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Capturing Brain Activity During Driving Automobile

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Abstract

The primary purpose of this article is to show which brain waves are activated while driving an automobile. The first part of this article deals with the theoretical information about brain waves and electroencephalogram (EEG). The activity of the brain is measured by EEG technology, which is represented by Emotiv System devices. The following section defines which devices have been selected. For measuring EEG was used headset Emotiv EPOC and for analysing measurements, the application Emotiv Brain Activity Map was used. The third part of this article focuses on the experimental section. The experimental part provides four various measurements. These measurements describe activated brain waves during different actions while driving. The last chapter of this paper is devoted to possible ways of using this technology.

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1. Introduction

The nervous system has two parts The nervous system has two parts – the central nervous system and the peripheral nervous system. The human brain and spinal cord are referred to as the central nervous system. The brain is divided into two hemispheres, left and right. The left hemisphere is responsible for logic, analytical thinking, speech. The right hemisphere is in charge of music, the basic way of thinking, intuition, creativity, and imagination. The human brain continuously sends electrical signals. These transmitted signals can be measured and processed. The electrical activity produced by the brain is known as brain waves, which are distinguished by frequency and reflect the state of our

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consciousness. Electroencephalogram (EEG) can record and interpret electrical actvity from the brain. It is noninvasive technique, which measure signals from the scalp. In our paper, we decide to choose EEG device from the company Emotiv system. They provide EEG helmet with 14 channels called Emotiv EPOC+. It is a scalable system applied in context research of the human brain. This technology device can record, identify and interpret brain activity. The most critical criteria of evaluation EEG is frequency. Frequency is a criterion for assessing abnormalities in clinical EEG and for understanding functional behaviors in cognitive research. There are five different types of brain waves: gamma, beta, alpha, theta and delta. Each brain wave has a different frequency, amplitude, and meaning. [1-3]

This paper describes and analyses the brainwaves while driving a car. The paper aims to describe which brainwave is active in some actions and compare this data for both genders. The first part of the article is devoted to methods of data measurement and analysis in the application. Another necessary part is the result section. It describes the course of measurement and the data obtained, which are explained and described. In the part of the discussion and conclusion, a summary of the research and other possible solutions are described.

2. Methods

We used the Emotiv Epoc+ headset, which works with EEG technology. This device was developed by Emotiv system and includes 16 sensors for recording brain activity. The device records the signal at 128 Hz with a sufficient resolution of 14 bits per channel and a frequency response in the range of 0.16 to 43 Hz. The helmet also provides 2.4 GHz wireless data transfer with battery. Therefore, the helmet can capture the brain activity for 8 hours.

Fig. 1: (a) Emotiv EPOC+ headset; (b) Emotiv Brain Activity Map - application

According to this technology, we have to work with the application developed by the same company. The application Emotiv Brain Activity Map v3.3.3 was the best option for displaying brain waves in real-time. This application measures and displays data of the brain activity. There are visibly four brain waves with different frequencies which can be measured and shown. These waves are Alpha, Beta, Theta and Delta. Each of the brain waves has a different frequency, amplitude and meaning. Human behaviors in each brainwave were analysed and described [5,6]. See Table 1.

Table 1. Human behaviours in each brainwave

Brainwave	State of Consciousness
Alpha	Reflecting / Relaxing / Thinking
Beta	Emotions / Working / Engaged mind
Theta	Intense creativity / Visualization Ability / Imagination / Problem-solving
Delta	Sleeping / Deeply relax

Selected persons for this measurement were male and female. The measurement took place in a vehicle. The tested person put on the Emotiv Epoc+ helmet and was seated into the automobile. The primary task for the testing person was only to drive. The person was navigated because the route did not discuss. Both persons drove the same route due to obtaining accurate results. Data were collected and consequently analysed in the application.

3. Results

This chapter aims to present the results of measuring brain activity during a driving a car. The results are taken in the application Emotiv Brain Activity Map. The results are not in data form, but as a visualization of brain activity. The spectrum of the colour, from blue to red, signalizes the strength of the signal from the weakest to the strongest.

Fig. 2: Measuring male brainwaves

3.1. Testing person – male

Data were measured in the car under normal conditions. The person was driving the car in normal traffic conditions. There were four different situations during the journey, which were further analysed. These actions are turning left and right, stop at the traffic lights, and the last was parking. Each of these actions was shown in Table 2.

Table 2. The presence of brain waves in a particular situation - male

Action	Alpha	Beta	Theta	Delta
Turning right	X	X	A	X
Turning left	A	A	A	X
Traffic lights	A	A	A	X
Parking	X	X	A	X

Table 1 shows four different activities and four brain waves, which can occur in these actions. The active brain wave which was recorded in the given situation was written into the table by the letter A. If the wave is not active, X

is written into the table. The first and second row describes turning. Turning left caused increasing only theta brain wave. However, turning right activates not only theta wave but also beta and alpha wave — different types of command cause these differentials. The instruction to turn left was given clearly. The explanation of theta waves could be in visualization and problem-solving. However, the instruction to turn right was given at the last moment, and the driver had to decide quickly. This situation caused activation of three brainwaves. Dr. Jeffrey D. Thompson mentioned that Beta/Alpha bridge state is the mental place the brain goes to when it becomes hyper-efficient in dealing with the task at hand because it can focus on the details as well as the overall scope of the problem or task at the same time. The explanation of these three waves is a significant focus on executing at the last minute. [6]

During a stop at the traffic lights increased the activity of three brain waves — alpha, beta, and theta. Alpha represents the thinking and concentrates on details. It could mean the focusing on "the green" colour at the traffic light. Theta, in this example, could involve intuition – because the man has already known that when he sees a red colour, he must stop. The beta wave may represent the actively engaged mind. It also indicated that beta is occurring on the left hemisphere, which means logic and analytical thinking.

The last row describes which brain wave is active during a parking a car. When the man started parking, the only visible brain wave was theta. It indicated that theta is associated with intense creativity, visualization ability, imagination and problem-solving. All of these features are essential for parking.

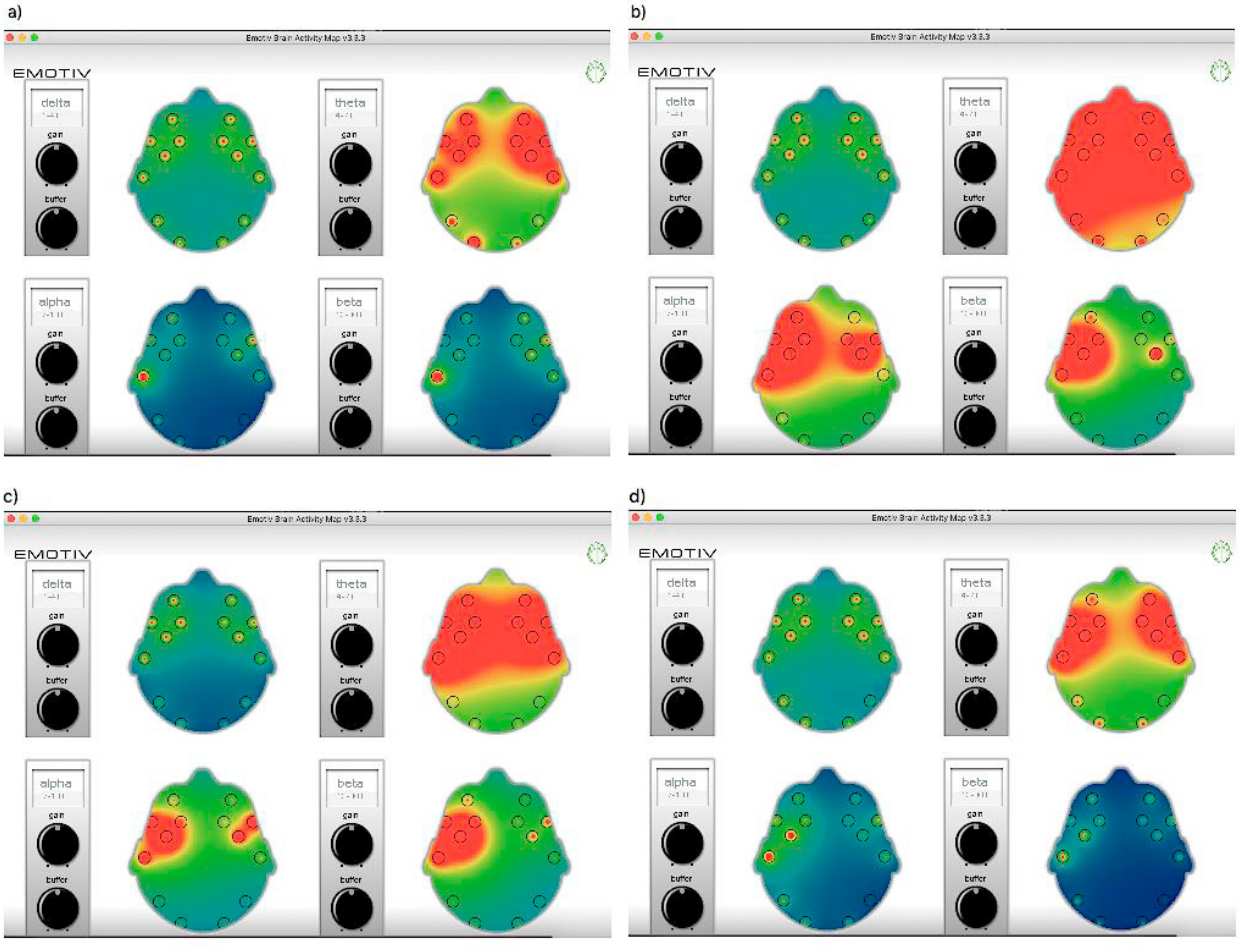


Fig. 3: Brain activity map - a man (a) Turning right; (b) Turning left; (c) Stopping at traffic lights; (d) Parking

3.2. Testing person – female

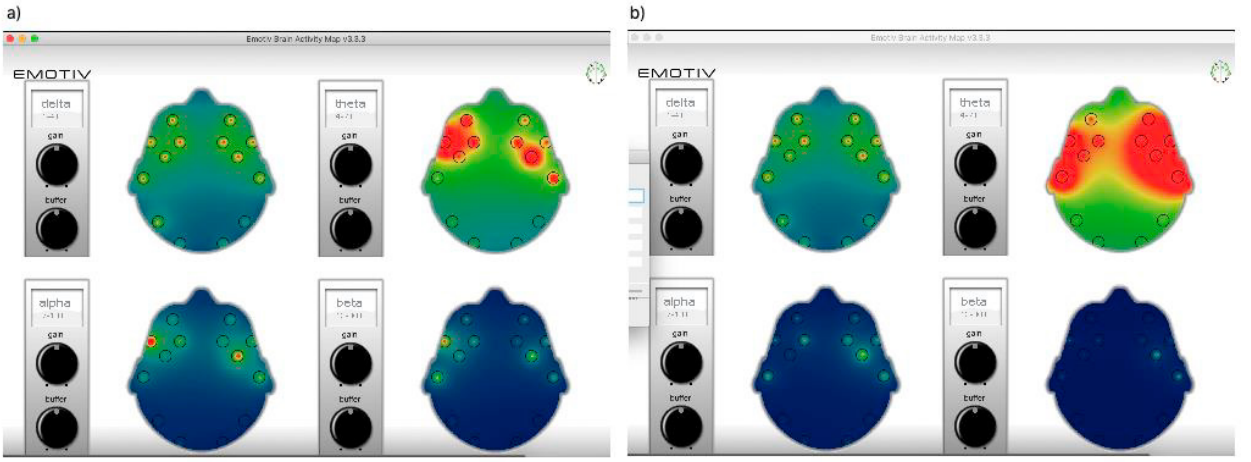
The conditions for testing was the same as in the previous measurement. The testing person was tested on the four different actions. These actions are turning left and right, stop at the traffic lights, and the last one was parking. Each of these actions was analysed and can be seen in Table 3.

Table 3. The presence of brain waves in a particular situation - female

Action	Alpha	Beta	Theta	Delta
Turning right	X	X	A	X
Turning left	X	X	A	X
Traffic lights	X	A	X	X
Parking	A	X	A	X

The first and second rows in Table 3 inform about turning. In both situations, one brain wave is active - theta. The explanation of increase activity this wave could be interpreted as thinking and visualization of command, which was given.

The third row shows brainwaves, which were occurring while the women stopped at traffic lights. The brainwave, which is involved in this action is beta. Beta is responsible for emotions and engaged mind. The presence of this wave can indicate the involvement of the mind when detecting the colour of the traffic light. It can also mean a negative emotion that is associated with stopping at traffic lights. The last row displays the brain waves during parking. The active brain waves are beta and theta. Engaged mind, problem-solving and visualization ability are reasons, which can reveal these brain waves.



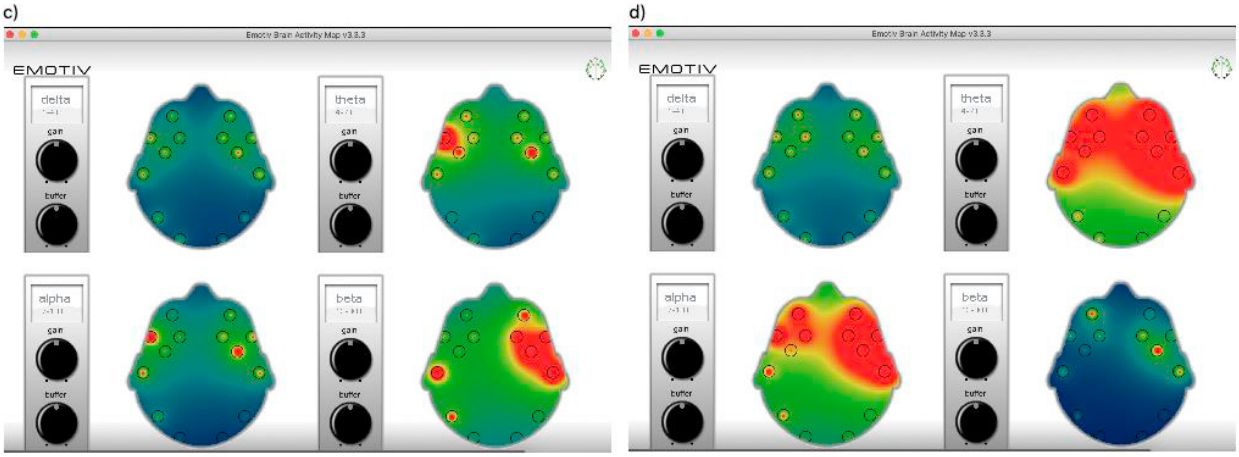


Fig. 4: Brain activity map - a woman (a) Turning right; (b) Turning left; (c) Stopping at traffic lights; (d) Parking

4. Discussion

The results of our research aimed to figure out which brainwave occur in different actions during car driving. The most frequent brainwave, which was indicated, was a theta wave in the frontal hemisphere. It proved that during driving engages creativity and reasoning. It is hard to compare gender results, because the condition for testing, was not the same: the first experiment was conducted in the evening, but the measuring of women was conducted in the morning. Also, the weather conditions were different. There are a couple of gender differences in measuring of brain activity. The power of signals was higher in the male results and also there some differences in active brainwave. But, this paper is not primary focused on gender difference. The main purpose was to find out what brain waves are active in a particular activity. Differences in these results may be due to non-physiological factors. However, the evaluating data match with the expected results. Compare to some studies we can say, that alpha activity in the female is higher than male activity. Some studies inform that brain waves can be affected by addictive substances. We should recognize the power of emotions, tiredness or using drugs or caffeine. All of these substances increase the beta brain wave. In our experiment, we did not register these phenomena. [6] [8]

This study can serve as a first introduction to EEG measurements while driving an automobile. More in-depth exploration could be useful in recognizing fatigue or reasoning by the car driver. For this analysis should be developed own interface for evaluating data. Another possibility for future work should be data processing in computing environments such as Matlab or Wolfram Mathematica.

Our research is not so objective because there was measured a small group of subjects. The better results of measure should be displayed in simulated driving. The driver's fatigue is poorly measured in normal traffic due to safety.

5. Conclusion

This paper deal with the analysis of EEG during the driving an automobile. Electroencephalography is the measurement of the electrical activity of the brain by recording from electrodes located on the scalp. In our experiment, two people were measured and subsequently analysed. This experiment was done with using Emotiv devices, especially Emotiv Epoc+. The results of the analysis were processed in the application Emotiv Brain Activity Map.

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References

[1] Mader, S., Windelspecht, M., 2012. *Human biology*. 12th ed. New York: McGraw-Hill.
[2] Kumar, J. S., & Bhuvaneswari, P., 2012. Analysis of Electroencephalography (EEG) Signals and Its Categorization–A Study. Procedia Engineering, 38, 2525–2536.
[3] Siuly, S., Li, Y., Zhang, Y., 2017. *EEG Signal Analysis and Classification*. Cham: Springer.
[4] EMOTIV EPOC - 14 Channel Wireless EEG Headset (n.d.). Retrieved from https://www.emotiv.com/epoc/
[5] Brahmankar, D. A., Dange, R. S., Mankar, V. H., 2012. The Effect of Resonance on Human Consciousness. International Journal of Computer Applications, 15-17.
[6] Thompson, J, 2000. Sleeping / Waking / Awakening. Scientific Sounds. Retrieved from https://scientificsounds.com/index.php/library/sleeping-waking-awakening
[7] 5 Types Of Brain Waves Frequencies: Gamma, Beta, Alpha, Theta, Delta. (2018, March 24). Retrieved from https://mentalhealthdaily.com/2014/04/15/5-types-of-brain-waves-frequencies-gamma-beta-alpha-theta-delta/
[8] Jaušovec, N., Jaušovec, K., 2010. Resting brain activity: Differences between genders. Neuropsychologia, 48(13), 3918–3925.
[9] Brebner, J., 2003. Gender and emotions. Personality and Individual Differences, 34(3), 387-394.
[10] Glaser G. H., 1963. *EEG and behavior*. New York: Basic Books.
[11] Empson J., 1986. *Human Brainwaves: The Psycological Significance of the Electroencephalogram.* London: the Macmillan Press Ltd.