ENGINEERING RESEARCH JOURNAL (ERJ)
Vol. 1, No. 44 April 2020, pp.97-102.
Journal Homepage: erj.bu.edu.eg

Statistical Analysis of EEG Signals to Find the Relation between Heart Rate, Blood Pressure and the Brain Activities

Abduelaziz Almulaifi, Michael N.Mikhael, Hala A. Mansour

Faculaty of Engineering at Shoubra, Benha University, Cairo, Egypt.

Abstract: The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp. The recorded waveforms reflect the cortical electrical activities. EEG activity is quite small, measured in microvolts (µV). The EEG signal frequency ranges from less than 4 Hz and little higher than 30 Hz. The aim of this paper is to find the relation between the heart rate, blood pressure and the brain activities. The helping tool used for the measuring and the analyzing the EEG signal is called Mindwave head set from Neurosky. The head set is used with its simulation tool in conjunction with Matlab for analyzing the EEG signal. The Matlab is used for the extraction of the EEG frequency components using the FFT Algorithm. The experiment was done for 9 participants with ages ranging between 26 and 59 years. The measurements are repeated 10 times on different days, with 2 minutes of signal recording. The average value of the main EEG signal components (i.e. Delta, Theta and Alpha1) were calculated. It is found that for the main EEG components as the blood pressure decrease the EEG main components values increases. On the other hand, as the heart rate increases the EEG main components values decrease.

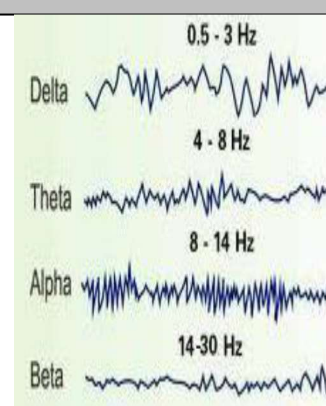
Keyword: EEG, Mindwave, FFT.

1. Introduction

The electroencephalogram (EEG) was first measured in humans by Hans Berger in 1929. Berger was the first to record the electrical activity of the human brain. Electrical impulses generated by nerve firings in the brain can be measured by electrodes placed on the scalp. The EEG gives a coarse view of neural activity and has been used to non-invasively study the physiology of the brain. EEG activity is quite small signal, measured in microvolt (µV) with the main frequencies of interest up to approximately 30 Hertz (Hz) and Signal range: 2µV (brain death) to several hundred µV. The frequency bands in EEG shown in the following table [1-3]:

TABLE 1: Ideal frequency ranges for EEG signals

EEG Signal	Frequency Ranges (Hz)	Remarks	Plot of EEG
Delta	<4	Deep sleep stages of normal adults.	
Theta	4-8	Normal infants and children as well as during drowsiness and sleep in adults.	
Alpha	8-14	Mostly below 50 µV, normal adults during relaxed and mentally inactive awakeness.	
Beta	14-30	Mostly below 30 µV, it is enhanced by expectancy states and tension.	
Gamma	>30	Usually, it is not of clinical and physiological interests and therefore often filtered out in EEG recordings.	



2. Literature Review

Zhengqiang Ni and others in 2011 describes how to extract the EEG signal and analyze it using feature extraction techniques [4]. Viktors Gopejenko, Ilja Mihailovs in 2015, their contributions are summed up in the determination of the brain rhythm frequency range and their implementation for the education of the psychic state identification classifiers. The proposed NCI allows the creation of the interaction scenarios with a computer based on the mental event control [5].

Rohit Mankar, Pranav Bawane, Tushar Landge in 2014, Their contributions are summed up in using the MATLAB for sensing and extracting brain waves. Using these extracted brainwaves, they made applications for different brain parameters like concentration and meditation. Such applications make life simpler and capable of showcasing creative aspects [6]. Wojciech SAŁABUN in 2014, presenting how to record and process the raw EEG signal from the MindWave MW001 in the MATLAB environment. His work shows how Fast Fourier Transform (FFT) is used to find the frequency components from a time domain signal. Based on a sample signal and spectral analysis, the basic EEG waves are presented [7].

Meenakshi, Dr. R.K Singh, Prof. A.K Singh in 2014, Linear discriminate analysis that are used to detect the discrete emotions (surprise, happy, fear, neutral and disgust) of human through EEG signals. measure EEG signals frequency range relating to seizure, divide them into five different domains such as α, β, γ, δ and θ related to the total range, and eliminate frequency distribution through FFT of EEG signals to compare the difference

3.2. The EEG Signal Extraction

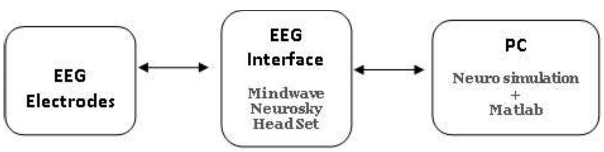


FIGURE 1: System Block Diagram.

As shown from the above figure the EEG signal extraction consists of Mindwave Neurosky head set as EEG interface. The Mindwave head set include electrodes, which are fixed on the patient head and connected through Bluetooth to the computer. The computer used to record the extracted signals

The recorded EEG signal are saved as a raw data for further processing. The first step for the processing was the FFT (i.e. fast Fourier Transform). The FFT used to find the different frequency components included in the EEG signal from which we can get the main EEG components (i.e. Delta, Theta, Alpha1, Alpha2, Beta1, Beta2, Gamma1 and Gamma2) [10].

After the signals were recorded, some statistical calculations carried out on the recorded samples (Min, Max, Average) and then compared to the measurements of both heart rate and the blood pressure.

3.3. Measuring the Heart Rate and Blood Pressure.

The measurement of the patient blood pressure and the heart rate is done using a simple digital device like the shown in the figure below.

between seizure and healthy subject. Calculations based on the selected frequency range [8]. In 2017 D.A. Blanco; A. Díaz-Méndez analyze the EEG signal using phase indexing technique to detect the human pain [9].

3. Experiment Explanation

3.1. Experiment Setup

The experiment was done for 9 persons with ages ranging from 26 years and up to 59 years, all of them were males. Each person carries out the measurement (i.e. EEG signal extraction and recording, and measuring booth heart rate and blood pressure) for 10 times on different days, with 2 minutes of signal recording. The following sections explains the measurement methods.

FIGURE 2: Heart rate and Blood pleasure measuring device.

3.4. Sample of the Experiment and data output for one person.

First step, is the fixing of the Mindwave Neurosky head set on the patient and start the signal extraction for 2 Mins. The recorded data of EEG signal will be saved in CSV file ad converted easily to excel file. The recorded signals are processed using the MATLAB to get the corresponding frequency components using the FFT [11] algorithm. In addition, the heart rate (HR) and blood pressure (BP) values should be taken simultaneously during or after the experiment and recorded in a table for each patient. The following table shows the results from saving the EEG signal for 2 Mins and the analysis using the FFT algorithm to the main EEG components.

TABLE 2: Example of EEG Signal Analysis and Saving into an Excel Sheet.

time	Delta	Theta	Alpha1	Alpha2	Beta1	Beta2	Gamma1	Gamma2
1	1.3	1264120	174231	93731	24713	25026	18022	18445
2	2.3	404412	4834	6447	1615	1771	1226	1185
3	3.3	326282	56004	10059	13041	4034	1649	2069
4	4.2	537986	54084	19835	8796	8397	2699	3721
5	4.8	551118	809884	13097	18097	15865	12497	7823
6	6.3	901822	95933	29842	52696	9617	4059	4982
7	7.2	2083258	853895	52593	109314	46644	36408	20289
8	8.2	1289426	71701	7006	6129	7905	5569	2847
9	9.2	111907	45309	2415	2046	1028	1335	1040
10	10.2	602568	308515	22390	65823	9815	19051	8073
11	11.2	448715	74171	27636	11646	13645	12161	15115
12	12.2	780878	38623	23756	16165	6126	6970	3117
13	13.2	587842	435903	7821	40587	18926	7512	5984
14	14.2	164613	32884	10843	31795	4825	4500	3967
15	15.2	631901	107627	2273	12130	4769	2815	1928
16	16.2	949586	54438	7715	7303	7470	5838	2333
17	17.2	343239	31720	11548	11176	10139	2857	3744
18	18.1	1807623	124832	9761	40858	17693	13799	13640
19	19.1	244601	107367	26250	6642	4649	2859	2372
20	20.1	567403	83210	27930	29296	40224	28309	10727
21	21.2	93637	13656	943	2159	3876	1896	1278
22	22.1	203674	86847	81308	27347	24513	29452	13020
23	23.1	1891539	253707	9257	28548	17084	22324	14194

The statistical analysis for 120 Samples (i.e. one sample per second from the EEG signal) are:

- Min and Max.
- The average.

The statistical analysis makes it easy to compare the EEG signal with the corresponding heart rate (HR) and Blood pressure (BP) recorded as shown in the following table:

TABLE 3: BP and HR for first patient during ten days.

Name : Abdulaziz AL Mulaifi -Age: 37 -Sex: Male -Nationality: Kuwaiti			
Exp.NO.	Date	Blood Pressure	Heart Rate
		#BP (mm Hg)	#HR (Pulse /Min)
1	15/09/2018	125/85	65
2	10/03/2018	122/78	63
3	11/11/2018	117/76	54
4	17/11/2018	116/71	56
5	18/11/2018	113/66	57
6	11/01/2019	124/84	66
7	12/01/2019	123/79	64
8	13/01/2019	118/77	55
9	14/01/2019	117/72	57
10	15/01/2019	114/67	58

3. Results analysis

The analysis divided into 2 parts:

- The relation between the EEG signal components and the Blood pressure (BP).
- The relation between the EEG signal components and the Heart Rate (HR).

The following figures shows the comparison between the EEG signal components values for different Blood Pressure for the same person (Person No. 4).

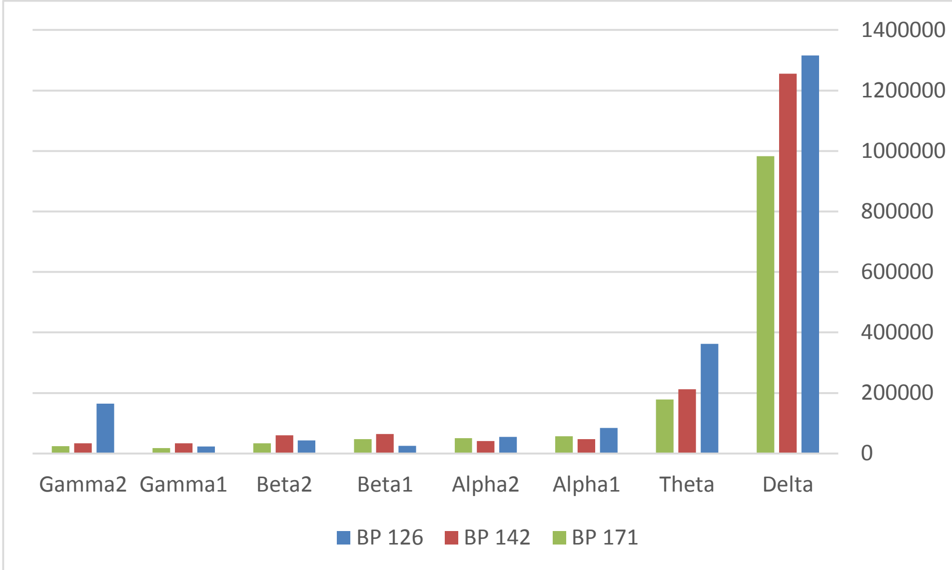


FIGURE 5: EEG Signal Components for different BP for person No. 4.

As shown from the above figure it is clear that for the main EEG components (i.e. Delta, Theta and Alpha1) as the Blood Pressure decrease the EEG main components values increases, the same analysis also, clear for person No. 7.

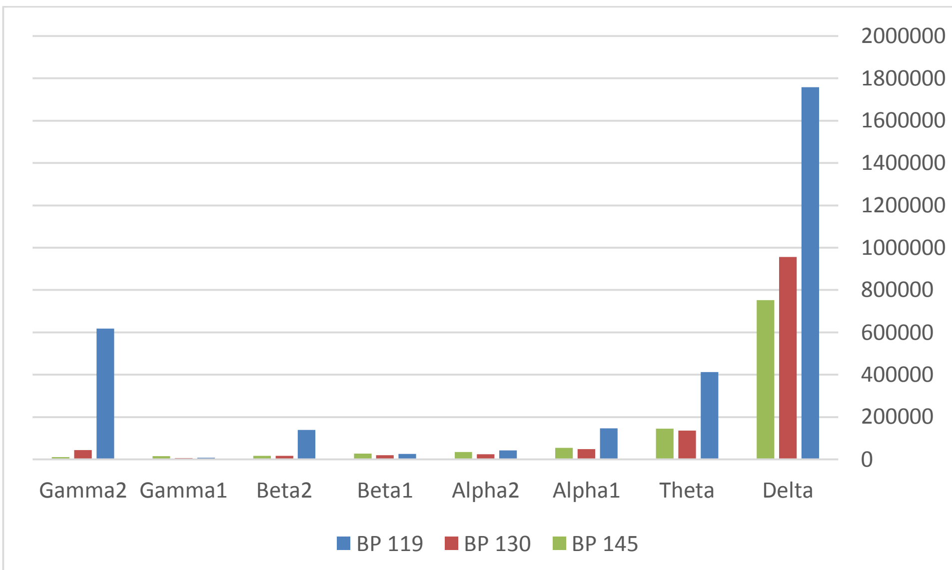


FIGURE 6: EEG Signal Components for different BP for person No. 7.

As shown from the above figure it is clear that for the main EEG components (i.e. Delta, Theta and Alpha1) as the Blood Pressure decrease the EEG main components values increases.

Another statistical comparison was done between 3 persons (i.e. person No1, 5 and 4), and also the same relation still holds. The following figure shows a comparison between the EEG signal components for 3 different persons, and it is clear that for the main EEG components (i.e. Delta, Theta and Alpha1) as the Blood Pressure decrease the EEG main components values increases.

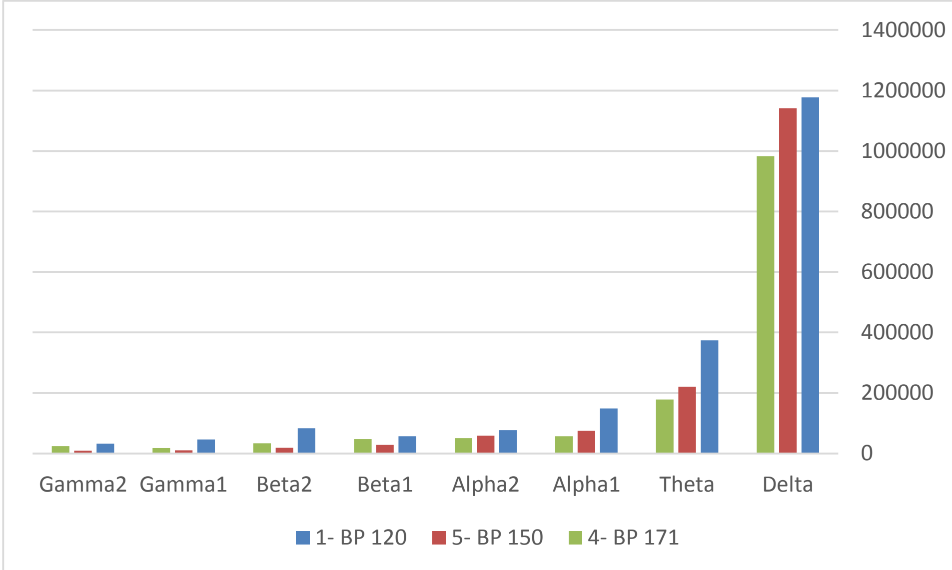


FIGURE 7: EEG Signal Components for different BP for 3 persons No. 1,5 and 4.

The following figures shows the comparison between the EEG signal components values for different Heart Rates for the same person (Person No. 5).

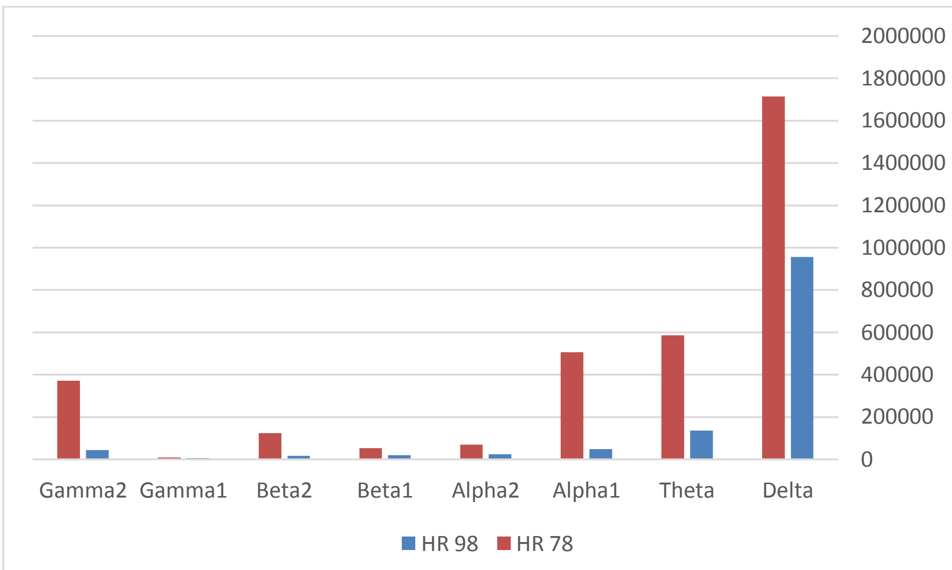


FIGURE 8: EEG Signal Components for different HR for person No. 5.

As shown from the above figure it is clear that for the main EEG components (i.e. Delta, Theta and Alpha1) as the Heart Rate Increases the EEG main components values decrease, the same analysis also, clear for person No. 8.

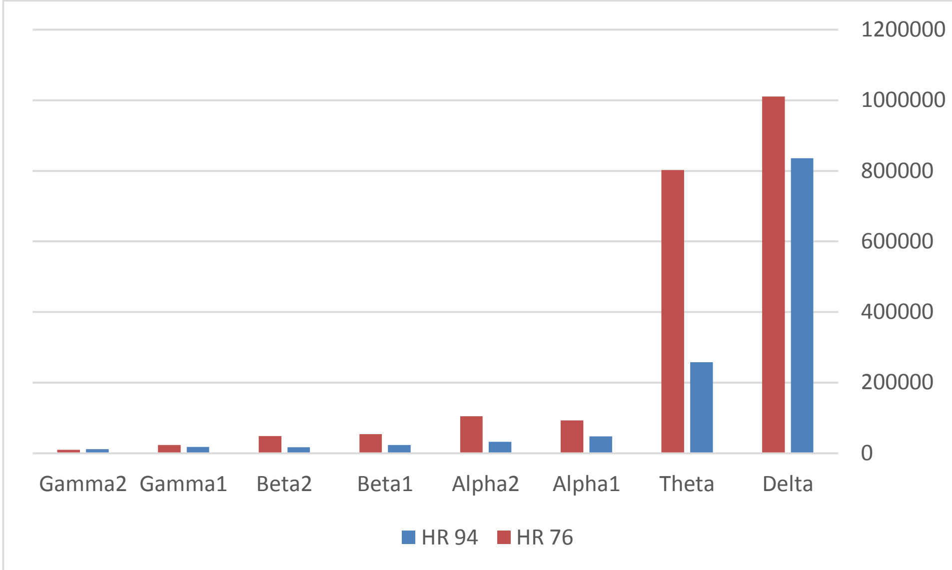


FIGURE 8: EEG Signal Components for different HR for person No. 8.

As shown from the above figure it is also confirm that, for the main EEG components (i.e. Delta, Theta and Alpha1) as the Heart Rate Increases the EEG main components values decrease.

5. Conclusions

This paper presents an experimental result, which is used to find a relation between their EEG signal data (delta, alpha, beta, gamma and theta) extracted from Mindwave Neurosky head set and the common diseases like high blood pressure, high pulse rate and diabetes. The experiment was done for 9 participants with ages ranging from 26 years and up to 59 years, all of them were males. Each person carries out the measurement (i.e. EEG signal extraction and recording, and measuring booth heart rate and blood pressure) for 10 times on different days, with 2 minutes of signal recording. It is found that for the main EEG components (i.e. Delta, Theta and Alpha1) as the Blood Pressure decrease the EEG main components values increases. On the other hand, as the Heart Rate Increases the EEG main components values decrease.

6. References

[1] Niedermeyer E.; da Silva F.L. (2004). Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. Lippincott Williams & Wilkins. ISBN 978-0-7817-5126-1.

[2] Tatum, William O. (2014). Handbook of EEG interpretation. Demos Medical Publishing. pp. 155–190. ISBN 9781617051807. OCLC 874563370.

[3] Chernecky, Cynthia C.; Berger, Barbara J. (2013). Laboratory tests and diagnostic procedures (6th ed.). St. Louis, Mo.: Elsevier. ISBN 9781455706945.

[4] Zhengqiang Nia, Lei Wanga, Jun Menga, Fuming Qiub, Jian Huangb, " EEG Signal Processing in Anesthesia Feature Extraction of Time and Frequency parameters", ICESB 2011: 25-26 November 2011, Maldives.

[5] Viktors Gopejenko ; Ilja Mihailovs , Neurocomputer interface, the classification of the brain waves and virtual reality control, 2015 9th International Conference on Application of Information and Communication Technologies (AICT) , DOI: 10.1109/ICAICT.2015.7338595.

[6] Rohit Mankar ; Pranav Bawane ; Tushar Landge ; Palash Dalal ; Vivek Gour, Brain wave sensing, 2014 Annual IEEE India Conference (INDICON) , DOI: 10.1109/INDICON.2014.7030595

[7] Wojciech SAŁABUN, Processing and spectral analysis of the raw EEG signal from the MindWave, West Pomeranian University of Technology, Szczecin PRZEGLĄD ELEKTROTECHNICZNY, ISSN 0033-2097, R. 90 NR 2/2014 DOI:10.12915/pe.2014.02.44

[8] Meenakshi, Dr. R.K Singh, Prof. A.K SinghFrequency Analysis of Healthy & Epileptic Seizure in EEG using Fast Fourier Transform International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, 2014, ISSN 2091-2730.

[9] D.A. Blanco; A. Díaz-Méndez, " Pain detection with EEG using Phase Indexes", 2017 IEEE Healthcare Innovations and Point of Care Technologies (HI-POCT).

[10] MindWave User Guide - Developer Neurosky.

[11] Van Loan, Charles (1992). Computational Frameworks for the Fast Fourier Transform. SIAM.