Comparison of Adult Human Emotional States Using Electroencephalography Signals with Voice Recording and Pictures

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Abstract *—In this study, it is aimed to evaluate the emotional state of individuals, who had a traffic accident and didn't have a traffic accident, in the face of auditory and visual stimuli using electroencephalography (EEG) signals. Two different types of stimuli are used that one is auditory and the other one is visual. Stimuli consist of a traffic accident sound effect and 3 traffic accident pictures. The study was carried out with 3 women at the age of 30 and 3 man subjects at the age of 30 who had a traffic accident in the same year, and 3 female at the age of 30 and 3 male subjects at the age of 30 who had no traffic accident in the same year. Education level of all participants is the same that all have associate degree. Traffic accident sound effect and traffic accident pictures are presented to the participants in order to determine the changes in the emotional stateof the participants. EEG signals are obtained with the Emotive EPOC+ device which is placed on the participant's head during the presentation of sound effect and pictures. The obtained data is purified by applying a notch filter and band pass filter. After performing feature extraction with power spectral density analysis, classification is made by linear discrimination analysis. As a result of the study, it is seen that the traffic effect sound effect is more effective on the emotions of the participants than the traffic accident pictures. While there is no significant difference between the genders on the emotions of the participants, it is observed that they create different emotions between those who have had traffic accidents and those who have not. The obvious result of the study is that people who have a traffic accident are affected more by the sound effect of traffic accident.*

Keywords — *Electroencephalography, EEG, Brain Computer Interface, Brain, Emotive EPOC+, Traffic Accident Sound Effect, Traffic Accident Pictures.*

I. INTRODUCTION

The brain is the control center of our body, enabling all our senses and muscles to become active. It is composed of many nerve cells. Nerve cells provide information transfer in the brain. The shape of the electrical movements of nerve cells is called "brain waves". Brain waves can be recorded by electroencephalography (EEG). The wave frequency of the EEG signals recorded in different states of consciousness is shown in Hertz (Hz) and the wave intensity in Microvolt (μV). Brain signals differ according to Hz values. Microvolt values provide information about the activation time [1].

The human brain, together with the stimuli that trigger the senses, records everything it is exposed to more effectively in its memory. Sometimes a smell, a musical sound is more effective than verbal information when remembering a memory or a skill. Most of the changes in emotions, sometimes a unique relief in the smell of a perfume in breeze of a wind or the smell of a food, sometimes compassion in a human voice, fear or panic when one hears a sudden break or siren of fire service are among the most important and invisible factors that lead to life. These invisible factors are coded into the human brain at every stage of life. Whether it is social relationships or choices in shopping for any physical need, they are influenced by the encodings in these emotions. For example, people can choose a brand because of the smell when buying a crayon. When pastel paints of Crayola brand are offered for sale as scented and odorless, it is seen that there have been a significant difference between sales [2]. In another study, it has been shown that people's emotions are affected by visuals that could not be seen by the eyes but trigger fear, innocence, and sexy feelings perceived by the brain [3]. There are many studies in the literature examining human emotional state changes with EEG signal analysis [4-18].

In this study, we analyze the emotional state of people who are at the same age, have the same education level and have had a traffic accident and have never had a traffic accident when presented traffic accident sound effect and traffic accident pictures. On the basis of this study, the emotional state changes of men and women who have had a traffic accident and didn't have a traffic accident analyzed monitoring the brain waves with Emotiv EPOC+ device which is a mobile system when the sound recording and visuals triggering the memories are presented in order to see what kind of emotional changes seen.

II. MATERIALS AND METHODS

The measurement of brain waves in the evaluation of human emotional state changes is done using Emotive EPOC+ device which can measure brain signals from 14 points and transfer data wirelessly to the management panel in the cloud system.

A. Emotiv EPOC+

Emotive EPOC+ device is a signal measuring device with 14 signal collection points and 2 reference points placed on the head and placed on the skull, which can transmit data wirelessly to the computer. Figure 1 shows an Emotive EPOC+ device image.

Fig 1:Emotive EPOC+ device

The technical features of the Emotive EPOC+ device are given in Table 1 [19].

Table I: The Technical and Systematic Features of Emotiv EPOC+

FEATURES	Emotiv EPOC+
Number of sensors	14+2 references
Sensor	AF3, AF4, F3, F4, FC5, FC6, F7,F8, T7, T8, P7, P8, O1, O2
References (Cms / Drl Configuration)	operationalized placing on the bony tissue behind the left/right auricle / Bottom P3-P4
Frequency Response	0.16 – 43 Hz
Sensor Technology	Felt pads soaked in salt
Connection	Registered 2.4GHz wireless (special USB receiver), Bluetooth (r) SMART 4.0 LE, Wired USB available only using Extender accessory
States used for this study	Sudden excitement, Long-term excitement,Frustration, Commitment,contemplation, Engaging

In studies conducted with EEG signals, the signals are firstly purified from noise. Independent components analysis, filtering (linear and nonlinear), wavelet transform, fundamental component analysis are used to remove noise [20]. After the feature extraction process, classification algorithms such as artificial neural networks, k-means classification algorithm, data mining, genetic algorithm, linear separation analysis (LSA), support vector machine (SVM), k-nearest neighbour (KNN) are used [20-22]. According to the classification process, it is possible to reach different results even in the same study. In this study, EEG signals are first purified by a notch filter and band pass filter. The noise-free data is analyzed by power spectral density analysis and the feature vectors are obtained by using the formulas shown in formula (1) (2) (3) (4) (5) (6). After obtaining the feature vectors, classification is made by linear discrimination analysis using the formulas shown in (7) (8) (9).

$$X(e^{jw}) = \sum_{n=-\infty}^{\infty} X[n]\, e^{-jw} \qquad (1)$$

X indicates EEG measurement, N indicates measurement index.

$$W = \frac{2\pi k}{N} \qquad (2)$$

W represents frequency, N represents sampling frequency, and k indicates frequency step number.

$$X(e^{jw}) = X_{re}(e^{jw}) + j.X_{im}(e^{jw}) \qquad (3)$$

X_{re} represents the real part of the number, X_{im} represents imaginary part. J is accepted as the complex number in space

$$e^{-jw} = \cos(wn) - j.\sin(wn) \qquad (4)$$

$$X(e^{jw}) = \sum_{-\infty}^{\infty} x[n].(\cos(wn) - j.\sin(wn)) \qquad (5)$$

$$X\left(e^{\frac{j2\pi k}{N}}\right) = \sum_{-\infty}^{\infty} X[n].(\cos\frac{2\pi k}{N}n - j.\sin\frac{2\pi k}{N}n) \qquad (6)$$

$x_e^{(j2\pi k)/(N)}$ shows the fourier coefficient at the W frequency specified in the second equation

The code for the power spectral density pretreatment written in the C# programming language is shown in Figure 2 as the C# code of the formula

```
for (int k = 0; k < 127; k++)
{
    double temp = 0;
    double temp1 = 0;
    for (int n = 0; n < 128; n++) {
     temp=temp+buffer[10,n]*Math.Cos((k*2*Math.PI/128)*(n-1));
     temp1 = temp1 + buffer[10,n] * Math.Sin((k * 2 * Math.PI / 128) * (n - 1));
    }
sonuc[k+1]=0;

    sonuc[k + 1] = Math.Sqrt(Math.Abs(temp * temp - temp1 * temp1));
}
```

Fig 2: The C# code of formula

Linear separation analysis (LSA) processes the mean between the classes of data to the highest and minimizes the variance intraclass. For the LSA method, the inter-class scattering matrix in the size reduction process is SB and the intraclass scattering matrix is SW. If represents the average value of data objects for a data set with c classes, these matrices are defined as follows:

$$S_B = \sum_{i=1}^{c} (\overline{x}_i - \overline{x})(\overline{x}_i - \overline{x})^T \qquad (7)$$

$$S_{W} = \sum_{i=1}^{c} \sum_{j=1}^{N_i} (x_{i,j} - \overline{x})(x_{i,j} - \overline{x})^T \qquad (8)$$

Here, $\overline{x}_i$, i. Represents the mean value of the class. The j. Sample of i class as shown with $\overline{x}_i$, $i.N_i$, i. İs the number of sample in class. After finding out S_B and S_W matrixes the problem of generalized basic values in equation 3 is solved:

$$S_B a = \lambda S_W a \qquad (9)$$

P transformation matrix is created using r basic vectors that correspond the largest r basic values which is the solution of this generalized basic values problem.

III. APPLICATION

The study has been carried out with 3 male, 3 female who have had a traffic accident in the same year and 3 female and 3 male subjects who haven't had a traffic accident in the same year. The subjects were at the age of 30 and all had an associate degree. Emotive EPOC+, which is a headdress, is used to perform emotion analyses of subjects. In the study, the person whose emotional state will be analyzed is taken to a quiet room. The person sits comfortably. Emotive EPOC+ headdress is placed on the head of the person. People are shown 3 traffic accident pictures first. After the picture display to all subjects, the traffic accident sound effect is played to the people in the same order. Changes in the brain are examined instantly.

Waves in the brain are evaluated according to the wave frequency and wave intensity of brain signals. Table 2 shows brain waves according to Hz values [23].

Table II.Brain waves

	Hz	Explanation
Delta	0-4	Deep sleep
Teta	4-8	Dreaming
Alpha	8-12	Relaxation
Smr	12-15	Concentration
Beta1	15-18	Problem solving
Beta2	18-36	Anxiety

Placing the Emotive EPOC+ device on the skull is important for accurate measurements. The device is in the form of a hood and should be placed on the skull by sliding it from top to bottom. Figure 3 shows the placement of the Emotive EPOC+ headdress.

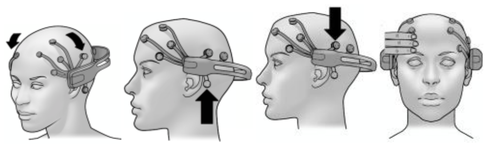

Fig 3: Placing the Emotiv EPOC+ headdress

The placement of the electrodes in the device is placed according to the international 10-20 system. The signal points to be obtained according to this system are AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4. The software panel is shown in figure 4.

Fig 4:EMOTIV Pure•EEG™ software panel

IV.

As a result of the study, no significant change was observed in emotional states in terms of gender. However, the traffic accident sound effect used in the study is more effective than the visually presented traffic accident pictures in both emotional state change of people who had traffic accident and didn't have traffic accident. At the same time, there are significant differences in emotional changes of the ones who have experienced traffic accidents when compared to those didn't have traffic accidents.

Table III. Emotional State Analysis of Persons Who Had Traffic Accidents and Who Didn't Have Traffic Accidents

	Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
		Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety
Those who had traffic accident	Women	12	30	11	25
	Women	11	31	9	22
	Women	12	32	12	27
	Men	10	28	10	21
	Men	12	31	11	28
	Men	12	33	9	30
Those who dşdn't have traffic accident	Women	10	19	8	16
	Women	9	25	10	20
	Women	12	21	8	18
	Men	10	22	9	14
	Men	8	20	9	16
	Men	9	18	8	14

Table IV. Emotional State Analysis of Women and Men

Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety
Average for Women	11	26	9	21
Average for men	10	25	9	20

Table V. Emotional State Analysis of Men and Women who had Traffic Accidents

Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety
The average for women who had traffic accident	11	31	10	24
The average for men who had traffic accident	11	30	10	26

Table VI. EmotionalState Analysis of Womenand Men whodidn'thave aTrafficAccident

Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety
The average for women who didn't have traffic accident	10	21	8	18
The average for men who didn't have traffic accident	9	20	8	14

Table VII. EmotionalState Analysis of Womenwho had a trafficaccidentandwomenwhodid not have a trafficaccident

Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety
The average for women who had traffic accident	11	31	10	24
The average for women who didn't have traffic accident	10	21	8	18

Table VIII. EmotionalState Analysis of men who had a trafficaccidentand men whodid not have a trafficaccident

Gender	Traffic Accident Sound Effect		Traffic Accident Picture	
	Alpha(8-12) Comfortable	Beta(12-36) attention-anxiety	Alpha(8-12) comfortable	Beta(12-36) attention-anxiety
The average for men who had traffic accident	11	30	10	26
The average for men who didn't have traffic accident	9	20	8	14

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