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Electrode Area Analysis of EEG Signals Received from Schizophrenic Individuals

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ABSTRACT

It is very difficult to distinguish between healthy and schizophrenic individuals based on raw data. However, with the analyzes made, the separation of healthy and sick individuals from each other has become quite evident. In the study, EEG signals were obtained by means of electrodes from the anterior region, middle and posterior regions of the brain, and analyzed according to their positions. Apart from the time-amplitude graph, PSD and STFT analyzes have also performed the analyzes and the results were compared. As a result of this study, the results of PSD analysis are quite successful in distinguishing between healthy and schizophrenic individuals. In this sense, this method includes features that can be used by physicians for diagnostic purposes. In addition, the analysis results are compatible with each other and the results are meaningful. In particular, the results of PSD analyses give very distinctive results that can be used for diagnosis. In addition, the results of the analyzes made with the STFT method are also compatible with the PSD analyses, where healthy individuals have a trend of around 10 Hz, and individuals diagnosed with schizophrenia have a trend of up to 20 Hz.

1. INTRODUCTION

Schizophrenia (SZ) is a brain disease that is characterized by the destruction of social bonds, the formation of cognitive deficits, and the impoverishment of the emotional-volitional area of the personality, belonging to the psychosis family, which occurs as a result of a yet unknown pathology in the human population, leading to progressive, chronic mental disorders [1].

If SZ disease is not treated, it generally shows a progressive course and negatively affects the quality of life of the individual. As a result of deterioration in cognitive functionality, which is one of the main features of the disease, the patient also causes personal, social, social and economic negativities. This is largely due to the deterioration of the psychosocial functionality of patients with SZ. Patients have difficulties in developing social relationships, getting or maintaining a job, and even meeting their simple daily needs without environmental support [2, 3].

The prevalence of SZ is approaching 1 percent internationally. Its incidence is 0.8-1% of the total population, and its annual incidence reaches 2 million individuals[4, 5]. Although the conditions leading to SZ are still unclear, many studies suggest that genetic disorders due to strong family relationships play a vital role in the incidence of the disease [6, 7]. Like many common medical diseases in society, SZ is an inherited disorder that arises from the interaction of both genetic and environmental sources. However, unlike disorders such as Huntington's disease, which is the result of a dominant mutation in a single gene, SZ is a common genetic variant such as type 2 diabetes, and ischemic heart disease, but also caused by common variants of many genes, each with a specific effect, but also such as culture, habits, and diet. It is a common medical disease caused by a complex gene/environment interaction that is also affected by other factors [8].

Along with the factors mentioned above, deprivations in individual psychology play an active role in the emergence of the disease. As a matter of fact, as reported in scientific research, it usually manifests itself with a high incidence in early adult people (between 15 and 25 years old) with low socio-cultural structure and income level, single and living alone, and progresses in episodes if not treated. The onset of the disease before the age of 10 and after the age of 60 is rare [4, 9, 10].

The drug treatment of SZ is complex. Treatment is usually a long-term process that lasts until the appropriate dose and drug are determined by trial and error method according to the patient. Antipsychotic drugs targeting positive symptoms are expensive and partially effective, and extrapyramidal side effects such as akathisia and tardive dyskinesia occur with the use of antipsychotics, and important side effects such as agranulocytosis and metabolic syndrome are are occur with the use of atypical antipsychotics [11]. Even if the existing drugs used in the treatment of SZ provide a significant improvement in the positive symptoms of the disease in the long term, they do not show sufficient effect on the negative and cognitive symptoms. In addition, this area has become an important target in terms of new drug development due to the inability to provide adequate treatment with available medical facilities in typical SZ.

Traditional clinical diagnoses can sometimes be inaccurate because people with schizophrenia sometimes deliberately hide their symptoms, and experts sometimes have trouble distinguishing schizophrenia from other mental illnesses because of similar symptoms.

To meet this challenge, researchers have made incredible progress in recent years, particularly in specialized centers for diagnosing people suffering from mental disorders and improving care in the broader sense and therefore quality of life.

The various tools that have been developed greatly assist psychiatrists and clinical psychologists in diagnosing schizophrenia [12]. Today, apart from the blood test, brain elaritama, positron emission tomography (PET), computerized tomography (CT), which combines cross-sectional images (slices) of the brain from different angles in a computer environment with the help of a series of X-rays, magnetic field to create detailed images of brain tissues, today help in clinical diagnosis. With the help of the Magnetic Resonance Imaging (MRI) technique, which uses computer-generated radio waves and computer-generated radio waves, there is an effort to develop an objective, quantitative biomarkers that can increase the overall accuracy of diagnosis with the help of neuroimaging technologies [13].

Despite all these technological possibilities, definitive objective criteria for the diagnosis of schizophrenia have still not been found and the morphological changes in the brains of the patients that will help the diagnosis have not been fully demonstrated. On the other hand, as a result of functional and structural imaging studies, it was understood that the source of schizophrenic symptoms was distributed in more than one anatomical region. Among the various neuroimaging methods, electroencephalography (EEG) is considered one of the most useful methods due to its ability to directly measure neural activity in the brain, its high temporal resolution, its ability to manage cognitive activities in the absence of behavioural responses, and its low cost [12]. An EEG is a voltage-time graph where the vertical axis (*y*) is voltage and the horizontal (*x*) axis is frequency. It is the voltage difference between two electrode areas (at least one of which is on the scalp) placed at a given moment. With EEG analysis, it can be explained how the brain works, which regions of the brain are active and how the active regions communicate with each other.

In this study, spectral features were extracted by comparing EEG data from patients with and without schizophrenia. With this time-frequency analysis, the EEG data of patients and non-patients were compared and its usability for diagnosis was investigated.

2. DATA COLLECTION AND MATHEMATICAL BACKGRAOUND

In the archive where the data were taken [14], there are two groups of EEG data taken from two subject groups. 39 of them were healthy and 45 of them were from the group showing schizophrenic symptoms. The sampling frequency of the data is 128kHz. The topographic locations of the electrodes from which the EEG data were collected are shown in Figure 1. In the study, the analysis of the EEG signals taken from the Cz, F4, P4, Pz, T3 and O1 electrode regions was performed. MATLAB© package program was used in the analysis. In addition, analyzes were made using Welch and STFT mathematical approaches.

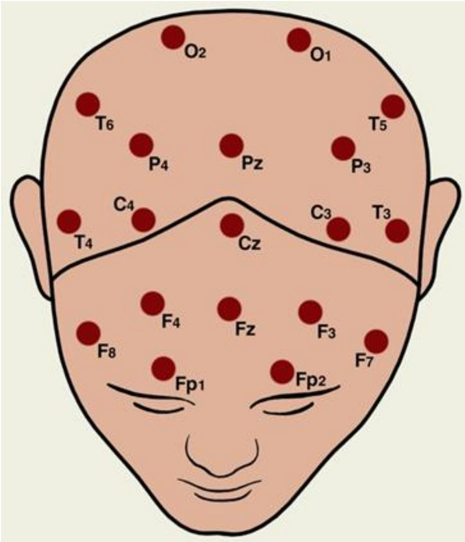

Figure 1. Representative map showing the locations of the electrodes [1]

2.1. Welch Method

The periodogram method used for GSY estimation of the frequency components of a signal is based on the Fourier transform. In order to obtain the GSY of a sign by the periodogram method, the sign is divided into the second power and frames such as 64, 128 and 256. In this method, the data is divided into overlapping segments and the GDP estimation is calculated by averaging the Fourier transform of each segment.

The disadvantage of non-parametric spectral estimation techniques such as the periodogram is that there are leaks in the lobes that occur in finite data sets. To overcome this problem, the Welch method was developed. The Welch method consists of 4 steps. First, the sign is divided into overlapping segments. Each segment of data is windowed to smooth the edges of the marks. Then, the periodogram of each windowed segment is taken and its estimated average is calculated. The Welch method estimates the power spectral density by averaging the improved periodograms. The i th improved periodogram is given in equation 1.

$$S_i(f) = \frac{Y}{K.M}\left|\sum_{n=1}^{M-1} x(n)w(n)e^{-j2\pi}\right|^2 \qquad (1)$$

It is given as in the equation. Here f = fsnormalized frequency variable *Ys* scaling factor, $w(n)$ windowing function and K normalized constant, and the following expression is given.

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

The power spectral density estimation of the Welch method is given in Equation 3. Here L is the length of the sign [15].

$$P(f) = \frac{1}{L}\sum_{i=0}^{L-1} S_i\,(f) \qquad (3)$$

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2.2. Short Time Fourier Transformation (STFT)

The short-time Fourier transform (STFT) is obtained by taking the classical Fourier transform of the signal divided by a time-shifting window. Spectrum estimation can be made by assuming that the part of the examined signal received with the window remains stationary.

FT is applied after the cue is passed through a defined window in the time domain. By shifting the window function in the time axis to cover the entire signal, frequency responses (frequency spectra) of the signal in time intervals in the width of the window function are obtained. In this way, it is as if the variation of the frequency response of the signal with time is obtained. Equation 4, which provides the STFT transformation, is given.

$$STFT(\tau, f) = \int_{-\infty}^{\infty} [x(t).w^*(t-\tau)].e^{-j2\pi ft}dt \tag{4}$$

Here; $x(t)$ is a principal sign, $w(t)$ is the window function, and * is the complex conjugate notation, translation in time. STFT consists of the FT of the sign multiplied by a window function. A new set of STFT coefficients is calculated for each t and f. As such, FT is a function of frequency only, while SFFD is a function of both frequency and time, and as such, it is three-dimensional (third-dimensional amplitude). STFT gains importance if the signal is not stationary. In this case, the signal is divided into segments that are considered stationary and the FT of each segment is different. If the sign is stationary, the FT each segment will be the same (or similar) and thus the CFFD and FT will be the same (or similar) [16-21].

3. DATA ANALYSIS of EEG SIGNALS of SCHIZOFRENIC AND NORMAL INDIVIDUALS

EEG signs of schizophrenic and normal individuals are given in Figure 2 and Figure 3 below. Figure 2 shows the time-amplitude graphs of healthy individuals according to the electrode positions. In terms of the comprehensiveness of the signs, the signs from each part of the brain were examined separately, and in terms of their significance, the electrodes in the anterior-middle and posterior parts were shown in the analysis. When Figure 2 and Figure 3 are examined, amplitude differences can be seen in the EEG data of healthy and schizophrenic patients.

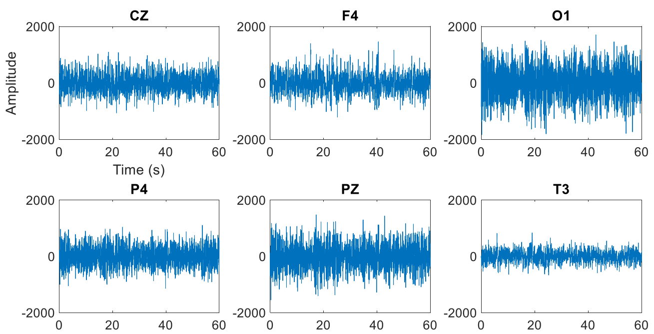

Figure 2 Time variation of EEG signals according to the positions of healthy individuals

In Figure 2, the amplitudes in the EEG data of healthy individuals have an amplitude of around 1000 dB, while in Figure 3 it can be seen that they reach higher amplitude values.

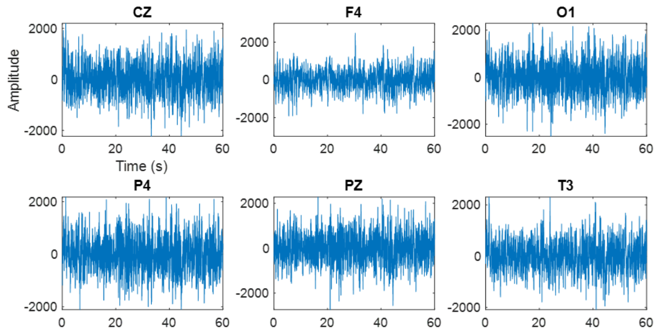

Figure 3. Change of EEG signals over time according to the positions of sick individuals

When an evaluation is made between the healthy and sick signs, it is seen that the amplitudes of the signals from the CZ, P4 and T3 electrodes are significantly higher than those of the sick ones. Especially in T3, this increase is at the maximum level.

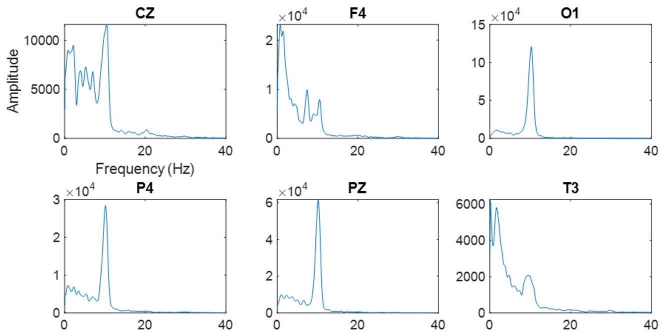

Figure 4. Change of power spectrum of EEG signals according to the positions of healthy individuals

Power spectrum analyzes of EEG signals were performed in Figure 4 and Figure 5. Power spectrum analysis of healthy individuals is given in Figure 4, and PSD analysis of EEG signs of individuals diagnosed with schizophrenia in Figure 5. Here, when the signals taken from the same electrodes are compared, it is seen that schizophrenic and healthy individuals can be detected very clearly in the analyzes with PSD. This application can be evaluated as an important criterion that can be used for diagnosis.

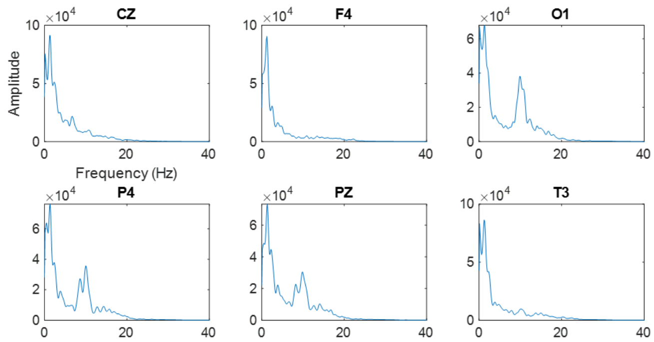

Figure 5. Change of power spectrum of EEG signals according to the positions of sick individuals

When the power spectrums are examined, an increase in the low frequency amplitudes of the diseased signals (delta and theta waves) compared to normal was observed in all electrode signals in general. This increase is more noticeable in the CZ, P4 and T3 electrodes. In high frequency waves (alpha, beta waves) a decrease and fading were observed in general. In particular, the amplitude decrease in O1 and PZ was observed as damping in the other electrodes.

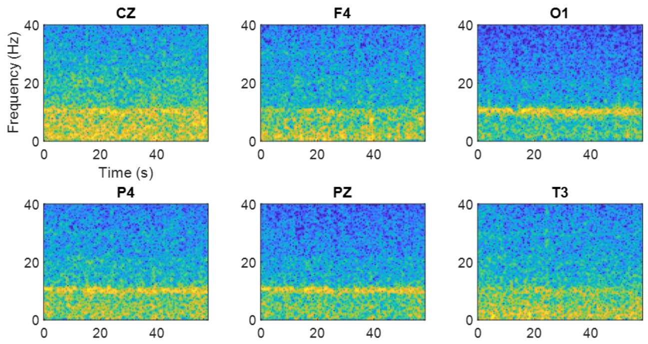

Figure 6. Spectrograms of EEG signals according to the positions of healthy individuals

STFT spectrograms of EEG data of healthy individuals and individuals diagnosed with Schizophrenia are given in Figure 6 and Figure 7. From the analyzes made here, it is possible to make a comparison in terms of frequency between healthy and schizophrenic individuals. In the analyzes made, it was determined that the EEG spectra were around 10 Hz in healthy individuals, while this value doubled, that is, around 20 Hz, although it varies according to the region where the electrodes are attached in patients diagnosed with schizophrenia.

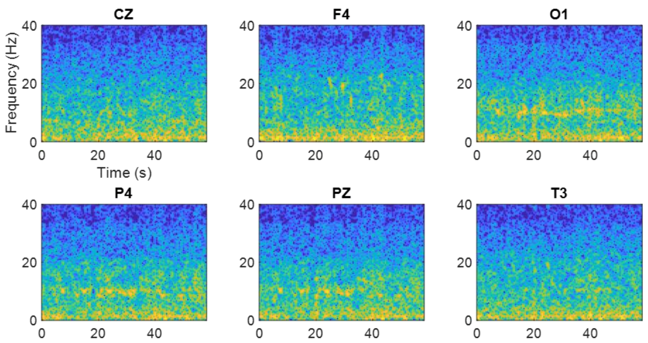

Figure 7. Spectrograms of EEG signals according to the positions of sick individuals

When the normal spectrograms are examined; It has been observed that alpha theta and delta waves are active in CZ, and alpha waves are very noticeable in the signals of O1, P4 and PZ electrodes. It is noteworthy that in general, alpha waves are considerably reduced in patient spectrograms. Again, in general, theta and delta waves are either protected or strengthened. Especially in O1 and P4 electrodes, theta and delta waves became stronger.

4. CONCLUSION

In this study, EEG data obtained from 39 healthy and 45 schizophrenic individuals were analyzed by time-frequency, PSD and Welch methods. It is very difficult to distinguish between healthy and schizophrenic individuals based on raw data. However, with the analyzes made, the separation of healthy and sick individuals from each other has become quite evident. In the study, EEG signals were obtained by means of electrodes from the anterior region, middle and posterior regions of the brain, and analyzed according to their positions. Apart from the time-amplitude graph, PSD and STFT analyzes have also performed the analyzes and the results were compared. As a result of this study, the results of PSD analysis are quite successful in distinguishing between healthy and schizophrenic individuals. In this sense, this method includes features that can be used by physicians for diagnostic purposes. In addition, the analysis results are compatible with each other and the results are meaningful.

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