the obtained spectral components' drawing shows the exact place of impermanency in time. With the help of wavelet transform, the compression or de-nosing process can be done easily without distorting the original form of signal. Wavelet transform is new developing way of operating signal and it is widely used in unstable signals and numeric signal operating. One of the best and oldest methods, Fourier transform transfers the signal to frequency part wile transforming it. The data of signal is lost in time. It is not a problem for stable and recurring signals but unstable ones like EEG and many other signals are changeable signals and wavelet transform is used to analyze them because of the structure of signals. Wavelet transform can be used in the analysis of unstable in different frequency time series [42]. Fourier Transform is not sufficient on analysis of unstable signals [38].

Many data signals can contain important instability and contemporary traits (slope, sudden change, breaking and starting and ends of events). The unexpected traits and instability can be important parts of data signal (especially EEG and EKG). At this point, wavelet transform is a must [43].

STFT signals, developed version of Fourier transform, are similar to wavelet transform in terms of signal analysis but the solubility of the analysis done with stable window is limited. All the signal that is analyzed is made by stable time window and thus decreasing the solubility. Unstable signals sometimes need sensitive approach and at this point STFT remains insufficient.

In wavelet transform which lets changing the size of window unstable signal analysis done by transferring to time-parameter part. Because of structure of the wavelets local signals analyzed in detail. This makes the EEG, EMG and EKG signals desirable signal

operation method in medicine especially. At the same time, wavelet transform provides right results for unstable signals due to the preservation of time-frequency data of all the signals [39].

In Fourier transform magnitude and frequency of signal can be seen in impermanent signals. Nevertheless, in wavelet transform we can observe the change of impermanency. Use of Fourier transform is disadvantageous in analyzing signals showing impermanency and steep strikes. Wavelet transform is successful in capturing slopes that cannot be captured by any other method and impairment points, high point derivatives and similarities [38].

Wavelet transform makes detailed analysis because of different size of measurement in various solubility and scale. Because the scale is doubled for each time and according to this the analysis is repeated. Thus, the solubility is increased and it becomes more detailed. This situation is desirable in this sense in medicine. It provides advantage especially in inspection of heartbeat and brain waves and it is highly used.

3.2.1 Continuous Wavelet Transform

CWT is composed of multiplication of signals in form of shifted and measured wavelet function during the intervals. End of the continuous wavelet transform so many wavelet parameters are obtained. These are functions of scale and position (11). Wavelet transform's main functions are (t)'s scale parameter and b time parameter By using shift it is applied totime based function f(t). The formulas making wavelet transform are like as follows. The formula is compounding of wavelet function and signal function based on time constraint.

$$W_{(a,b)} = \int X(t).\overline{\psi}_{a,b}(t)dt \tag{3.3}$$

$$W_{(a,b)} = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} f(t).\overline{\psi}\left(\frac{t-b}{a}\right).dt \tag{3.4}$$

In this equality W (a, b) are the parameters in wavelet transform.ψ (*t*), ψ (*t*) are complex conjugateof basic wavelet function.

The work principal of CWT: Main wavelet is chosen to be used in priority for wavelet transfer, the main wavelet is compared with the signal in which our data take place. Through C parameter, comparison between wavelet signal and the first part of the signal is done. The bigger the parameter is, the more similar the main wavelet and signal are.

At the end of these processes, we obtain different parameters in different scales in different phases of the signal. This provides us with scale-time catenary of the signal and we obtain the catenaries below. There is no change or impairment, just the analysis is carried out, all data is available in the signal. At the end of wavelet transfer we obtain scales and parameters, wide scale main wavelet parameters reveal overall signal features of the signal while small scale main wavelet parameters reveal small detailed features. This is advantageous in complicated signal analysis and this is desirable. According to the process in the wavelet transfer, it is important to choose main wavelet prototype.

3.2.2 Discrete Wavelet Transform

İf there be a full analyzing in terms of the whole scale in wavelet transform, huge amount of data stack will arise and it requires too much process. This is an unwanted situation that's why when we establish specific scale groups and analyse this duration, we can call this analyse as Discrete Wavelet Transform. The most common method that is used in practice, is the method which is chosen as powers of two in terms of scale and position rates. Everything as Mathematical theory and working system, is like the system in CWT. DWT was developed by Mallat with using filters. This procedure which is also known as Mallat algorithm, is anfilterion algorithm which makes a fast Wavelet transform with two base channel coder [44-46].

DWT separates signals into two main component. This process is made by using filters. One of these components is lower frequency component, in other words; filter way puts that is reflected low and the other one is high frequency component, in other words again; filter way puts that is reflected high.

A lower frequency component which is constituted in main components of DWT, is called as approximations and high frequency components are called as details. S signal which is exposed DWT process by separating is separated into approximations and details equally.

Like EEG signals and lots of the other signals, Lower frequency components contain important rates. The important component which is in signal, are lower frequency components. Of course, both of these two components constitutes this signal, in other words signal contains both components. This lower frequency component contains perceiving features of signal. The waves which is produced by human brain; Alpha, Theta and Delta also in lower frequency.

Process of separating into lower components, can be made real on the same signal for several times, it is up to how much it is needed and Generally the way outs which reflects basely (approximations) is exposed DWT, again. The process of DWT continues until a reasonable signal solution is produced. This process also called as tree of separating Wavelet.

$$
\begin{aligned}
S &= A_1 + D_1 \\
&= A_2 + D_2 + D_1 \\
&= A_3 + D_3 + D_2 + D_1
\end{aligned}
$$

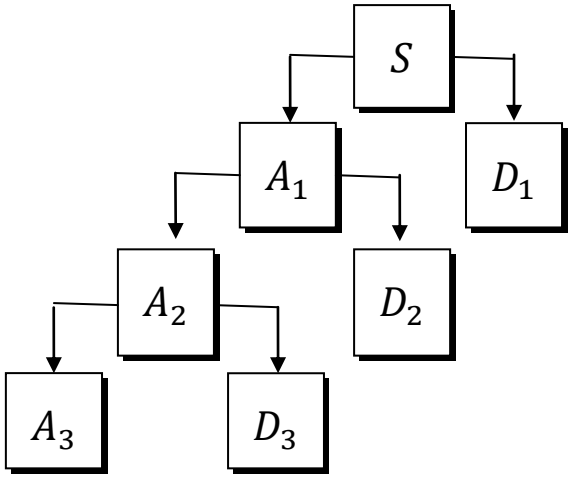


Figure 3.2 Wavelet decomposition tree

There is an example of how a signal separated into approximation and detail components by being exposed more than one filter process. As it can be seen in image 3.2, the signal which is exposed DWT, does not lost anything, it just separated into its components by being exposed multiplication with main Wavelet. This A3 approximation component is the main component. Approximations are high weighted, lower frequency components. Details are lower weighted high frequency components.

In DWT, main purpose is separating the signal into approximations and details. The approximation that is gained is separated into second level separation of approximation and details and this process can be maintained until the expected results are gained.

3.3 PSD Assumption With Non-Parametric Methods

Non-parametric methods make assumption about power spectral intensity from the signal directly. The easiest method of non-parametric methods is periodogram method. The more developed version of periodogram method is the Welch method.

These methods are used to interpret complex and long lasting marks like EEG. In that, they make assumptions about power spectral intensity by using signal directly. If they are used, they do not give clear information to interpret the mark.

3.3.1 Welch's method

Periodogram method is based on Fast Fourier transform method. It is a classical spectral prediction method. The power spectral intensity is obtained by dividing it into frames as double prime ofthe mark for time series mark periodogram method.Perodogram's developed version is Welch's method.

In this method the mark is divided into the overlapping parts. The divided parts' developed periodograms and then the median is taken. No matter how the overlapping between parts causes irrelevant information for signals, rectangular frames are used to reduce the effect. The prediction of first grade periodogram is the developed version of periodogram with Welch's method.

$$S_{xx}^{\wedge(i)}(f) = \frac{T_s}{K.M}\left|\sum_{n=0}^{M-1} x_i(n)w(n).e^{-j2\pi/n}\right|^2 \qquad (3.5)$$

It is presented like this demonstration. Here is the f normalized frequency. It is factor of T_S scaling and it provides equality for magnitude of split time mark spectrum and analogue mark spectrum. In the last equation, w(n) windowing function and K-normalized stable is given with the following statement [47-48].

$$K = \frac{1}{M}\sum_{n=0}^{M-1} w^2(n) \tag{3.6}$$

As conclusion, the prediction of power spectral intensity is present like this:

$$\hat{P}_{Welch\,(f)} = \frac{1}{L}\sum_{i=0}^{L-1} \hat{S}_{xx}^{(i)}(f) \tag{3.7}$$

Here the L is length of time series. The bindings of short data recordings and inspection with non-rectangular frames reduce the solubility. Welch's method enables to obtain better solubility compared periodogram if the rate of mark- noise rate is low [49].

CHAPTER 4

RESULTS AND DISCUSSION

In this study, we use data set. The data consists of 3 versions. We use large data set in our study. The large data set consists of 10 subjects who used alcohol and 10 subjects of control group [50].

We assessed the EEG marks of alcohol consumers with spectral analysis in this study. In control group with alcohol consumers, the analysis of EEG results is assessed by Fourier and wavelet transform to understand whether the alcohol has effect or not. The effects of it on EEG signals are tried to be understood. Here, non-parametric Welch method is used to analyze and compare.

We use ‘wavedec’ on Matlab for Multilevel 1-D wavelet decomposition. We perform decomposition at level 4 of s using db3. We use ‘wrcoef’ on Matlab for reconstruction the single branch from 1-D wavelet coefficients. We reconstruct approximation at level 3. Then, we use Welch method, namely, we find PSD peak value of 10 channels and subjects (10 alcoholic and 10 control subjects). The 10 channels are FP2, TP7, C5, FT7, F8, PO7, CPZ, FCZ, CP3, CP2 which found results from similar research. After that we compare them.

As a result, it shows that generally alcoholic subject frequencies value is higher than control subjects on 6 channels which are FP2, F8, C5, FT7, PO7, TP7. The other channels frequencies value is unsteady.

Tugce Balli et al made use of complexity and energy (power) analysis which included two distinctive methods was implemented to inspect the difference EEGs of alcoholic and control subjects in their work. As a result of the work they found that there are differences generally in occipital, parietal and frontal lobes [4]. When we look at the results of our study, we found meaningful result in these regions, too.

Madhavi Rangaswamy et al analyzed of theta energy on eyes-closed EEGs of alcoholic subjects. They compared to effect of gender differences by using Anova. They found escalating theta power especially at the central and parietal lobes [15].

This table is data set of FP1 channel of only one alcoholic subject. The three columns of data are: sensor position, sample number (0-255), and sensor value (in micro volts).

Table 4.1 Data set of FP1 channel of only one alcoholic subject

FP1 0 9.064	FP1 64 7.111	FP1 128 7.111	FP1 192 9.552
FP1 1 6.622	FP1 65 8.575	FP1 129 8.087	FP1 193 12.482
FP1 2 4.669	FP1 66 7.599	FP1 130 9.064	FP1 194 15.411
FP1 3 3.693	FP1 67 2.228	FP1 131 10.529	FP1 195 17.853
FP1 4 3.693	FP1 68 -3.143	FP1 132 11.505	FP1 196 19.318
FP1 5 3.693	FP1 69 -4.608	FP1 133 12.482	FP1 197 20.294
FP1 6 4.181	FP1 70 -1.190	FP1 134 11.993	FP1 198 21.271
FP1 7 4.181	FP1 71 4.669	FP1 135 10.529	FP1 199 20.294
FP1 8 5.157	FP1 72 9.064	FP1 136 8.575	FP1 200 18.829
FP1 9 6.134	FP1 73 9.552	FP1 137 7.599	FP1 201 16.876
FP1 10 7.111	FP1 74 7.599	FP1 138 8.087	FP1 202 15.411
FP1 11 7.111	FP1 75 5.646	FP1 139 9.064	FP1 203 16.388
FP1 12 5.646	FP1 76 5.646	FP1 140 9.552	FP1 204 19.806
FP1 13 4.669	FP1 77 7.599	FP1 141 10.040	FP1 205 24.200
FP1 14 3.693	FP1 78 9.552	FP1 142 10.040	FP1 206 28.595
FP1 15 4.181	FP1 79 10.529	FP1 143 10.529	FP1 207 33.966
FP1 16 4.669	FP1 80 9.552	FP1 144 11.017	FP1 208 39.825
FP1 17 4.181	FP1 81 8.087	FP1 145 10.529	FP1 209 47.150
FP1 18 3.204	FP1 82 7.599	FP1 146 9.064	FP1 210 57.404
FP1 19 1.740	FP1 83 7.599	FP1 147 6.622	FP1 211 69.611
FP1 20 2.228	FP1 84 7.599	FP1 148 5.157	FP1 212 83.771
FP1 21 4.181	FP1 85 6.622	FP1 149 5.157	FP1 213 98.907
FP1 22 5.646	FP1 86 5.157	FP1 150 6.622	FP1 214 113.556
FP1 23 6.134	FP1 87 2.228	FP1 151 8.575	FP1 215 126.251
FP1 24 5.646	FP1 88 0.275	FP1 152 9.064	FP1 216 135.529
FP1 25 4.181	FP1 89 -0.702	FP1 153 8.087	FP1 217 142.853
FP1 26 3.693	FP1 90 0.763	FP1 154 5.646	FP1 218 150.665

FP1 27 3.204	FP1 91 4.181	FP1 155 3.693	FP1 219 160.919
FP1 28 2.716	FP1 92 7.599	FP1 156 3.693	FP1 220 172.150
FP1 29 0.275	FP1 93 11.017	FP1 157 5.157	FP1 221 180.939
FP1 30 -3.143	FP1 94 13.947	FP1 158 7.599	FP1 222 183.868
FP1 31 -5.096	FP1 95 15.900	FP1 159 8.575	FP1 223 180.939
FP1 32 -3.143	FP1 96 16.388	FP1 160 8.087	FP1 224 173.126
FP1 33 1.251	FP1 97 15.900	FP1 161 5.646	FP1 225 163.849
FP1 34 6.622	FP1 98 13.458	FP1 162 4.181	FP1 226 155.548
FP1 35 9.064	FP1 99 11.017	FP1 163 4.669	FP1 227 147.736
FP1 36 6.134	FP1 100 10.040	FP1 164 9.064	FP1 228 139.923
FP1 37 0.763	FP1 101 11.017	FP1 165 13.458	FP1 229 132.599
FP1 38 -3.143	FP1 102 13.458	FP1 166 16.388	FP1 230 126.251
FP1 39 -2.655	FP1 103 15.411	FP1 167 16.876	FP1 231 120.392
FP1 40 1.251	FP1 104 15.411	FP1 168 14.435	FP1 232 115.021
FP1 41 4.669	FP1 105 12.970	FP1 169 12.970	FP1 233 108.673
FP1 42 4.669	FP1 106 10.529	FP1 170 13.458	FP1 234 101.349
FP1 43 1.251	FP1 107 10.040	FP1 171 16.388	FP1 235 95.490
FP1 44 -1.678	FP1 108 10.529	FP1 172 19.806	FP1 236 92.072
FP1 45 -1.190	FP1 109 12.482	FP1 173 20.294	FP1 237 91.095
FP1 46 1.251	FP1 110 13.458	FP1 174 18.341	FP1 238 89.630
FP1 47 3.204	FP1 111 13.458	FP1 175 13.947	FP1 239 85.724
FP1 48 2.716	FP1 112 12.970	FP1 176 10.529	FP1 240 77.911
FP1 49 0.275	FP1 113 12.970	FP1 177 9.064	FP1 241 69.611
FP1 50 -0.702	FP1 114 13.458	FP1 178 11.017	FP1 242 64.728
FP1 51 3.204	FP1 115 13.947	FP1 179 15.411	FP1 243 63.263
FP1 52 9.552	FP1 116 13.947	FP1 180 20.782	FP1 244 63.263
FP1 53 13.947	FP1 117 12.482	FP1 181 24.689	FP1 245 61.798
FP1 54 13.458	FP1 118 10.040	FP1 182 24.689	FP1 246 56.915
FP1 55 8.087	FP1 119 9.064	FP1 183 20.782	FP1 247 51.056
FP1 56 2.228	FP1 120 10.040	FP1 184 15.411	FP1 248 47.150
FP1 57 -0.702	FP1 121 11.993	FP1 185 10.040	FP1 249 45.685
FP1 58 1.251	FP1 122 14.435	FP1 186 8.087	FP1 250 45.685
FP1 59 4.181	FP1 123 14.923	FP1 187 8.087	FP1 251 43.732
FP1 60 5.646	FP1 124 13.458	FP1 188 9.064	FP1 252 39.825

FP1 61 4.181	FP1 125 10.529	FP1 189 9.552	FP1 253 35.919
FP1 62 2.716	FP1 126 8.087	FP1 190 9.064	FP1 254 33.966
FP1 63 4.181	FP1 127 7.111	FP1 191 8.575	FP1 255 33.966

Table 4.2 Psd peak value of alcoholic subjects

Subject	FP2	F8	CP2	FT7	C5	TP7	CP3	PO7	FCZ	CPZ
1.	3,0373	5,041	0,089	3,217	2,616	2,426	0,575	3,819	0,09	0,08
2.	1,2419	1,413	0,182	0,341	0,234	0,38	0,211	3,036	0,067	0,136
3.	0,816	4,358	0,075	0,202	7E-04	0,308	0,005	0,274	0,036	8E-04
4.	1,4571	1,663	0,152	1,104	0,465	0,848	0,294	1,697	0,277	0,189
5.	1,5383	1,113	0,076	0,475	0,255	0,555	0,129	0,966	0,144	0,033
6.	1,1159	0,666	0,071	3,772	0,649	3,183	0,211	1,915	0,034	0,048
7.	0,4793	2,107	0,034	0,507	0,159	0,299	0,145	0,441	0,031	0,019
8.	0,5629	1,073	0,122	0,853	0,2	0,996	0,136	0,535	0,075	0,026
9.	0,3787	0,323	0,039	0,476	0,299	2,332	0,101	0,965	0,024	0,041
10.	0,4121	0,797	0,058	0,945	0,315	0,391	0,172	0,392	0,026	0,029

Table 4.3 Psd peak value of control subject

Subject	FP2	F8	CP2	FT7	C5	TP7	CP3	PO7	FCZ	CPZ
1.	1,1765	1,5396	0,3624	0,7627	0,7692	1,2888	0,5578	0,7868	0,1679	0,034
2.	0,7076	0,955	0,0628	0,3443	0,1391	0,2901	0,104	0,729	0,1024	0,0628
3.	0,4796	0,6093	0,0495	0,3905	0,2365	0,4554	0,3202	0,5992	0,0179	0,0348
4.	1,0248	2,0357	0,3801	1,1398	0,3432	0,7738	0,2293	1,9213	0,2051	0,1651
5.	0,5312	0,7157	0,3214	0,5956	0,4332	0,605	0,2545	0,7124	0,2096	0,1515
6.	0,5625	0,613	0,039	0,4034	0,2097	0,3381	0,122	0,5726	0,0611	0,0328
7.	0,6279	0,3564	0,0898	0,7006	0,3628	0,5734	0,1993	0,2468	0,0909	0,0746
8.	0,2409	0,5067	0,0573	0,5944	0,3463	0,5721	0,215	0,3164	0,1062	0,2792
9.	0,8626	0,5047	0,1439	0,7132	0,2389	1,4735	0,1608	1,2074	0,0348	0,032
10.	0,8741	0,7121	0,1229	0,1549	0,2662	0,594	0,3891	0,5299	0,0648	0,1156

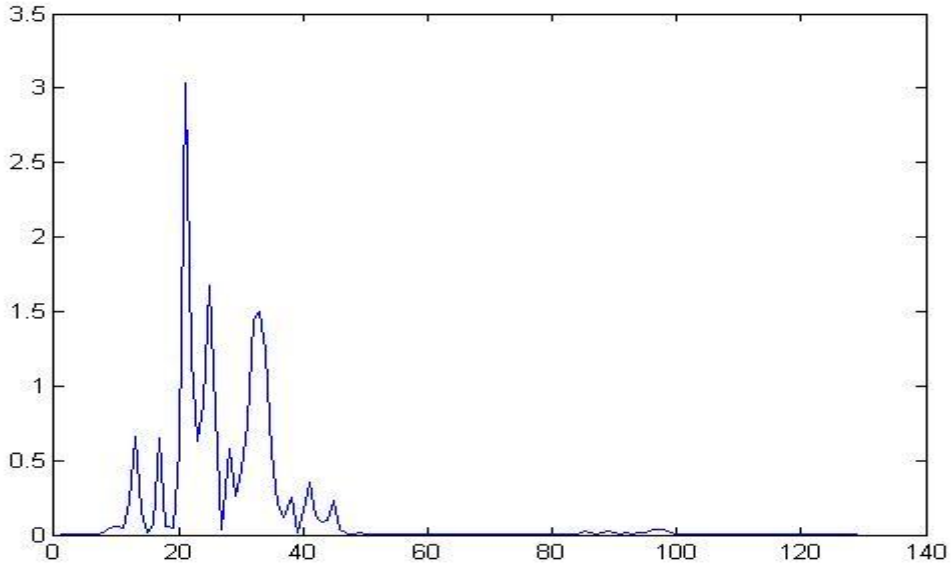


Figure 4.1 Welch power spectral density estimate for Fp2 channel on Alcoholic subject

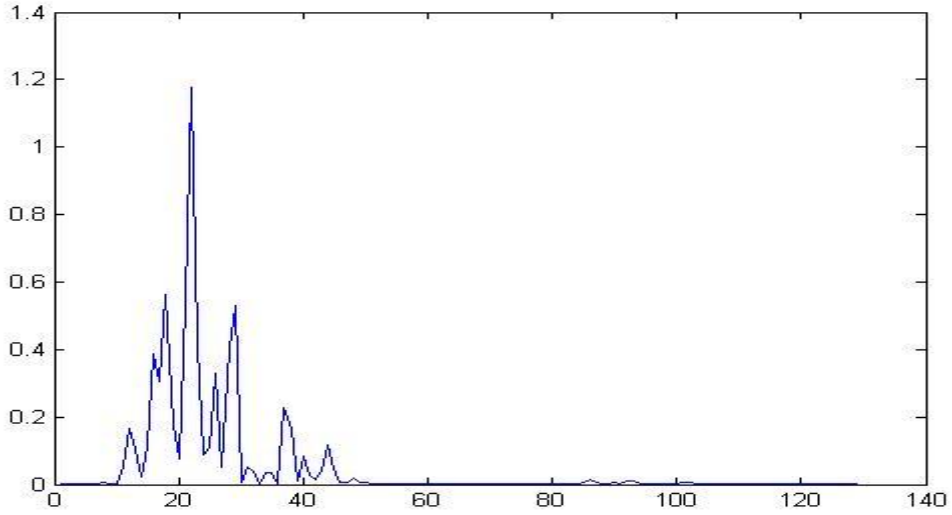


Figure 4.2 Welch power spectral density estimate for Fp2 channel on Control subject

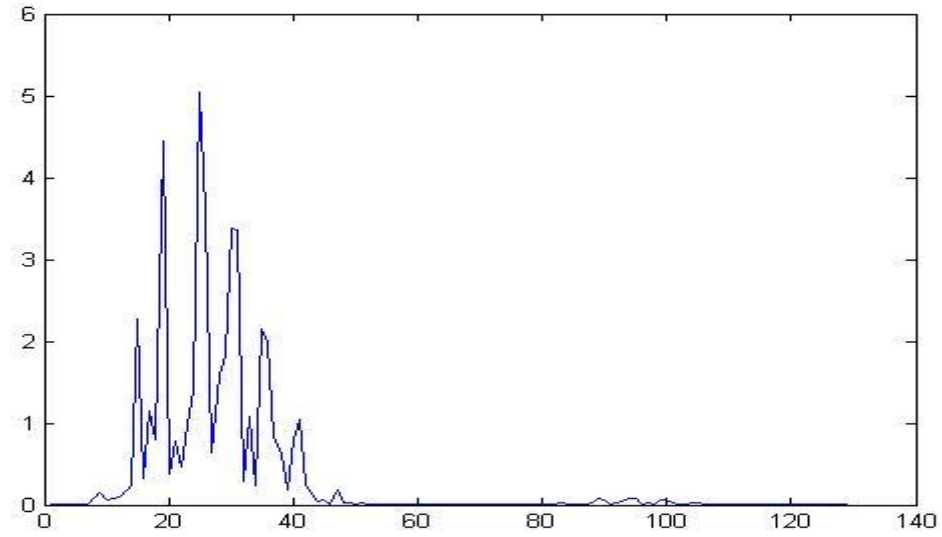


Figure 4.3 Welch power spectral density estimate for F8 channel on Alcoholic subject

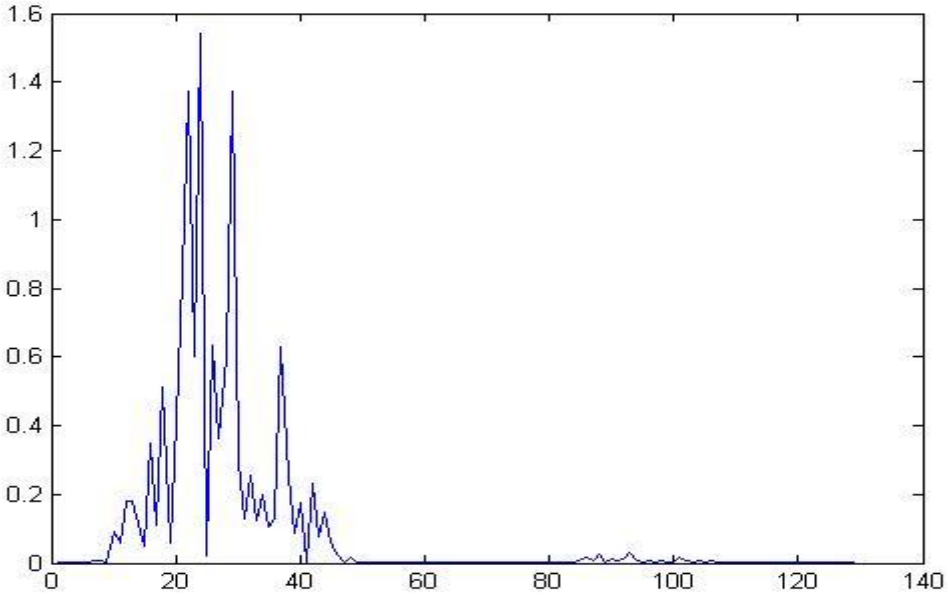


Figure 4.4 Welch power spectral density estimate for F8 channel on Control subject

CONCLUSIONS AND RECOMMENDATIONS

As a result, it shows that generally alcoholic subject frequencies value is higher than control subjects on 6 channels which are FP2, F8, C5, FT7, PO7, TP7. The other channels frequencies value is unsteady.

We have used Wavelet transform method, but PSD is FFT – based method.

In future, we can advance more details as we will find wavelet's coeffient corresponding for Beta, Alpha, Theta, Delta that it will be used to reconstruct signal. If we use the same based method, we will have more efficient results than this result.

If we use EEGs signals of alcoholic subjects shortly after drinking, the result of our study may surely be more meaningful than now. Furthermore, we will use gender-difference for using EEG datas. Because the effect of alcohol may be different in terms of gender.

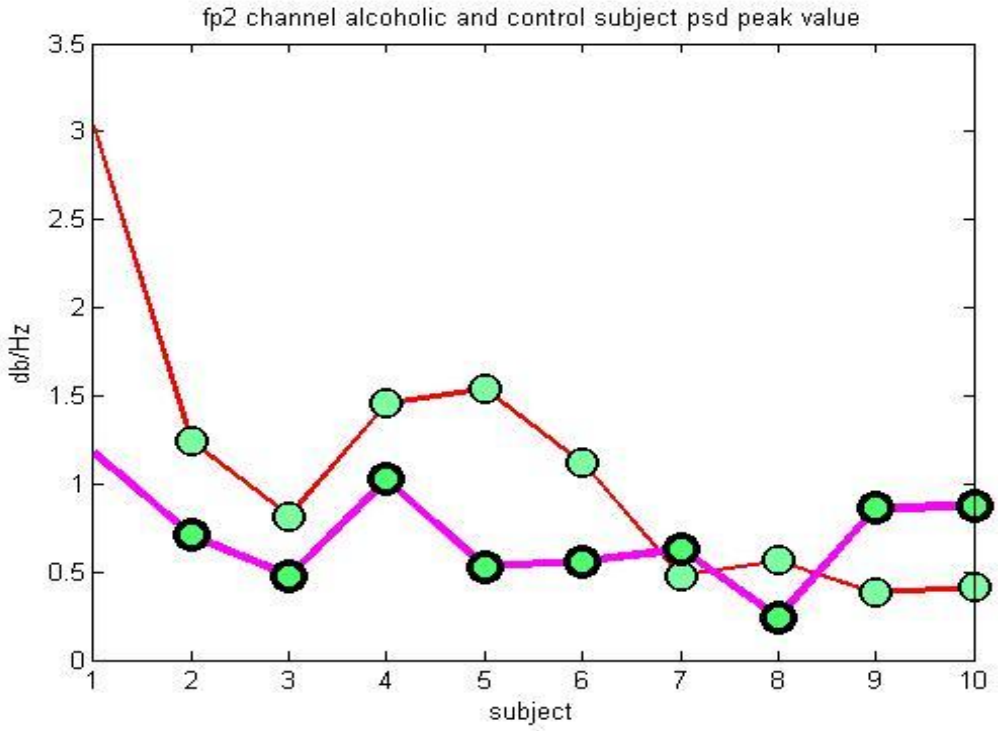


Figure 4.5 Fp2 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject , Pink line: Control subject)

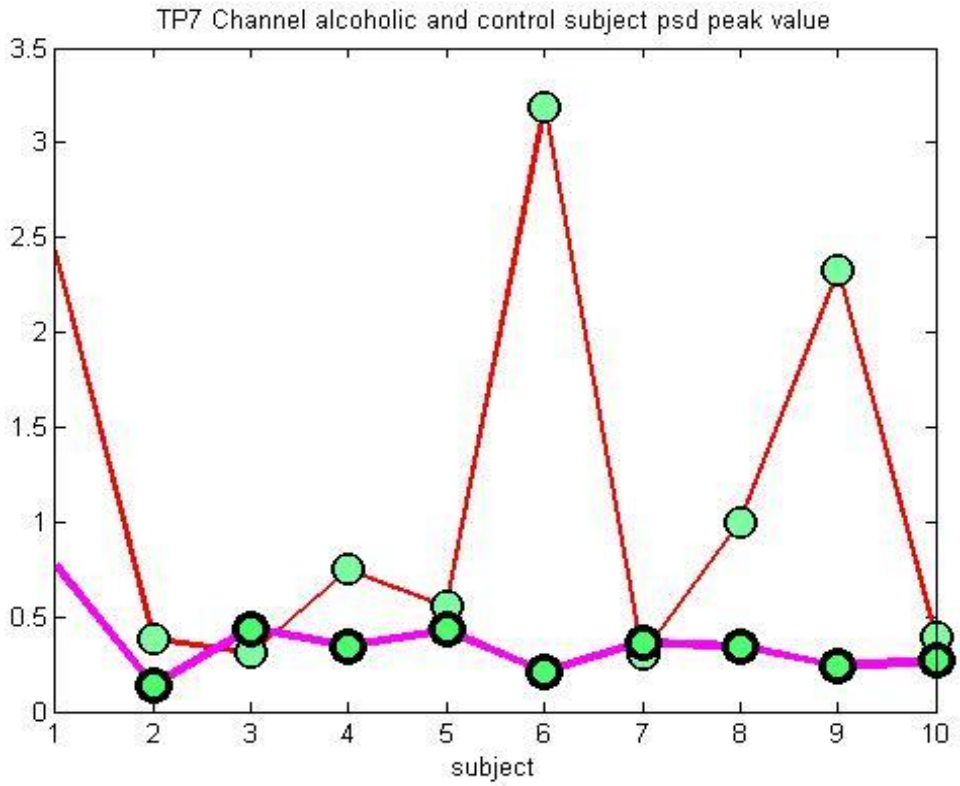


Figure 4.6 TP7 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

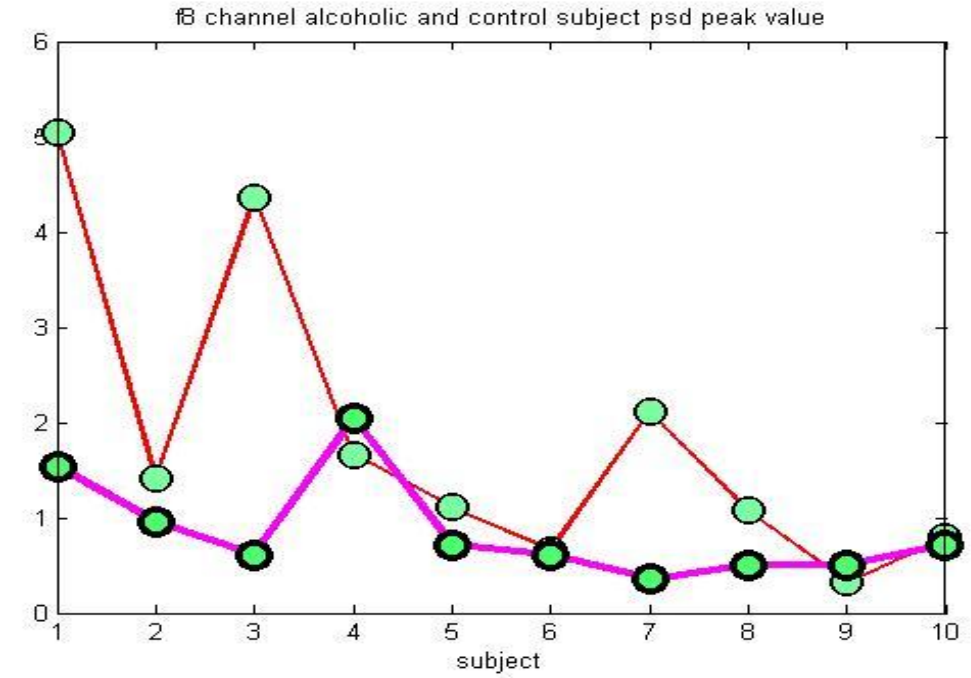


Figure 4.7 F8 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject, Pink line: Control subject)

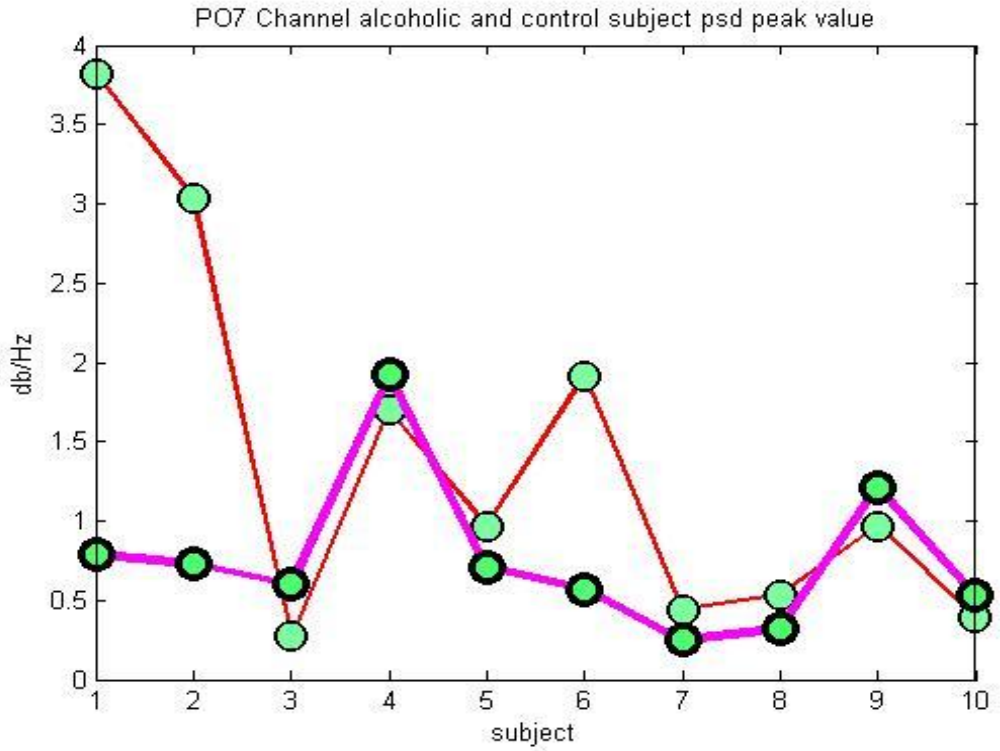


Figure 4.8 PO7 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

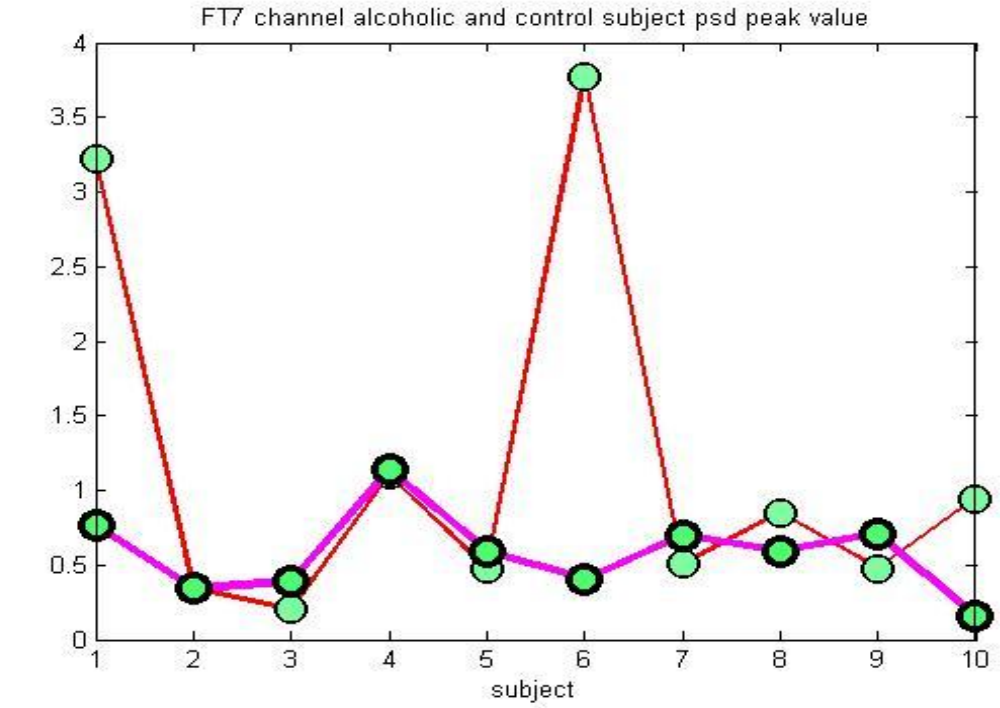


Figure 4.9 FT7 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

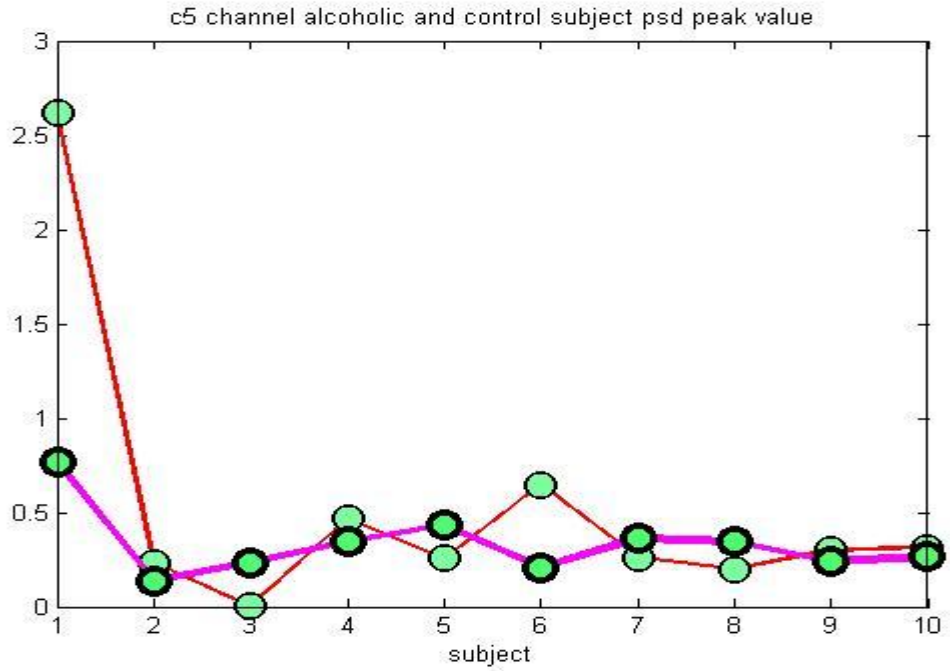


Figure 4.10 C5 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

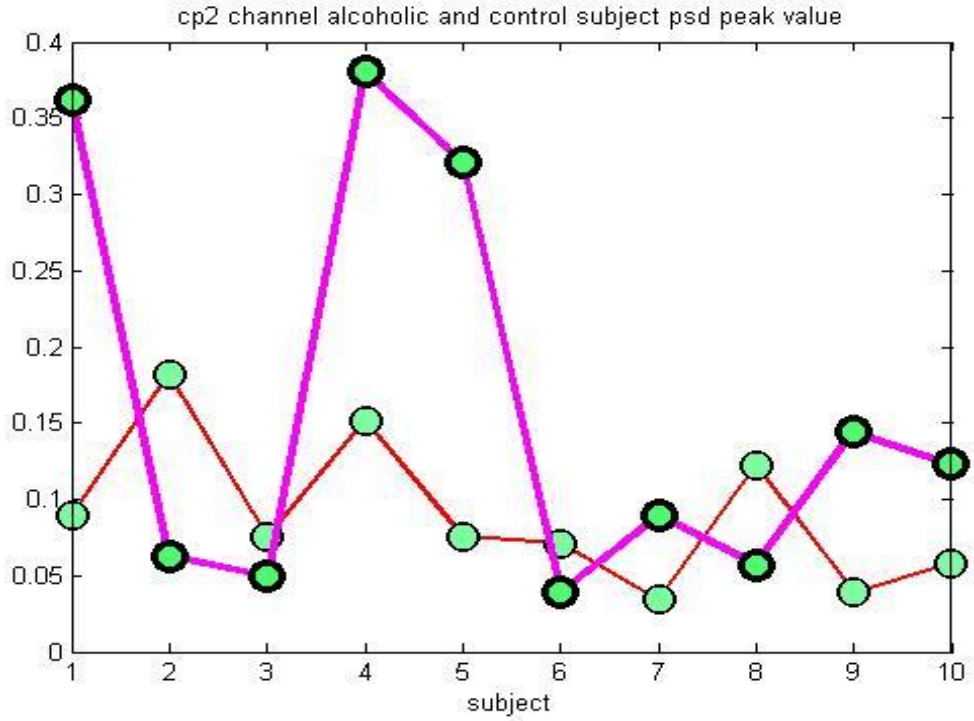


Figure 4.11 CP2 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject, Pink line: Control subject)

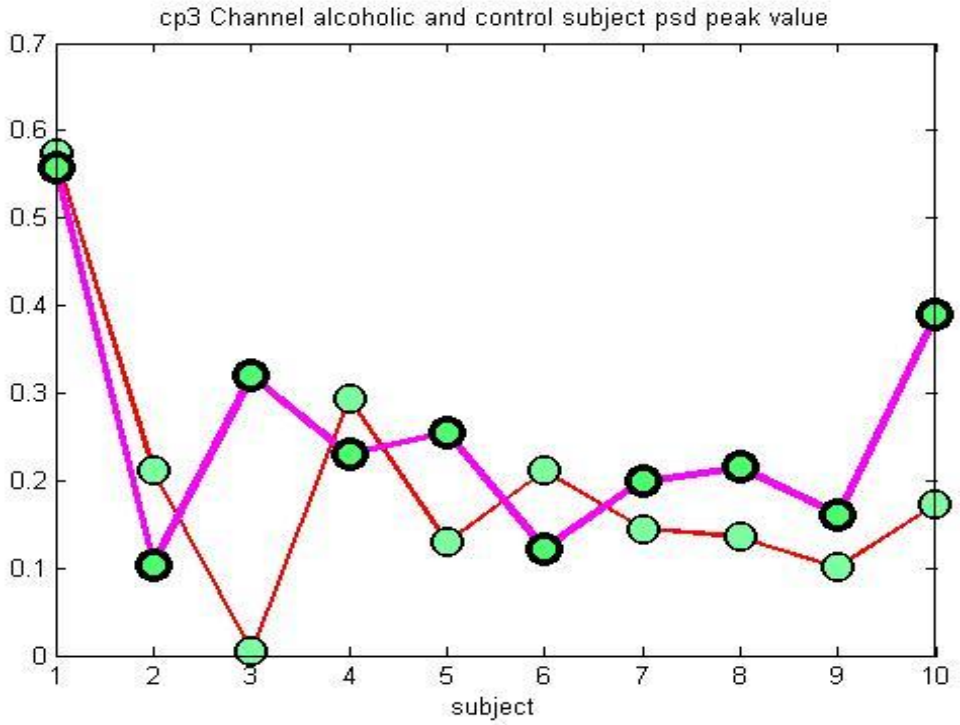


Figure 4.12 CP3 channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject,Pink line: Control subject)

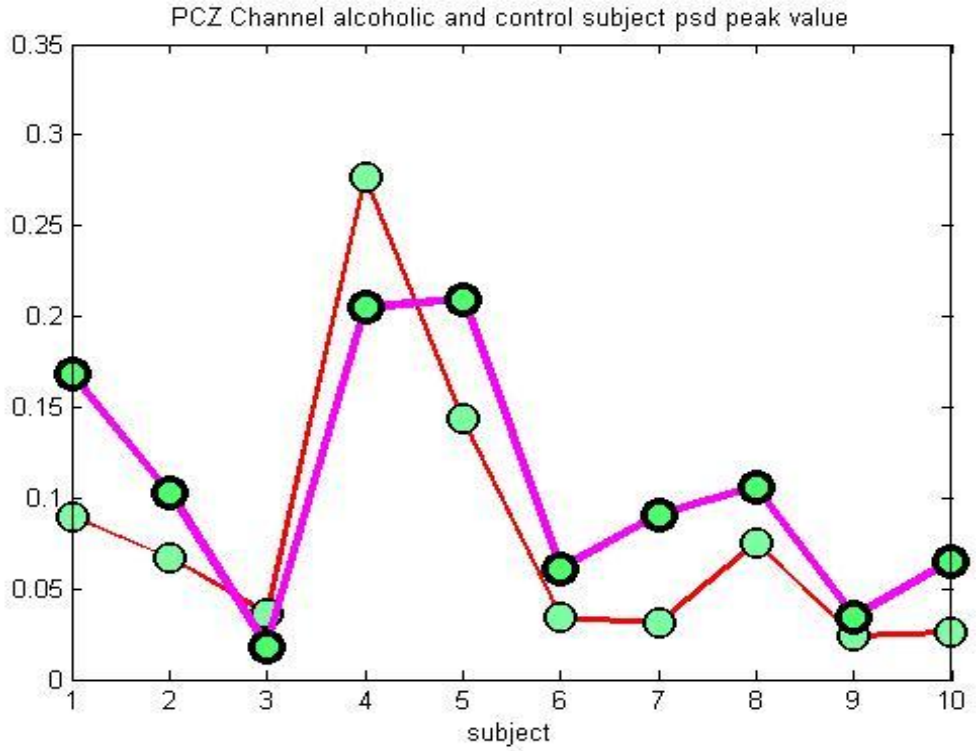


Figure 4.13 PCZ channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

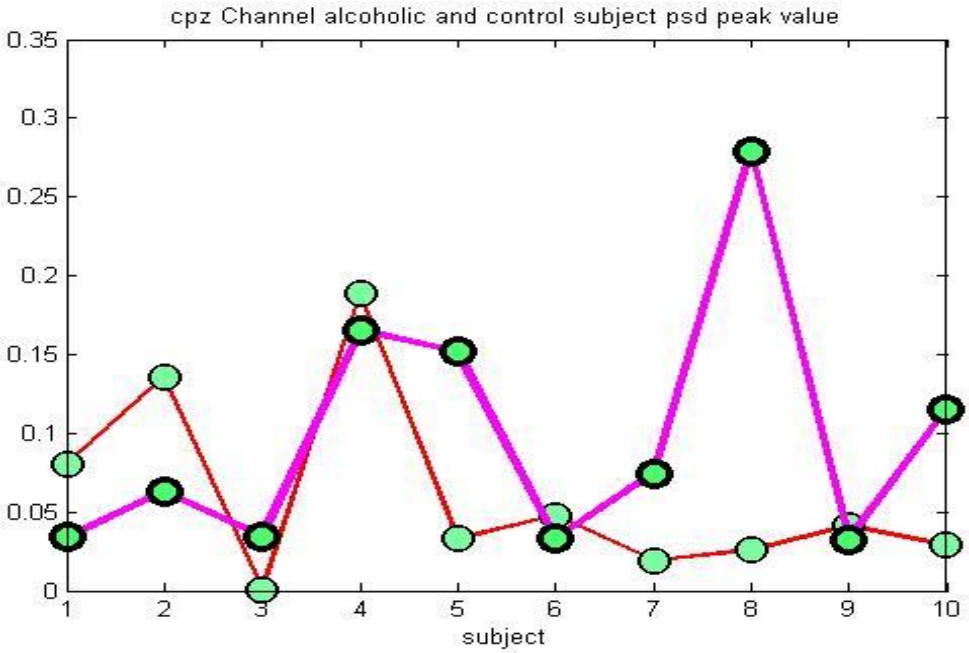


Figure 4.14 CPZ channel alcoholic and control subject psd peak value (Red line: Alcoholic Subject Pink line: Control subject)

REFERENCES

[1] Gururaj, G. N. Girish, and V. Benegal. Burden and socio-economic impact of alcohol: the Bangalore study. World Health Organization, Regional Office for South-East Asia, 2006.

[2] Oscar-Berman, M.and K. Marinkovic. "Alcoholism and the brain: an overview." Alcohol Research and Health (US NATIONAL INSTITUTE ON ALCOHOL ABUSE AND ALCOHOLISM) 27, no. 2 (2003): 125-133.

[3] Rehm, J. "The Risks Associated With Alcohol Use and Alcoholism." Alcohol Research and Health 34, no. 2 (2011): 135.

[4] T. Balli and R. Palaniappan. On the Complexity and Energy Analyses in EEG between Alcoholic and Control Subjects During Delayed Matching to Sample Paradigm International Journal of Computational Intelligence and Applications, 7(3):301–315, September 2008.

[5] Hayden, E.P., et al. "Patterns of Regional Brain Activity in Alcohol-Dependent Subjects." Alcoholism: Clinical and Experimental Research (Wiley Online Library) 30, no. 12 (2006): 1986-1991.

[6] Coan, J.A., and J.J.B. Allen. "Frontal EEG asymmetry as a moderator and mediator ofemotion." Biological psychology (Elsevier) 67, no. 1 (2004): 7-50.

[7] Ong, K. M. et al. "Selection of a Subset of EEG Channels using PCA to classify Alcoholics and Non-alcoholics." Conference proceedings: Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference. Vol. 4 2005.

[8] Courtney, Kelly E., and John Polich. "Binge drinking effects on EEG in young adult humans." International journal of environmental research and public health7.5 (2010): 2325-2336.

[9] Oliver Faust, Wenwei Yu, and Nahrizul Adib Kadri, J. mech. med. biol. 13, 1350033 (2013) doi: 10.1142/s0219519413500334

[10] Lin, C. F., Yeh, S. W., Chien, Y. Y., Peng, T. I., Wang, J. H., and Chang, S. H., A HHT-based time frequency analysis scheme in clinical alcoholic EEG signals. WSEAS Transactions on Biology and Biomedicine 5(10):249–260, 2008

[11] Liu, Jihong, and Jing Xu. "Compared study of the analyzing methods for EEG data." Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference on. Vol. 9. IEEE, 2010.

[12] Sharmilakanna, P., and Ramaswamy Palaniappan. "EEG artifact reduction in VEP using 2-stage PCA and N4 analysis of alcoholics." Intelligent Sensing and Information Processing, 2005. ICISIP 2005. Third International Conference on. IEEE, 2005.

[13] Rangaswamy, Madhavi, et al. "Beta power in the EEG of alcoholics." Biologicalpsychiatry (Elsevier) 52, no. 8 (2002): 831-842.

[14] Porjesz, Bernice, and Henri Begleiter. "Alcoholism and Human Electrophysiology." Alcohol Research and Health (US NATIONAL INSTITUTE ON ALCOHOL ABUSE AND ALCOHOLISM) 27, no. 2 (2003): 153-160.

[15] Rangaswamy, Madhavi, et al. "Theta power in the EEG of alcoholics." ALCOHOLISM: CLINICAL AND EXPERIMENTAL RESEARCH (Wiley Online Library) 27, no. 4 (2003): 607-615.

[16] YAZGAN E., KORÜREK M. Tıp Elektroniği. İTÜ Matbaası. 1996.

[17] SANEI S. CHAMBERS, J.A. EEG Signal Processing. 2007.

[18] Vista, Tutor. "Parts of Central Nervous System." http://www.tutorvista.com. 2010. http://www.tutorvista.com/content/science/science-ii/control/coordination/centralnervous-system.php (accessed July 12, 2012)

[19] Lodish, H., A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, and J. Darnell. Molecular Cell Biology. WH Freeman, 2000.

[20] Niedermeyer E. and da Silva F.L. (2004). Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. Lippincot Williams & Wilkins. ISBN 0-7817-5126-8

[21] Steriade, M., 'Basic mechanisms of sleep generation', Neurology, 42 (Suppl. 6), 1992, 9–17.

[22] Kubicki, S., Scheuler, W., and Wittenbecher, H., 'Short-term sleep EEG recordings after partial sleep deprivation as a routine procedure in order to uncover epileptic phenomena: an evaluation of 719 EEG recordings', Epilepsy Res. Suppl., 2, 1991, 217–230.

[23] Niedermeyer, E., 'Sleep and EEG', Chapter 10, in Electroencephalography Basic Principles, Clinical Applications, and Related Fields, Eds E. Niedermeyer and F. Lopes da Silva, 4th edn, Lippincott, Williams and Wilkins, Philadelphia, Pennsylvania, 1999, 174–188.

[24] Caton, Richard (1875), British Medical Journal

[25] Blinowska, Katarzyna, and Piotr Durka. "Electroencephalography (EEG)."Wiley Encyclopedia of Biomedical Engineering (2006).

[26] Pravdich-Neminsky, VV. (1913). "Ein Versuch der Registrierung der elektrischen Gehirnerscheinungen". Zbl Physiol 27: 951–60.

[27] M. A. B. Brazier, A History of the Electrical Activity of the Brain. The First Half-Century. London: Pitman, 1961

[28] P. Gloor, Hans Berger on the Electroencephalogram of Man. Amsterdam: Elsevier, 1969.

[29] Haas, L F (2003). "Hans Berger (1873-1941), Haas, L F (2003). "Hans Berger (1873-1941), Richard Caton (1842-1926), and electroencephalography". Journal of Neurology, Neurosurgery & Psychiatry 74 (1): 9. doi:10.1136/jnnp.74.1.9. PMC 1738204. PMID 12486257.

[30] Millet, David (2002). "The Origins of EEG". International Society for the History of the Neurosciences (ISHN).

[31] http://www.ibva.co.uk/images/berger_patient.jpg

[32] http://en.wikipedia.org/wiki/Neuron

[33] Budzynski, H., Budzynski, T., Evans, J. Introduction to Quantitative EEG and Neurofeedback: Advanced Theory and Applications. 2nd Edition. Elsevier Inc. 2009.

[34] RECHTSCHAFFEN A, KALES A. A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects. Brain Research Institute, UCLA, Los Angeles, USA, 1968.

[35] Aydemir Ö. ve Kayıkçıoğlu T., EEG TABANLI BEYiN BİLGİSAYAR ARAYÜZLERİ, Akademik Bilişim'09 - XI. Akademik Bilişim Konferansı Bildirileri, 7-13, 2009

[36] Shar brough F, Chatrian G-E, Lesser RP, Lüders H, Nuwer M, Picton TW (1991): American Electroencephalographic Society Guidelines for Standard Electrode Position Nomenclature. J. Clin. Neurophysiol 8: 200-2.

[37] Abbak, R.A, 2007, Jeodezide zaman dizilerinin dalgacık(wavelet) analizi, doktora semineri, jeodezi ve fotogrametri Müh. Anabilim dalı Selçuk Üniversitesi, Konya. 27 s.

[38] Polikar, R. 1999, The engineer's ultimate guide to wavelet analysis the wavelet tutorial, http://engineering.rowan.edu/~polikar/wavelets/wtpart3.html.DPT, (1985).

[39] Miner, N.E., 1998, An introduction to wavelet theory and analysis. Sandia Report, NM, October:1-25 p.

[40] Batar, H., 2005, EEG işaretlerinin dalgacık analiz yöntemleri kullanılarak yapay sinir ağlarıyla sınıflandırılması, yüksek lisans tezi, fen bilimleri enstitüsü, elektrik-elektronik müh. Anabilim dalı, Sütçü İmam Üniv., Kahramanmaraş.

[41] Fliege, N.J. 1996, Multirate digital signal processing (Multirate systems-filter bankswavelets). John Wiley & Sons, Chichester, 251 p.

[42] Daubechies, I. 1990, The wavelet transform, time-frequency localization and signal analysis, I. Daubechies, "The wavelet transform, time-frequency localization and signal analysis", IEEE Transactions on Information Theory, 36(5), 961-1005.

[43] Daubechies I, 1992, Ten lectures on wavelets, SIAM, Philadelphia.

[44] Percival, D.B., ve Walden, A.T., 2002, Wavelet methods for time series analysis, Cambridge University pres, second edition.56

[45] Lee, J.J., Lee, S.M., Kim, I.Y., Min, H.K., ve Hong, H.S., 1999, comparison between short time fourier and wavelet transfrom for feature extraction of heart sound, IEEE TEnCON,Volume:102:18-55.

[46] Misiti, M., Misiti, Y., Oppenheim, G., Poggi, J.M., Wavelet toolbox users guide, copyright 1996-1997 by the MathWorks, Inc.

[47] Bronzino, J. D., The Biomedical Engineering handbook, IEEE Pres,3erd edition.

[48] Proakis, J.G., Manolakis, D.G., Digital Signal Processing Principles, Algorithms, and Applications , Prentice-Hall, New Jersey, 1996.

[49] Übeyli, E. D., Güler, I., Selection of optimal AR spectral estimation method for internal carotid arterial Doppler signals using Cramer-Rao bound. Comput. Electr. Eng, 30,491–508, 2004.

[50] http://kdd.ics.uci.edu/databases/eeg/eeg.html

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