UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierías

Analysis of EEG Signals During Auditory Binaural Beat Stimulation

Kevin Alexander Serrano Hidalgo

Ingeniería Electrónica

Trabajo de fin de carrera presentado como requisito
para la obtención del título de
Ingeniero Electrónico

Quito, 24 de Diciembre de 2020

UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierías

HOJA DE CALIFICACIÓN
DE TRABAJO DE FIN DE CARRERA

Analysis of EEG Signals During Auditory Binaural Beat Stimulation

Kevin Alexander Serrano Hidalgo

Nombre del profesor, Título académico **Diego Benítez, Ph.D.**

Quito, 24 de Diciembre de 2020

DERECHOS DE AUTOR

Por medio del presente documento certifico que he leído todas las Políticas y Manuales de la Universidad San Francisco de Quito USFQ, incluyendo la Política de Propiedad Intelectual USFQ, y estoy de acuerdo con su contenido, por lo que los derechos de propiedad intelectual del presente trabajo quedan sujetos a lo dispuesto en dichas Políticas.

Asimismo, autorizo a la USFQ para que realice la digitalización y publicación de este trabajo en el repositorio virtual, de conformidad a lo dispuesto en el Art. 144 de la Ley Orgánica de Educación Superior.

Nombres y apellidos: Kevin Alexander Serrano Hidalgo

Código: 00135417

Cédula de identidad: 1719134783

Lugar y fecha: Quito, 24 de Diciembre de 2020

ACLARACIÓN PARA PUBLICACIÓN

Nota: El presente trabajo, en su totalidad o cualquiera de sus partes, no debe ser considerado como una publicación, incluso a pesar de estar disponible sin restricciones a través de un repositorio institucional. Esta declaración se alinea con las prácticas y recomendaciones presentadas por el Committee on Publication Ethics COPE descritas por Barbour et al. (2017) Discussion document on best practice for issues around theses publishing, disponible en http://bit.ly/COPETheses.

UNPUBLISHED DOCUMENT

Note: The following capstone project is available through Universidad San Francisco de Quito USFQ institutional repository. Nonetheless, this project – in whole or in part – should not be considered a publication. This statement follows the recommendations presented by the Committee on Publication Ethics COPE described by Barbour et al. (2017) Discussion document on best practice for issues around theses publishing available on http://bit.ly/COPETheses.

RESUMEN

Los pulsos auditivos binaurales (BB) aparecen cuando dos tonos de frecuencias diferentes se colocan por separado en los oídos izquierdo y derecho, respectivamente. El sujeto puede percibir un tono que varía en amplitud de frecuencia digital a la diferencia entre los tonos colocados en sus oídos. Los informes anecdóticos sobre los pulsos auditivos binaurales sugieren que pueden estar asociados a la actividad del EEG (electroencefalograma) y afectar los estados de conciencia.

En este estudió, se analizó la percepción de pulsos binaurales (BB) en diferentes sujetos en los rangos de frecuencia EEG tetha, EEG alpha principalmente, cada participante estuvo expuesto a dos condiciones. Una condición contenía una señal auditiva que provocaba el pulso binaural (BB) y otra no. La señal BB se creó reproduciendo un tono sinusoidal puro a 400 Hz en el oído izquierdo y un tono similar a 406 Hz en el oído derecho, embebidos dentro de una pieza musical de fondo. El efecto BB es la diferencia entre los dos tonos, es decir, 6Hz. Para la condición de control sin elementos BB, cada tono estaba a 403Hz. En el caso del BB, este produce un pulso en la diferencia (en este caso 6 Hz) y algunas personas informan que pueden escuchar conscientemente ese pulso.

Usando técnicas de análisis de tiempo-frecuencia STFT (Short Time Fourier Transform) se analizó los datos tomados con distintos electrodos de EEG y se graficó espectrogramas para el análisis de las bandas de frecuencia en ambas condiciones con lo cual se pudo observar la información del espectro, para obtener medidas cuantitativas se realizó la estimación de la densidad espectral de potencia mediante un periodograma obteniendo los valores promedio, mínimo y máximo en la banda de frecuencia deseada.

Palabras claves: Latidos binaurales, EEG electroencefalograma, pulso sinusoidal puro, espectrograma, STFT Short Time Fourier Transform, periodograma, densidad espectral de potencia.

ABSTRACT

Binaural hearing beats (BB) are shown when two tones of different frequencies are placed separately in the left and right ear, respectively. The subject can perceive a tone that varies in digital frequency amplitude to the difference between the two tones placed in their ears. Anecdotal reports of binaural hearing beats suggest that they may be associated to EEG (electroencephalogram) activity and affect states of consciousness.

This study analyzed the perception of binaural beats (BB) in different subjects in the EEG theta and alpha frequency ranges, each participant was exposed to two conditions. One condition contained an auditory signal that caused the binaural beat (BB) and the other did not. The BB signal was created by reproducing a pure sinusoidal tone at 400 Hz in the left ear and a similar tone at 406 Hz in the right ear embedded within a musical track. The BB effect is the difference between the two tones, i.e. 6Hz. For the control condition without BB elements, each tone was at 403Hz. In this case of the BB, it produces a pulse on the difference (in this case 6Hz) and some people report that they can consciously hear that pulse.

Data was analyzed using time-frequency analysis techniques using the STFT (Short Time Fourier Transform), the EEG and spectrograms were plotted for the analysis of the frequency bands in both conditions, in which the spectrum information could be observed. For quantitative measurements, the power spectral density was estimated by means of the periodogram, obtaining the average, minimum and maximum values in the desired frequency band.

Key Words: Binaural beats, EEG electroencephalogram, pure sinusoidal tone, spectrogram, STFT Short Time Fourier Transform, periodogram, power spectral density.

TABLA DE CONTENIDO

Introduction 12

Materials and Methods 14

Prepocessing Method 14

Data adquisition 14

Filtering 15

Short Time Fourier Transform 15

Spectrogram 16

Periodogram 17

Results and discussion 20

Conclusions 22

References 23

ÍNDICE DE TABLAS

Table 1 Quantitive measurement of PSD for participant No.8 under condition A for the theta band.. ……..24

Table 2 Quantitive measurement of PSD for participant No.8 under condition A for the alpha band…….....24

Table 3 Quantitive measurement of PSD for participant No.8 under condition B for the theta band……..25

Table 4 Quantitive measurment of PSD for participant No.8 under condition B for the alpha band…….…..25

Table 5 Quantitive measurement of PSD for participant No.9 under condition A for the theta band……..…26

Table 6 Quantitive measurement of PSD for participant No.9 under condition A for the alpha band.……..26

Table 7 Quantitive measurement of PSD for participant No.9 under condition B for the theta band……..27

Table 8 Quantitive measurement of PSD for participant No.9 under condition B for the alpha band...…..27

Table 9 Quantitive measurement of PSD for participant No.11 under condition A for the theta band…...28

Table 10 Quantitive measurement of PSD for participant No.11 under condition A for the alpha band…..28

Table 11 Quantitive measurement of PSD for participant No.11 under condition B for the theta band…..…29

Table 12 Quantitive measurement of PSD for participant No.11 under condition B for the alpha band…….29

Table 13 Quantitive measurement of PSD for participant No.12 under condition A for the theta band……..30

Table 14 Quantitive measurement of PSD for participant No.12 under condition A for the alpha band …..30

Table 15 Quantitive measurement of PSD for participant No.12 under condition B for the theta band …..31

Table 16 Quantitive measurement of PSD for participant No.12 under condition B for the alpha band ….....31

Table 17 Quantitive measurement of PSD for participant No.13 under condition Afot the theta band ……..32

Table 18 Quantitive measurement of PSD for participant No.13 under condition A for the alpha band 32

Table 19 Quantitive measurement of PSD for participant No.13 under condition B fot the theta band …..33

Table 20 Quantitive measurement of PSD for participant No.13 under condition B for the alpha band.....33

Table 21 Quantitive measurement of PSD for participant No.14 under condition A for the theta band …..34

Table 22 Quantitive measurement of PSD for participant No.14 under condition A for the alpha band…....34

Table 23 Quantitive measurement of PSD for participant No.14 under condition B for the theta band …….35

Table 24 Quantitive measurement of PSD for participant No.14 under condition B for the alpha band …...35

Table 25 Quantitive measurement of PSD for participant No.15 under condition A for the theta band …..36

Table 26 Quantitive measurement of PSD for participant No.15 under condition A for the alpha band…..36

Table 27 Quantitive measurement of PSD for participant No.15 under condition B for the theta band …..37

Table 28 Quantitive measurement of PSD for participant No.15 under condition B for the alpha band …...37

ÍNDICE DE FIGURAS

Figure 1. Emotiv EEG headset with electrode position in 10/20 international system…….13

Figure 2 Workflow graph of the steps involved in the signal analysis …….……...…14

Figure 3 Example of a STFT for electrodes P7,P8,T7,T8 under condition A ……...…….16

Figure 4 Example of a spectrograms for electrodes P7/P8 under condition A(left) – P7/P8 under condition B(right)……...……...……...…….……17

Figure 5 Example of a power spectral density estimation for electrodes P7/P8 under condition A for the alpha band welch method(left) – periodogram(left)……...……19

Figure 6 Spectrogram corresponding to the theta band for the P7(top) and P8(bottom) electrodes during condition A(left) and condition B(right**)**……..… …20

INTRODUCTION

The binaural beats were discovered by a German researcher H.W. Dove in 1839, they consist of subjective auditory sensations that occur as a result of hearing two slightly different sounds at a low frequency. The ability of a human being to hear binaural beats seems to be the result of evolutionary assimilation, which many advanced species can detect binaural beats depending on the size of the skull. (Kasprzak, 2011)

The human brain is complex in nature and to understand the complexity of interconnected neurons, brain information signals are needed. The electroencephalogram (EEG) is a non-invasive neurological diagnosis which records and measures brain waves.

The brain waves change according to the task that a person performs, are classified according to different frequency bands called delta between 0.1 – 4 Hz, theta between 4 - 7 Hz, alpha between 7 - 13 Hz, beta between 13 – 30 Hz. In this study, the frequencies of interest are in bands between 4 - 7 Hz (theta waves), 7 - 13 Hz (alpha waves). We focus on these frequency bands because we apply a pure sine wave signal at 400 Hz and one at 406 Hz, the binaural beat is concentrated in the theta band and is the difference of the two frequencies (6 Hz).

It is well known that EEG signal processing is classified by stages: data acquisition, pre-processing, extraction and classification of characteristics. (Ameera, 2018) EEG signals are chaotic signals, which makes them difficult to interpret. They are usually analyzed in an observational manner, which results in the obviating of important characteristics of the signals. However, with the use of general and specialized techniques we can test the signals to obtain relevant information.

Data recording was done with an inexpensive EEG device (EMOTIV EPOC +) that, although less sensitive than medical grade devices is enough for the purposes of monitoring

brain activity during binaural test stimulation. The electrode settings are 10/20 International system and Emotiv's electrodes placement. (Gwizdka,2017)

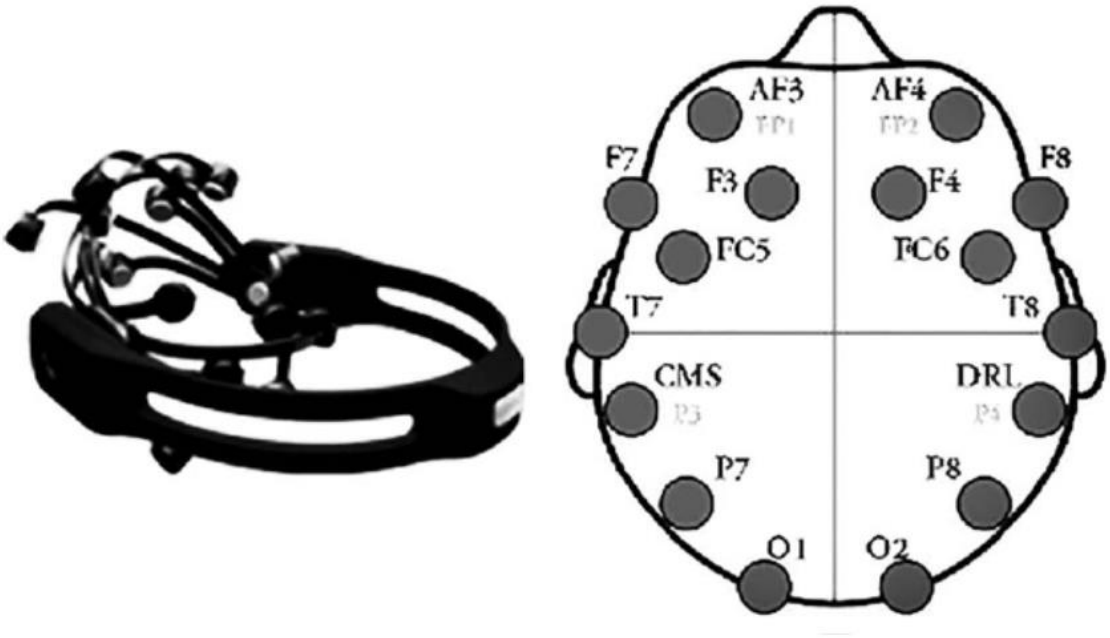

FIGURE 1. EMOTIV EEG HEADSET WITH ELECTRODE POSITION IN 10/20 INTERNATIONAL SYSTEM.

During the pre-processing stage, a bandpass filter is applied to each signal obtained from the 14 channels of the EMOTIV hull to filter into different sub-bands, then time-frequency analysis methods are used to analyze the spectral and phase content as well as its changes over time.

Finally, in the classification stage, the power spectral density (PSD) of the filtered signal is estimated by means of a periodogram.

MATERIALS AND METHODS

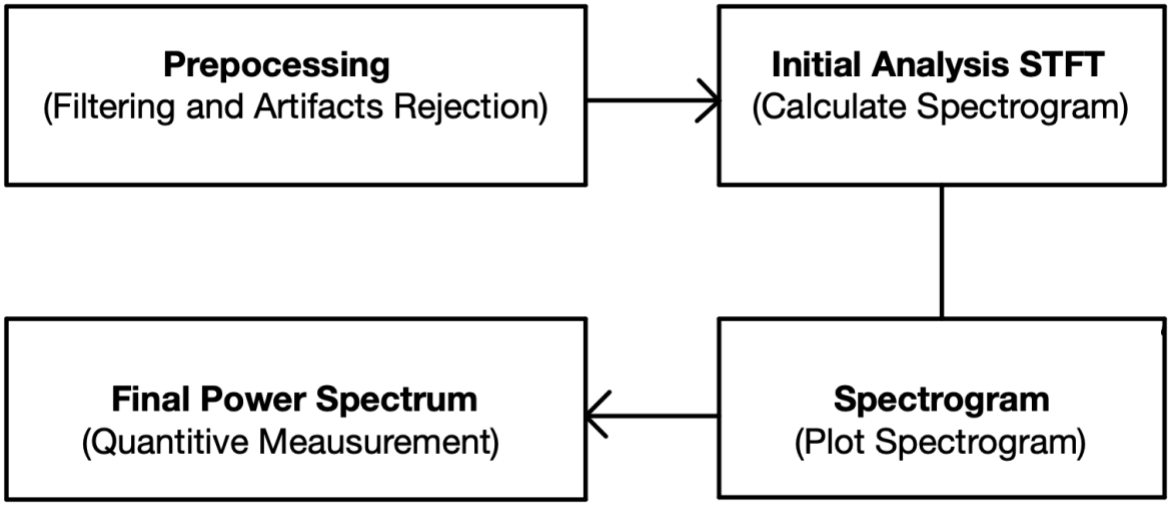

FIGURE 2. WORKFLOW GRAPH OF THE STEPS INVOLVED IN THE SIGNAL ANALYSIS.

Preprocessing Method

Data acquisition

Data were taken from 7 participants with a low-cost EMOTIV headset that has 14 electrodes (channels) and a sampling frequency of 128 Hz. The data was recorded after 5 minutes of placing the helmet over the skull of each participant, this procedure guarantees an stable data collection over the duration of data recording which was approximately 8 minutes. Two recordings were obtained from each participant for the condition when the binaural heartbeat was applied and for the condition when it was not applied. To unbiases the analysis, the condition where the binaural test was applied by the physician applying the test was hidden for the signal labeling so signals were label either as condition A or condition B, but no information about the signal containing the binaural test was provided at this stage of the analysis in order to do not influence the signal analysis. Condition labels A and B were placed at random for the study.

Filtering

For signal filtering, Butterworth filters were designed with the MATLAB tool, where the signal of each EMOTIV EPOC+ channel was filtered to obtain the theta and alpha frequency sub-bands.

Butterworth filters parameters:

- Bandpass for the Thetha band:

$$f_{c1} = 4\ Hz, f_{c2} = 7\ Hz, n = 2$$

- Bandpass for the Alpha band:

$$f_{c1} = 7Hz, f_{c2} = 12\ Hz, n = 2$$

Where f_{c1}, f_{c2} are the frequencies for the band allowed, and n is the order of the filter.

Short Time Fourier Transform

The Short Term Fourier Transform (STFT) is a general purpose signal processing tool which defines a particularly useful class of time-frequency distributions representing the amplitude versus time and frequency for the signal to be tarted.(Zamorano,s.f.)

Continuous Time:

$$STFT\ \{x(t)\} = X(\tau, \omega) = \int_{-\infty}^{\infty} x(t) w(t-\tau) e^{-j\omega t}\, dt$$

Discrete Time:

$$STFT\ \{x[t]\} = \sum_{n=-\infty}^{\infty} x[n] w[n-m]\, e^{-j\omega n}$$

Where $x(t), x[n]$ is the signal to processing, $w(t-\tau), w[n-m]$ is a window for the analysis, this applies to both continuous and discrete time. STFT is a complex function that represents the phase and magnitude of the signal over time and frequency.

In this study the STFT with MATLAB was applied to the filtered signals in sub-bands, the properties of the STFT used are :

- Hamming window size 1024.
- Overlap 256.
- nFFT 4096.
- Sampling Frequency 128 Hz.

Which returns the short-term Fourier transform of the signal, its time and frequency vector to able to perform the spectrogram.

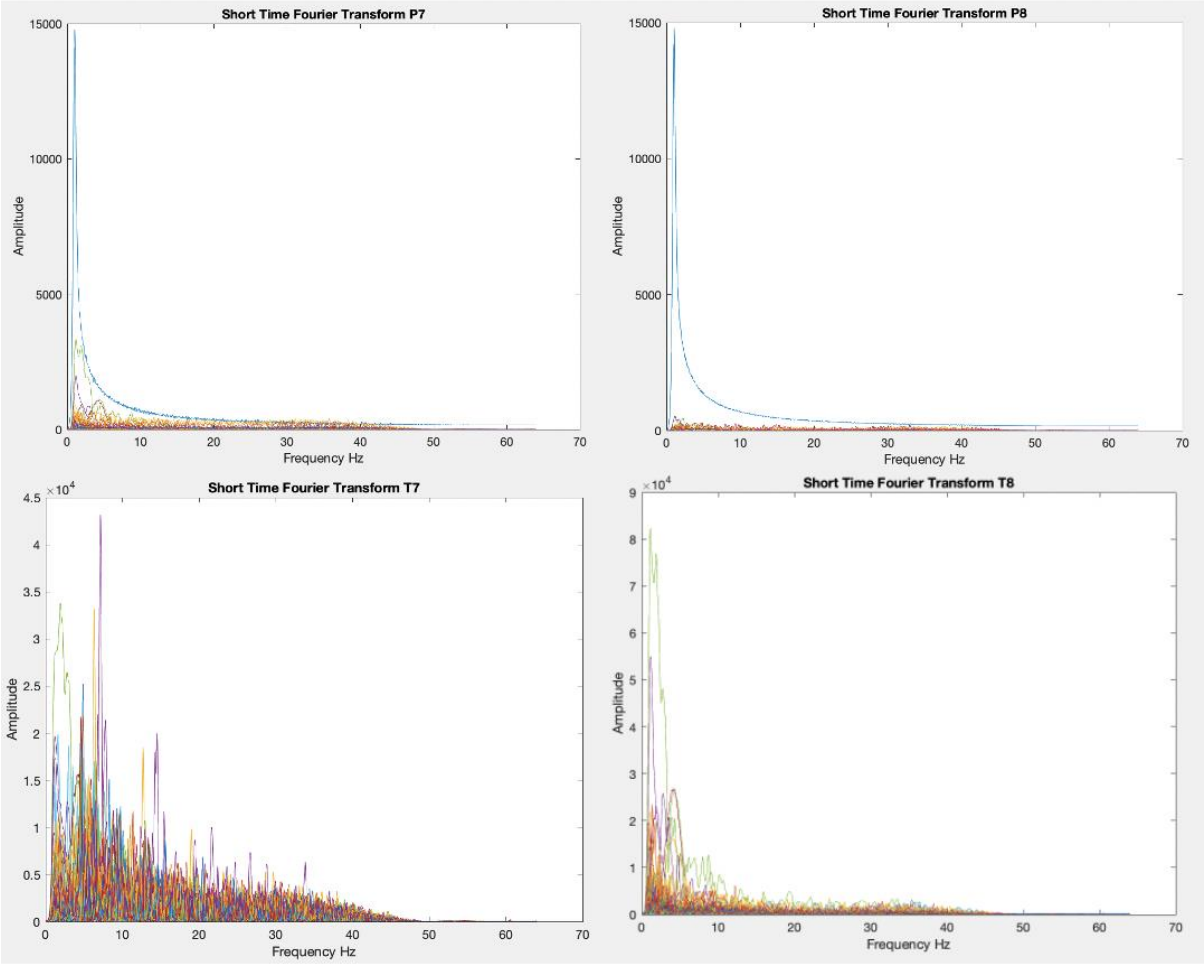

FIGURE3. EXAMPLE OF A STFT FOR ELECTRODES P7,P8,T7,T8 UNDER CONDITION A.

Spectrogram

The signal spectrogram was plotted for tetha and alpha bands of each channel, each frequency spectrum shows a full range of colors in which each element specifies the color of 1

pixel of the image to visually obtain the information of the spectrum where there are frequency changes for conditions A and B.

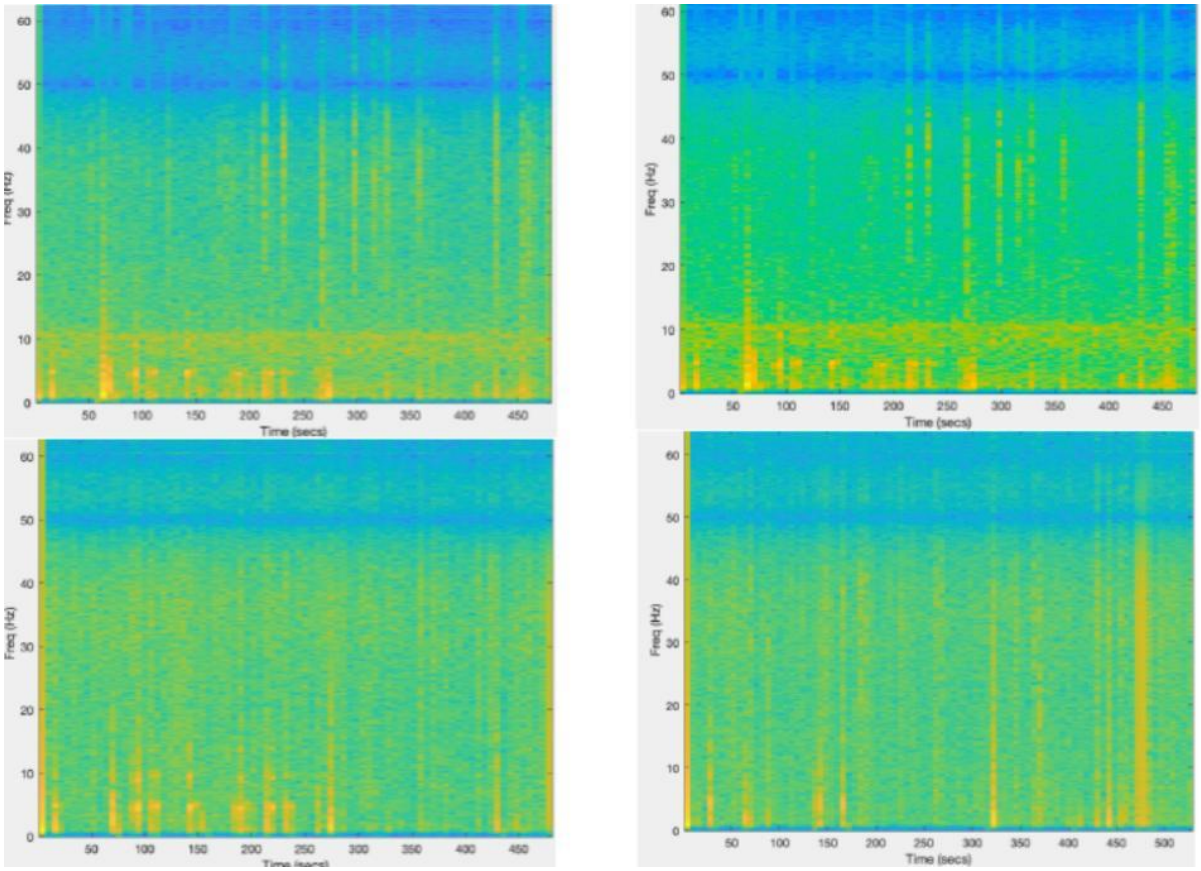

FIGURE4. EXAMPLE OF A SPECTROGRAMS FOR ELECTRODES P7/P8 UNDER CONDITION A(LEFT) – P7/P8 UNDER CONDITION B(RIGHT)

Periodogram

The power spectrum for a stationary random process such as EEG signals, which are stochastic signals, is the Fourier transform of the autocorrelation sequence:

$$S_x(e^{jw}) = \sum_{k=-\infty}^{\infty} r_x(k)e^{-jw}$$

For the use of known signals at a finite interval ($n =$ ***N-1***),

$$\hat{r}_x(k) = \frac{1}{N}\sum_{n=k}^{N-1} x(n)\, x^*(n-k)\ ; k = 0,1, \ldots N-1$$

And applying the Fourier transform to the autocorrelation sequence, the power spectral estimator or Periodogram is obtained:

$$S_x(e^{jw}) = \sum_{k=-N+1}^{N-1} r_x(k) e^{-jkw}$$

It may be more convenient to express the spectral power estimator as a function of the signal or *x(n)* process, in this way we can consider the product of the signal with a rectangular window, and by taking the Fourier transform and applying the convolution theorem we have to:

$$S_x(e^{jw}) = \frac{1}{N} X_N(e^{jw})\, X^*{}_N(e^{jw}) = \frac{1}{N} \left|X_N(e^{jw})\right|^2$$

Where $X_N(e^{jw})$ is the discrete Fourier transform (DFT) of the sequence. Thus the periogram is proportional to the square of the DFT.(Estévez,2008)

Using MATLAB we obtained the periodicity of the filtered signals of each channel of EMOTIV, this is an estimation of the unilateral power spectral density (PSD) of a single channel, the parameters for the calculation are:

- Hamming window with size of signal.
- Sampling Frequency 128 Hz.

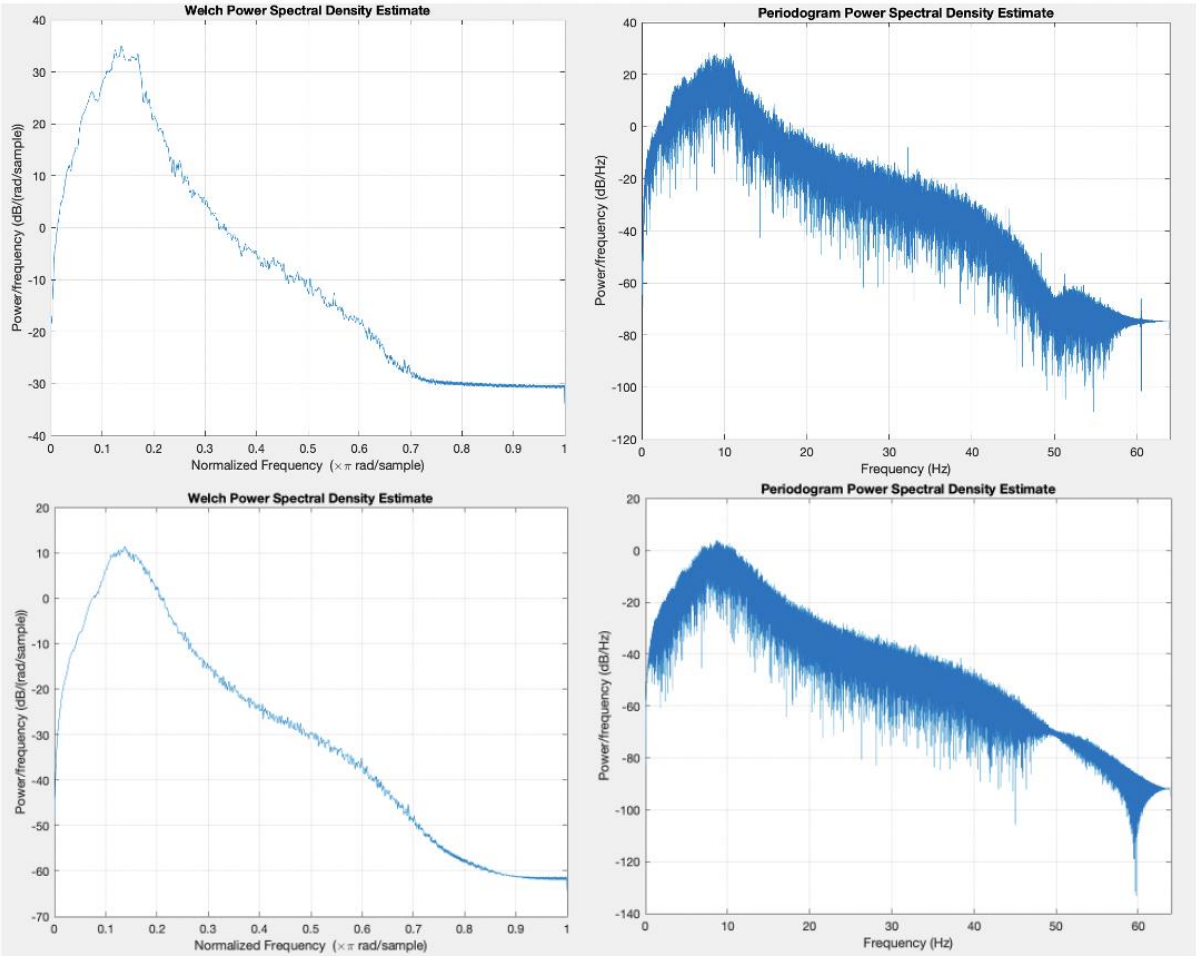

FIGURE5. EXAMPLE OF A POWER SPECTRAL DENSITY ESTIMATION FOR ELECTRODES P7/P8 UNDER CONDITION A FOR THE ALPHA BAND WELCH METHOD(LEFT) – PERIODOGRAM(LEFT)

RESULTS AND DISCUSSION

The EEG data for test consists of 14 channels of raw EEG data, each recording has a duration of approximately 8 minutes, with a sampling frequency of 128 hz. The results obtained after applying the methodology proposed above are shown in Tables 1,2,3 and 4.

As an example, from Figure 5 we can see the comparison of the most interesting electrodes to diagnose in which condition the binaural beats was applied.

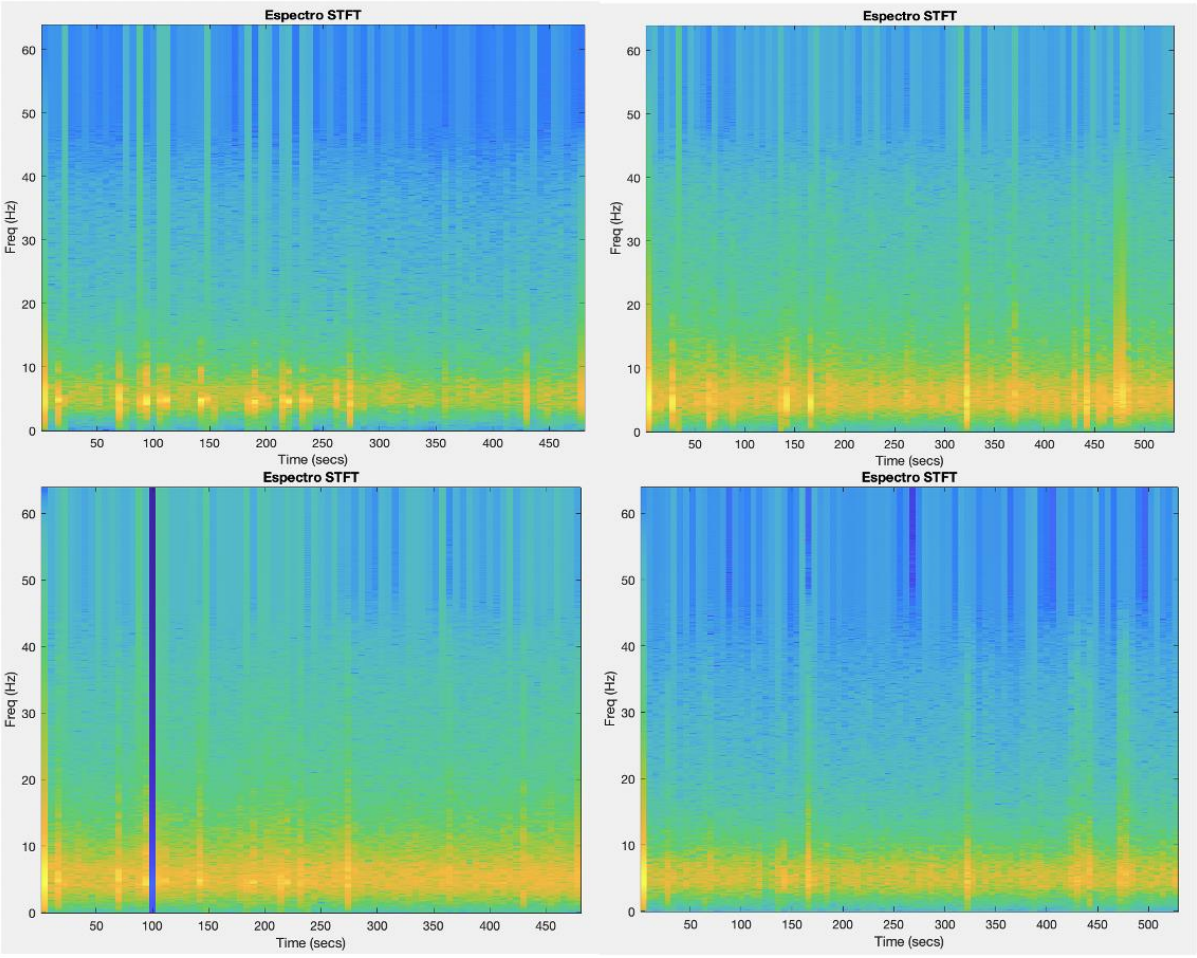

FIGURE6. SPECTROGRAM CORRESPONDING TO THE THETA BAND FOR THE P7(top) AND P8(bottom) ELECTRODES DURING CONDITION A(LEFT) AND CONDITION B(RIGHT)

The electrode P7 correspond to the left side and P8 to the right side of the head, then, we can clearly observe that in condition A the electrodes P7 and P8 do not present significant changes in their frequency spectrum, that is, the same tone is applied to the same frequency on both sides. Unlike condition B, we can see a notable change from the left side (P7) to the right side (P8) in the frequency spectrum, which is due to the application of a tone at different frequencies, and with this spectrum information we confirm that the binaural beat was applied in condition B.

The changes in the average power spectral density shown in Table 1 and 3 for the theta band in conditions A and B at electrodes P7 and P8 prove that condition B contains the binaural beat corresponding to the difference between the two pulses applied which will be 6 Hz and its power is located around 3-11dB.

To probe that our analysis was correct, we requested the physician to unveil one patient case. In this case patient No. 8, were condition B corresponded to the binaural beat condition, confirming therefore that our previous analysis was correct. Therefore, we provide a similar analysis for the other blind cases, but at this stage of the study, this information is been analyzed by our research partners at the Brain research center which are also conducting a related psychological study with the data.

CONCLUSION

From this study, by analyzing the frequency spectrum of the signals and the power spectral density, we conclude that the signals during the exposure of the binaural beat are in the theta band (4 - 7) Hz and with a power around 3 - 11 dB. The results obtained based on the experiment under the influence of a binaural beat with frequency 6 Hz confirm that exposure to them causes significant changes in the EEG. Therefore, we conclude that the proposed method is suitable for analyzing the brain activity during binaural test exposure, with further enhancements and refinements the proposed method could provide valuable insides about frequency bands activity during BB test and those results could then be associated with the psychological studies that are also been conducted.

REFERENCES

Ahirwal, M., Iondhe, N. (2012). Power Spectrum Analysis of EEG Signals for Estimating Visual Attention. *International Journal of Computer Applications* (0975-8887)

Ameera, A., Saidatul, A., Ibrahim, Z. (2018). Analysis of EEG Spectrum Bands Using Power Spectral Density for Pleasure and Displasure State. *Materials Science and Engineering* 557 (2019) 012030. doi:10.1088/1757-899X/557/1/012030

Cabañero, L. (2017). Análisis de señales de electroencefalografía (EEG) para evaluar actividad cognitive durante el uso de videojuegos. Retrieved from https://ruidera.uclm.es/xmlui/bitstream/handle/10578/15441/TFG-Luis%20Caba%C3%B1ero%20G%C3%B3mez.pdf?sequence=1&isAllowed=y

Chen Wan Fazdal, C., Mansor, W., Khuan, L. (2011). An Analysis of EEG Signal Generated From Grasping and Writing. Retrieved from https://www.researchgate.net/publication/239765719_An_analysis_of_EEG_signal_generated_from_grasping_and_writing

Dressler, O., Schneider, G., Stockmanns, G. (2004). Awareness and the EEG power spectrum: analysis of frequencies. *British Journal of Anasthesia* 93 (6): 806-9 doi: 10.1093/bja/aeh270

Estévez, M., Machado, A., Estévez, J. (2008). El periodograma como método para la estimación de la densidad espectral de potencia. Retrieved from http://www.fbio.uh.cu/ginvest/mesna/vfc_docs/ElPeriodogramaComoMetodoParaEstimacionDensidadEspectralDePotencia.pdf

Gwizdka, J., Hosseini, R., Cole, M., Wang, S. (2017). Temporal Dynamics of Eye-Tracking and EEG During Reading and Relevance Decisions. *Journal of the association for information science and technology*, 00(00):00-00

Kasprzak, C. (2011). Influence of binaural beats on EEG Signal. Retrieved from https://assets.thegrommet.com/product-comments/Sleep+Shepherd/Influence-on-EEG-Readings.pdf

Kumar, J., Bhuvaneswari, P. (2012). IAnalysis of electroencephalography (EEG) signals and its categorization. *Procedia Engineering.*

Lane, J., Kasian, S., Owens, J., Marsh, G. (1998). Los latidos auditivos binaurales afectan el rendimiento y el estado de ánimo de la vigilancia**.** Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0031938497004368

Pramanick, P. (2013). Classification of Electroencephalogram (EEG) Signal Based on Fourier Transform and Neural Network. Retrieved from https://core.ac.uk/download/pdf/53189287.pd

TABLES

Participant 8				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	5,363	2,06E+03	1,99E-12	EEGAF3
4 - 7 Hz (theta)	5,147	1,71E+03	2,12E-10	EEGAF4
4 - 7 Hz (theta)	1,295	442,4	1,01E-13	EEGF3
4 - 7 Hz (theta)	3,706	1,19E+03	8,11E-13	EEGF4
4 - 7 Hz (theta)	4,228	1,38E+03	6,83E-12	EEGF7
4 - 7 Hz (theta)	12,958	2,25E+03	7,69E-11	EEGF8
4 - 7 Hz (theta)	0,054	1,689	3,00E-16	EEGFC5
4 - 7 Hz (theta)	0,902	317,29	2,33E-12	EEGFC6
4 - 7 Hz (theta)	0,485	140,13	2,47E-13	EEGO1
4 - 7 Hz (theta)	5,62	1,41E+03	3,43E-12	EEGO2
4 - 7 Hz (theta)	0,365	113,67	3,23E-12	EEGP7
4 - 7 Hz (theta)	0,062	4,6	3,97E-13	EEGP8
4 - 7 Hz (theta)	2,558	1,01E+03	2,29E-12	EEGT7
4 - 7 Hz (theta)	0,712	267,01	1,89E-12	EEGT8

TABLE1. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 8 UNDER CONDITION A FOR THE THETA BAND.

Participant 8				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	2,529	434,29	5,08E-10	EEGAF3
7 - 12 Hz (alpha)	2,889	458,32	1,47E-09	EEGAF4
7 - 12 Hz (alpha)	1,117	184,14	6,18E-11	EEGF3
7 - 12 Hz (alpha)	2,412	382,41	1,06E-10	EEGF4
7 - 12 Hz (alpha)	2,096	257,75	4,94E-11	EEGF7
7 - 12 Hz (alpha)	5,004	417,81	9,09E-10	EEGF8
7 - 12 Hz (alpha)	0,031	0,665	1,21E-17	EEGFC5
7 - 12 Hz (alpha)	0,479	72,18	2,79E-11	EEGFC6
7 - 12 Hz (alpha)	0,528	71,24	2,11E-11	EEGO1
7 - 12 Hz (alpha)	2,895	395,13	3,56E-10	EEGO2
7 - 12 Hz (alpha)	0,072	12,2	1,82E-11	EEGP7
7 - 12 Hz (alpha)	0,034	1,24	7,77E-13	EEGP8
7 - 12 Hz (alpha)	0,359	45,4	4,42E-11	EEGT7
7 - 12 Hz (alpha)	0,25	33,01	2,01E-11	EEGT8

TABLE2. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 8 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 8				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	20,264	2,59E+03	2,27E-11	EEGAF3
4 - 7 Hz (theta)	11,23	1,90E+03	5,68E-11	EEGAF4
4 - 7 Hz (theta)	6,225	1,03E+03	3,76E-12	EEGF3
4 - 7 Hz (theta)	14,061	2,61E+03	8,50E-11	EEGF4
4 - 7 Hz (theta)	14,144	2,83E+03	5,61E-12	EEGF7
4 - 7 Hz (theta)	15,906	2,90E+03	5,50E-11	EEGF8
4 - 7 Hz (theta)	0,052	2,76	4,52E-16	EEGFC5
4 - 7 Hz (theta)	5,499	977,88	1,29E-11	EEGFC6
4 - 7 Hz (theta)	0,215	32,22	8,70E-13	EEGO1
4 - 7 Hz (theta)	15,182	2,58E+03	8,10E-13	EEGO2
4 - 7 Hz (theta)	0,085	11,21	2,17E-14	EEGP7
4 - 7 Hz (theta)	0,052	2,72	2,26E-15	EEGP8
4 - 7 Hz (theta)	22,31	3,29E+03	6,76E-09	EEGT7
4 - 7 Hz (theta)	20,696	3,59E+03	1,52E-11	EEGT8

TABLE3. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 8 UNDER CONDITION B FOR THE THETA BAND.

Participant 8				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	7,689	681,61	1,13E-11	EEGAF3
7 - 12 Hz (alpha)	4,274	378,45	1,30E-11	EEGAF4
7 - 12 Hz (alpha)	2,95	269,75	6,23E-14	EEGF3
7 - 12 Hz (alpha)	5,626	537,75	4,09E-13	EEGF4
7 - 12 Hz (alpha)	5,015	416,09	3,03E-11	EEGF7
7 - 12 Hz (alpha)	5,483	467,05	1,66E-11	EEGF8
7 - 12 Hz (alpha)	0,029	0,882	1,05E-15	EEGFC5
7 - 12 Hz (alpha)	2,078	183,68	3,44E-12	EEGFC6
7 - 12 Hz (alpha)	0,086	6,73	1,21E-13	EEGO1
7 - 12 Hz (alpha)	5,829	447,73	5,23E-13	EEGO2
7 - 12 Hz (alpha)	0,042	2,44	4,75E-14	EEGP7
7 - 12 Hz (alpha)	0,03	1,15	6,60E-15	EEGP8
7 - 12 Hz (alpha)	20,897	2,49E+03	1,11E-08	EEGT7
7 - 12 Hz (alpha)	6,589	635,1	2,52E-13	EEGT8

TABLE4. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 8 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 9				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,273	28,19	7,40E-12	EEGAF3
4 - 7 Hz (theta)	0,344	53,17	1,04E-11	EEGAF4
4 - 7 Hz (theta)	0,365	44,89	2,80E-13	EEGF3
4 - 7 Hz (theta)	0,399	47,7	9,20E-13	EEGF4
4 - 7 Hz (theta)	0,196	25,13	5,16E-11	EEGF7
4 - 7 Hz (theta)	0,241	40,65	4,49E-14	EEGF8
4 - 7 Hz (theta)	0,055	1,87	5,50E-19	EEGFC5
4 - 7 Hz (theta)	0,334	52,3	3,43E-14	EEGFC6
4 - 7 Hz (theta)	0,263	44,6	7,78E-12	EEGO1
4 - 7 Hz (theta)	0,258	45,68	7,15E-12	EEGO2
4 - 7 Hz (theta)	0,066	4,29	4,89E-16	EEGP7
4 - 7 Hz (theta)	0,057	2,35	8,25E-14	EEGP8
4 - 7 Hz (theta)	0,065	4,33	2,89E-12	EEGT7
4 - 7 Hz (theta)	0,366	48,45	2,55E-13	EEGT8

TABLE5. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 9 UNDER CONDITION A FOR THE THETA BAND.

Participant 9				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,274	24,11	7,95E-14	EEGAF3
7 - 12 Hz (alpha)	0,333	33,59	1,70E-12	EEGAF4
7 - 12 Hz (alpha)	0,262	23,83	1,88E-12	EEGF3
7 - 12 Hz (alpha)	0,314	28,84	1,73E-12	EEGF4
7 - 12 Hz (alpha)	0,194	19,94	1,10E-12	EEGF7
7 - 12 Hz (alpha)	0,255	31,16	6,39E-13	EEGF8
7 - 12 Hz (alpha)	0,031	0,703	1,94E-22	EEGFC5
7 - 12 Hz (alpha)	0,317	32,64	7,67E-13	EEGFC6
7 - 12 Hz (alpha)	0,334	42,79	2,27E-11	EEGO1
7 - 12 Hz (alpha)	0,36	39,29	1,86E-13	EEGO2
7 - 12 Hz (alpha)	0,05	2,65	6,01E-16	EEGP7
7 - 12 Hz (alpha)	0,033	1	5,29E-13	EEGP8
7 - 12 Hz (alpha)	0,047	2,45	3,51E-12	EEGT7
7 - 12 Hz (alpha)	0,427	38,03	2,49E-13	EEGT8

TABLE6. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 9 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 9				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,291	43,06	6,67E-13	EEGAF3
4 - 7 Hz (theta)	0,441	51,96	3,74E-13	EEGAF4
4 - 7 Hz (theta)	0,211	37,62	8,51E-12	EEGF3
4 - 7 Hz (theta)	0,253	34	3,00E-12	EEGF4
4 - 7 Hz (theta)	0,491	41,83	3,90E-15	EEGF7
4 - 7 Hz (theta)	0,433	54,05	2,65E-12	EEGF8
4 - 7 Hz (theta)	0,062	4,37	6,73E-15	EEGFC5
4 - 7 Hz (theta)	0,267	30,78	6,45E-12	EEGFC6
4 - 7 Hz (theta)	0,105	11,39	9,95E-15	EEGO1
4 - 7 Hz (theta)	0,151	14,41	1,20E-14	EEGO2
4 - 7 Hz (theta)	0,059	2,9	1,60E-15	EEGP7
4 - 7 Hz (theta)	0,059	3,25	3,89E-15	EEGP8
4 - 7 Hz (theta)	0,156	19,87	2,97E-12	EEGT7
4 - 7 Hz (theta)	0,282	30,91	2,73E-14	EEGT8

TABLE7. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 9 UNDER CONDITION B FOR THE THETA BAND.

Participant 9				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,288	27,23	3,85E-12	EEGAF3
7 - 12 Hz (alpha)	0,479	44,8	8,91E-12	EEGAF4
7 - 12 Hz (alpha)	0,193	19,44	4,75E-14	EEGF3
7 - 12 Hz (alpha)	0,285	23,76	4,09E-13	EEGF4
7 - 12 Hz (alpha)	0,33	27,71	3,17E-12	EEGF7
7 - 12 Hz (alpha)	0,526	48,51	7,99E-12	EEGF8
7 - 12 Hz (alpha)	0,04	2,05	9,17E-14	EEGFC5
7 - 12 Hz (alpha)	0,32	29,62	1,80E-12	EEGFC6
7 - 12 Hz (alpha)	0,084	7,24	4,13E-15	EEGO1
7 - 12 Hz (alpha)	0,071	4,87	2,31E-12	EEGO2
7 - 12 Hz (alpha)	0,04	2,03	7,84E-14	EEGP7
7 - 12 Hz (alpha)	0,037	1,87	7,91E-14	EEGP8
7 - 12 Hz (alpha)	0,129	9,55	8,27E-14	EEGT7
7 - 12 Hz (alpha)	0,33	32,19	7,54E-12	EEGT8

TABLE8. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 9 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 11				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,133	16,68	6,91E-13	EEGAF3
4 - 7 Hz (theta)	0,361	55,09	2,77E-13	EEGAF4
4 - 7 Hz (theta)	0,237	39,32	1,18E-11	EEGF3
4 - 7 Hz (theta)	0,128	14,98	9,69E-14	EEGF4
4 - 7 Hz (theta)	0,133	23,7	1,67E-12	EEGF7
4 - 7 Hz (theta)	0,215	30,51	4,06E-13	EEGF8
4 - 7 Hz (theta)	0,055	1,32	1,60E-23	EEGFC5
4 - 7 Hz (theta)	0,152	18,22	5,19E-13	EEGFC6
4 - 7 Hz (theta)	0,217	22,95	4,36E-13	EEGO1
4 - 7 Hz (theta)	0,148	15,68	6,83E-15	EEGO2
4 - 7 Hz (theta)	0,056	2,08	1,12E-23	EEGP7
4 - 7 Hz (theta)	0,056	2,14	4,03E-16	EEGP8
4 - 7 Hz (theta)	0,132	18,6	8,79E-14	EEGT7
4 - 7 Hz (theta)	0,202	21,04	1,09E-14	EEGT8

TABLE9. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 11 UNDER CONDITION A FOR THE THETA BAND.

Participant 11				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,152	12,53	1,06E-12	EEGAF3
7 - 12 Hz (alpha)	0,407	46,64	1,36E-10	EEGAF4
7 - 12 Hz (alpha)	0,342	35,15	9,87E-13	EEGF3
7 - 12 Hz (alpha)	0,155	12,95	6,17E-13	EEGF4
7 - 12 Hz (alpha)	0,135	11,72	7,86E-12	EEGF7
7 - 12 Hz (alpha)	0,286	29,21	1,80E-11	EEGF8
7 - 12 Hz (alpha)	0,031	0,441	1,44E-22	EEGFC5
7 - 12 Hz (alpha)	0,2	16,99	1,94E-11	EEGFC6
7 - 12 Hz (alpha)	0,51	57,1	1,33E-11	EEGO1
7 - 12 Hz (alpha)	0,444	60,56	7,83E-12	EEGO2
7 - 12 Hz (alpha)	0,033	0,94	1,00E-22	EEGP7
7 - 12 Hz (alpha)	0,032	0,749	1,97E-15	EEGP8
7 - 12 Hz (alpha)	0,146	12,77	6,00E-12	EEGT7
7 - 12 Hz (alpha)	0,349	32,33	3,48E-12	EEGT8

TABLE10. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 11 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 11				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,301	48,15	5,08E-13	EEGAF3
4 - 7 Hz (theta)	0,368	44,77	1,44E-11	EEGAF4
4 - 7 Hz (theta)	0,161	27,2	1,95E-14	EEGF3
4 - 7 Hz (theta)	0,216	26,21	1,37E-11	EEGF4
4 - 7 Hz (theta)	0,218	29,95	1,47E-12	EEGF7
4 - 7 Hz (theta)	0,172	23,69	6,17E-12	EEGF8
4 - 7 Hz (theta)	0,055	1,32	1,64E-23	EEGFC5
4 - 7 Hz (theta)	0,064	3,89	1,99E-14	EEGFC6
4 - 7 Hz (theta)	0,096	10,33	4,67E-12	EEGO1
4 - 7 Hz (theta)	0,138	15,94	7,62E-12	EEGO2
4 - 7 Hz (theta)	0,057	2,51	4,45E-16	EEGP7
4 - 7 Hz (theta)	0,057	2,21	1,01E-15	EEGP8
4 - 7 Hz (theta)	0,173	23,32	8,22E-12	EEGT7
4 - 7 Hz (theta)	0,232	25,73	2,80E-12	EEGT8

TABLE11. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 11 UNDER CONDITION B FOR THE THETA BAND.

Participant 11				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,239	21,8	3,42E-13	EEGAF3
7 - 12 Hz (alpha)	0,314	21,39	3,50E-14	EEGAF4
7 - 12 Hz (alpha)	0,12	10,18	1,57E-12	EEGF3
7 - 12 Hz (alpha)	0,173	12,16	5,75E-15	EEGF4
7 - 12 Hz (alpha)	0,191	16,53	5,76E-12	EEGF7
7 - 12 Hz (alpha)	0,156	12,37	9,25E-12	EEGF8
7 - 12 Hz (alpha)	0,031	0,43	1,47E-22	EEGFC5
7 - 12 Hz (alpha)	0,043	2,81	1,47E-13	EEGFC6
7 - 12 Hz (alpha)	0,081	5,48	1,37E-11	EEGO1
7 - 12 Hz (alpha)	0,146	13,5	1,70E-11	EEGO2
7 - 12 Hz (alpha)	0,033	1,19	5,64E-16	EEGP7
7 - 12 Hz (alpha)	0,032	0,89	8,17E-15	EEGP8
7 - 12 Hz (alpha)	0,167	18,03	9,00E-13	EEGT7
7 - 12 Hz (alpha)	0,243	20,09	4,99E-12	EEGT8

TABLE12. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 11 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 12				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	38,18	3,86E+03	1,05E-12	EEGAF3
4 - 7 Hz (theta)	34,63	3,56E+03	9,72E-12	EEGAF4
4 - 7 Hz (theta)	15,22	1,87E+03	1,23E-13	EEGF3
4 - 7 Hz (theta)	22,07	2,42E+03	5,29E-14	EEGF4
4 - 7 Hz (theta)	15,14	1,80E+03	7,09E-19	EEGF7
4 - 7 Hz (theta)	52,06	4,94E+03	1,60E-10	EEGF8
4 - 7 Hz (theta)	0,058	2,51	1,12E-17	EEGFC5
4 - 7 Hz (theta)	0,344	39,82	3,85E-15	EEGFC6
4 - 7 Hz (theta)	4,9	597,75	1,69E-13	EEGO1
4 - 7 Hz (theta)	18,75	2,04E+03	1,71E-13	EEGO2
4 - 7 Hz (theta)	0,387	43,82	6,57E-14	EEGP7
4 - 7 Hz (theta)	0,066	4,8	1,58E-16	EEGP8
4 - 7 Hz (theta)	0,774	87,09	3,57E-12	EEGT7
4 - 7 Hz (theta)	18,5	1,95E+03	4,60E-13	EEGT8

TABLE13. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 12 UNDER CONDITION A FOR THE THETA BAND.

Participant 12				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	18,68	1,48E+03	3,59E-12	EEGAF3
7 - 12 Hz (alpha)	17,1	1,28E+03	4,37E-12	EEGAF4
7 - 12 Hz (alpha)	6,94	472,68	1,56E-11	EEGF3
7 - 12 Hz (alpha)	10,58	767,74	2,09E-11	EEGF4
7 - 12 Hz (alpha)	7,058	479,43	7,55E-13	EEGF7
7 - 12 Hz (alpha)	25,92	2,12E+03	3,87E-13	EEGF8
7 - 12 Hz (alpha)	0,033	1,066	5,12E-19	EEGFC5
7 - 12 Hz (alpha)	0,178	15,59	9,23E-14	EEGFC6
7 - 12 Hz (alpha)	2,387	153,97	5,30E-11	EEGO1
7 - 12 Hz (alpha)	9,354	688,41	4,90E-10	EEGO2
7 - 12 Hz (alpha)	0,29	22,63	4,11E-14	EEGP7
7 - 12 Hz (alpha)	0,042	2,11	3,80E-15	EEGP8
7 - 12 Hz (alpha)	0,542	39,39	1,86E-12	EEGT7
7 - 12 Hz (alpha)	9,37	724,58	7,96E-14	EEGT8

TABLE14. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 12 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 12				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,366	58,71	2,83E-12	EEGAF3
4 - 7 Hz (theta)	0,861	94,56	1,16E-12	EEGAF4
4 - 7 Hz (theta)	0,419	44,67	1,03E-12	EEGF3
4 - 7 Hz (theta)	0,554	63,67	2,52E-12	EEGF4
4 - 7 Hz (theta)	0,485	72,86	4,59E-12	EEGF7
4 - 7 Hz (theta)	0,79	84,52	9,22E-11	EEGF8
4 - 7 Hz (theta)	0,054	1,31	1,81E-23	EEGFC5
4 - 7 Hz (theta)	0,297	34,07	2,11E-13	EEGFC6
4 - 7 Hz (theta)	0,547	54,02	3,32E-14	EEGO1
4 - 7 Hz (theta)	0,415	42,95	9,95E-13	EEGO2
4 - 7 Hz (theta)	0,119	11,07	1,98E-15	EEGP7
4 - 7 Hz (theta)	0,057	2,7	1,37E-14	EEGP8
4 - 7 Hz (theta)	0,417	45,34	4,86E-13	EEGT7
4 - 7 Hz (theta)	0,921	109,51	7,10E-11	EEGT8

TABLE15. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 12 UNDER CONDITION B FOR THE THETA BAND.

Participant 12				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,331	27,69	6,13E-12	EEGAF3
7 - 12 Hz (alpha)	0,739	57,3	5,23E-11	EEGAF4
7 - 12 Hz (alpha)	0,295	16,65	3,57E-12	EEGF3
7 - 12 Hz (alpha)	0,508	48,19	4,48E-12	EEGF4
7 - 12 Hz (alpha)	0,391	29,3	7,97E-12	EEGF7
7 - 12 Hz (alpha)	0,67	53,02	3,62E-12	EEGF8
7 - 12 Hz (alpha)	0,03	0,43	1,63E-22	EEGFC5
7 - 12 Hz (alpha)	0,267	25,04	9,87E-13	EEGFC6
7 - 12 Hz (alpha)	0,332	17,35	2,78E-15	EEGO1
7 - 12 Hz (alpha)	0,252	16,64	2,11E-14	EEGO2
7 - 12 Hz (alpha)	0,089	6,14	2,68E-13	EEGP7
7 - 12 Hz (alpha)	0,033	1,19	1,38E-13	EEGP8
7 - 12 Hz (alpha)	0,282	21,31	2,52E-13	EEGT7
7 - 12 Hz (alpha)	0,886	83,67	4,51E-12	EEGT8

TABLE16. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 12 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 13				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,502	77,65	8,03E-12	EEGAF3
4 - 7 Hz (theta)	0,567	83,52	5,57E-13	EEGAF4
4 - 7 Hz (theta)	0,429	50,97	7,16E-13	EEGF3
4 - 7 Hz (theta)	0,329	42,76	2,13E-13	EEGF4
4 - 7 Hz (theta)	0,226	28,39	5,20E-12	EEGF7
4 - 7 Hz (theta)	0,467	62,91	1,09E-12	EEGF8
4 - 7 Hz (theta)	0,055	1,35	1,50E-23	EEGFC5
4 - 7 Hz (theta)	0,081	6,69	9,75E-14	EEGFC6
4 - 7 Hz (theta)	0,079	6,31	5,46E-12	EEGO1
4 - 7 Hz (theta)	0,403	48,89	5,93E-11	EEGO2
4 - 7 Hz (theta)	0,071	5,056	1,72E-13	EEGP7
4 - 7 Hz (theta)	0,057	2,288	4,64E-15	EEGP8
4 - 7 Hz (theta)	0,124	12,72	1,12E-12	EEGT7
4 - 7 Hz (theta)	0,333	35,13	1,03E-13	EEGT8

TABLE17. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 13 UNDER CONDITION A FOR THE THETA BAND.

Participant 13				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	1,302	193,44	1,33E-10	EEGAF3
7 - 12 Hz (alpha)	1,575	261,2	4,99E-12	EEGAF4
7 - 12 Hz (alpha)	1,08	164,23	1,67E-11	EEGF3
7 - 12 Hz (alpha)	0,932	162,33	4,17E-11	EEGF4
7 - 12 Hz (alpha)	0,473	92,67	1,27E-10	EEGF7
7 - 12 Hz (alpha)	1,328	227,91	2,64E-12	EEGF8
7 - 12 Hz (alpha)	0,031	0,45	1,34E-22	EEGFC5
7 - 12 Hz (alpha)	0,108	14,33	8,98E-13	EEGFC6
7 - 12 Hz (alpha)	0,159	19,55	7,25E-12	EEGO1
7 - 12 Hz (alpha)	2,144	298,25	1,01E-10	EEGO2
7 - 12 Hz (alpha)	0,053	4,66	1,00E-12	EEGP7
7 - 12 Hz (alpha)	0,032	0,88	3,79E-13	EEGP8
7 - 12 Hz (alpha)	0,11	9,03	2,54E-15	EEGT7
7 - 12 Hz (alpha)	1,252	184,27	4,31E-11	EEGT8

TABLE18. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 13 UNDER CONDITION A FOR THE ALPHA BAND..

Participant 13				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,712	76,52	4,04E-10	EEGAF3
4 - 7 Hz (theta)	0,789	94,31	7,11E-12	EEGAF4
4 - 7 Hz (theta)	0,708	88,21	1,77E-11	EEGF3
4 - 7 Hz (theta)	0,318	41,7	3,24E-11	EEGF4
4 - 7 Hz (theta)	0,604	75,15	1,21E-10	EEGF7
4 - 7 Hz (theta)	0,75	89,86	2,73E-10	EEGF8
4 - 7 Hz (theta)	0,055	1,54	1,65E-23	EEGFC5
4 - 7 Hz (theta)	0,629	77,67	2,29E-11	EEGFC6
4 - 7 Hz (theta)	0,698	110,84	2,28E-12	EEGO1
4 - 7 Hz (theta)	0,833	98,68	1,17E-10	EEGO2
4 - 7 Hz (theta)	0,057	2,38	8,59E-16	EEGP7
4 - 7 Hz (theta)	0,056	2	1,83E+16	EEGP8
4 - 7 Hz (theta)	0,06	2,99	3,64E-14	EEGT7
4 - 7 Hz (theta)	0,055	1,5	1,06E-14	EEGT8

TABLE19. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 13 UNDER CONDITION B FOR THE THETA BAND.

Participant 13				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,799	68,31	1,36E-10	EEGAF3
7 - 12 Hz (alpha)	0,836	63,46	5,00E-10	EEGAF4
7 - 12 Hz (alpha)	0,775	67,07	8,05E-11	EEGF3
7 - 12 Hz (alpha)	0,343	28,61	3,14E-11	EEGF4
7 - 12 Hz (alpha)	0,569	44,39	8,49E-12	EEGF7
7 - 12 Hz (alpha)	0,801	65,456	6,10E-11	EEGF8
7 - 12 Hz (alpha)	0,031	0,513	1,48E-22	EEGFC5
7 - 12 Hz (alpha)	0,715	58,23	6,60E-10	EEGFC6
7 - 12 Hz (alpha)	1,204	142,72	2,12E-10	EEGO1
7 - 12 Hz (alpha)	1,77	197,37	3,93E-11	EEGO2
7 - 12 Hz (alpha)	0,034	1,25	3,54E-16	EEGP7
7 - 12 Hz (alpha)	0,031	0,73	1,01E-15	EEGP8
7 - 12 Hz (alpha)	0,038	1,88	1,90E-14	EEGT7
7 - 12 Hz (alpha)	0,031	0,52	6,58E-15	EEGT8

TABLE20. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 13 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 14				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,32	30,84	7,12E-12	EEGAF3
4 - 7 Hz (theta)	0,296	29,96	7,38E-12	EEGAF4
4 - 7 Hz (theta)	0,335	52,54	5,59E-12	EEGF3
4 - 7 Hz (theta)	0,341	34,2	6,17E-13	EEGF4
4 - 7 Hz (theta)	0,294	30,26	5,86E-11	EEGF7
4 - 7 Hz (theta)	0,413	42,22	2,51E-13	EEGF8
4 - 7 Hz (theta)	0,067	1,6	2,20E-24	EEGFC5
4 - 7 Hz (theta)	0,397	37,03	1,93E-16	EEGFC6
4 - 7 Hz (theta)	0,201	25,89	1,00E-10	EEGO1
4 - 7 Hz (theta)	0,377	48,56	3,68E-11	EEGO2
4 - 7 Hz (theta)	0,163	16,29	7,14E-13	EEGP7
4 - 7 Hz (theta)	0,083	8,04	2,17E-14	EEGP8
4 - 7 Hz (theta)	0,23	32,71	2,44E-11	EEGT7
4 - 7 Hz (theta)	202,37	2,78E+04	1,00E-12	EEGT8

TABLE21. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 14 UNDER CONDITION A FOR THE THETA BAND.

Participant 14				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,838	141,59	1,00E-11	EEGAF3
7 - 12 Hz (alpha)	0,768	155,73	8,65E-12	EEGAF4
7 - 12 Hz (alpha)	0,793	171,4	2,43E-12	EEGF3
7 - 12 Hz (alpha)	0,982	224,97	1,75E-12	EEGF4
7 - 12 Hz (alpha)	0,583	90,15	4,04E-12	EEGF7
7 - 12 Hz (alpha)	0,849	172,27	9,16E-16	EEGF8
7 - 12 Hz (alpha)	0,037	0,53	1,97E-23	EEGFC5
7 - 12 Hz (alpha)	0,847	174,19	7,96E-12	EEGFC6
7 - 12 Hz (alpha)	0,584	188,44	9,43E-13	EEGO1
7 - 12 Hz (alpha)	2	586,54	8,60E-10	EEGO2
7 - 12 Hz (alpha)	0,092	7,73	1,27E-14	EEGP7
7 - 12 Hz (alpha)	0,048	2,45	2,26E-15	EEGP8
7 - 12 Hz (alpha)	0,205	22,54	1,04E-11	EEGT7
7 - 12 Hz (alpha)	104,88	1,10E+04	2,62E-11	EEGT8

TABLE22. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 14 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 14				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	26,72	2,39E+03	9,84E-12	EEGAF3
4 - 7 Hz (theta)	24,92	2,31E+03	1,16E-11	EEGAF4
4 - 7 Hz (theta)	17,25	1,50E+03	1,82E-12	EEGF3
4 - 7 Hz (theta)	7,34	689,9	2,89E-13	EEGF4
4 - 7 Hz (theta)	31,52	2,85E+03	3,76E-12	EEGF7
4 - 7 Hz (theta)	31,46	3,03E+03	2,59E-12	EEGF8
4 - 7 Hz (theta)	0,057	2,47	1,43E-23	EEGFC5
4 - 7 Hz (theta)	26,809	2,56E+03	2,19E-11	EEGFC6
4 - 7 Hz (theta)	24,82	2,27E+03	7,23E-12	EEGO1
4 - 7 Hz (theta)	7,779	769.38	9,40E-12	EEGO2
4 - 7 Hz (theta)	0,088	8,09	1,07E-16	EEGP7
4 - 7 Hz (theta)	0,06	3,28	1,74E-13	EEGP8
4 - 7 Hz (theta)	40,62	3,49E+03	1,34E-12	EEGT7
4 - 7 Hz (theta)	34,773	3,23E+03	1,24E-11	EEGT8

TABLE23. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 14 UNDER CONDITION B FOR THE THETA BAND.

Participant 14				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	19,21	2,04E+03	3,62E-11	EEGAF3
7 - 12 Hz (alpha)	17,86	1,91E+03	3,44E-12	EEGAF4
7 - 12 Hz (alpha)	12,31	1,34E+03	5,03E-11	EEGF3
7 - 12 Hz (alpha)	5,52	604,95	6,19E-11	EEGF4
7 - 12 Hz (alpha)	21,23	2,05E+03	1,05E-11	EEGF7
7 - 12 Hz (alpha)	21,21	2,15E+03	1,59E-12	EEGF8
7 - 12 Hz (alpha)	0,033	0,92	1,28E-22	EEGFC5
7 - 12 Hz (alpha)	18,699	1,98E+03	7,89E-14	EEGFC6
7 - 12 Hz (alpha)	17,409	1,38E+03	1,43E+03	EEGO1
7 - 12 Hz (alpha)	6,339	507,78	2,56E-11	EEGO2
7 - 12 Hz (alpha)	0,056	3,99	5,72E-13	EEGP7
7 - 12 Hz (alpha)	0,036	1,398	7,65E-14	EEGP8
7 - 12 Hz (alpha)	26,39	2,17E+03	2,40E-11	EEGT7
7 - 12 Hz (alpha)	23,58	2,19E+03	2,01E-11	EEGT8

TABLE24. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 14 UNDER CONDITION B FOR THE ALPHA BAND.

Participant 15				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,354	48,72	1,09E-11	EEGAF3
4 - 7 Hz (theta)	0,4117	49,79	2,09E-12	EEGAF4
4 - 7 Hz (theta)	0,284	45,37	4,10E-12	EEGF3
4 - 7 Hz (theta)	0,433	70,21	5,00E-11	EEGF4
4 - 7 Hz (theta)	0,391	52,58	3,43E-12	EEGF7
4 - 7 Hz (theta)	0,362	46,01	1,73E-11	EEGF8
4 - 7 Hz (theta)	0,055	1,71	1,05E-20	EEGFC5
4 - 7 Hz (theta)	0,442	55,18	5,43E-11	EEGFC6
4 - 7 Hz (theta)	0,114	12,103	1,20E-12	EEGO1
4 - 7 Hz (theta)	0,327	48,89	8,19E-11	EEGO2
4 - 7 Hz (theta)	0,281	47,54	5,83E-13	EEGP7
4 - 7 Hz (theta)	0,316	42,84	3,28E-11	EEGP8
4 - 7 Hz (theta)	0,182	19,89	5,47E-12	EEGT7
4 - 7 Hz (theta)	0,402	65,6	4,37E-12	EEGT8

TABLE25. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 15 UNDER CONDITION A FOR THE THETA BAND.

Participant 15				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,529	37,35	1,88E-11	EEGAF3
7 - 12 Hz (alpha)	0,64	48,45	6,33E-12	EEGAF4
7 - 12 Hz (alpha)	0,395	38,47	1,21E-11	EEGF3
7 - 12 Hz (alpha)	0,665	58,23	7,20E-12	EEGF4
7 - 12 Hz (alpha)	0,473	35,14	3,15E-12	EEGF7
7 - 12 Hz (alpha)	0,607	65,51	9,49E-12	EEGF8
7 - 12 Hz (alpha)	0,031	0,632	1,61E-22	EEGFC5
7 - 12 Hz (alpha)	0,713	66,45	1,66E-13	EEGFC6
7 - 12 Hz (alpha)	0,109	8,71	1,79E-11	EEGO1
7 - 12 Hz (alpha)	0,809	83,51	5,90E-12	EEGO2
7 - 12 Hz (alpha)	0,178	12,88	8,36E-14	EEGP7
7 - 12 Hz (alpha)	0,56	59,23	2,99E-12	EEGP8
7 - 12 Hz (alpha)	0,203	17,95	5,36E-14	EEGT7
7 - 12 Hz (alpha)	0,71	64,13	8,52E-13	EEGT8

TABLE26. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 15 UNDER CONDITION A FOR THE ALPHA BAND.

Participant 15				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
4 - 7 Hz (theta)	0,469	63,9	5,85E-12	EEGAF3
4 - 7 Hz (theta)	0,342	47,8	1,13E-12	EEGAF4
4 - 7 Hz (theta)	0,457	98,74	6,22E-12	EEGF3
4 - 7 Hz (theta)	0,432	63,86	8,94E-13	EEGF4
4 - 7 Hz (theta)	0,352	44,11	8,89E-13	EEGF7
4 - 7 Hz (theta)	0,442	60,54	6,46E-12	EEGF8
4 - 7 Hz (theta)	0,057	1,37	1,01E-23	EEGFC5
4 - 7 Hz (theta)	0,524	90,44	3,69E-12	EEGFC6
4 - 7 Hz (theta)	0,343	54,92	3,23E-13	EEGO1
4 - 7 Hz (theta)	0,368	53,72	8,02E-13	EEGO2
4 - 7 Hz (theta)	0,059	2,62	4,84E-15	EEGP7
4 - 7 Hz (theta)	0,391	56,25	7,93E-13	EEGP8
4 - 7 Hz (theta)	0,074	7,77	9,99E-14	EEGT7
4 - 7 Hz (theta)	0,507	111,21	7,86E-11	EEGT8

TABLE27. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 15 UNDER CONDITION B FOR THE THETA BAND.

Participant 15				
Frecuency Band	**Mean Power (dB/Hz)**	**Max. Power (dB/Hz)**	**Min.Power (dB/Hz)**	**Electrode**
7 - 12 Hz (alpha)	0,692	54,81	4,50E-12	EEGAF3
7 - 12 Hz (alpha)	0,457	46,65	2,29E-11	EEGAF4
7 - 12 Hz (alpha)	0,568	44,31	3,10E-12	EEGF3
7 - 12 Hz (alpha)	0,564	43,26	7,21E-12	EEGF4
7 - 12 Hz (alpha)	0,431	29,02	8,94E-12	EEGF7
7 - 12 Hz (alpha)	0,544	44,83	1,77E-11	EEGF8
7 - 12 Hz (alpha)	0,032	0,45	9,12E-23	EEGFC5
7 - 12 Hz (alpha)	0,807	69,47	5,88E-12	EEGFC6
7 - 12 Hz (alpha)	0,542	44,16	1,45E-11	EEGO1
7 - 12 Hz (alpha)	1,116	121,49	3,90E-12	EEGO2
7 - 12 Hz (alpha)	0,034	1,072	6,32E-13	EEGP7
7 - 12 Hz (alpha)	0,797	71,47	1,95E-12	EEGP8
7 - 12 Hz (alpha)	0,057	3,94	1,57E-11	EEGT7
7 - 12 Hz (alpha)	0,767	68,06	6,36E-13	EEGT8

TABLE28. QUANTITIVE MEASUREMENT OF PSD FOR PARTICIPANT No. 15 UNDER CONDITION B FOR THE ALPHA BAND.