

# Spectral and spatial features of encephalograms in mental disorders

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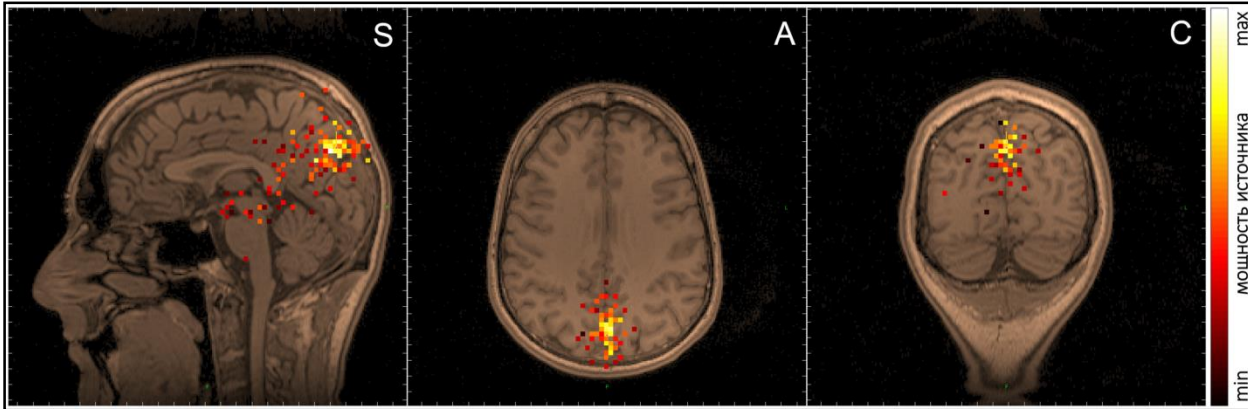
# Spectral and spatial characteristics of electroencephalography (EEG) | magnetoencephalography (MEG) of human brain:

- Spectral power of the considered frequency range
- Localization of frequency band activity sources

The work uses the traditional frequency division of the electrical activity of the brain into frequency bands corresponding to the following spectral ranges:

- Delta rhythm - from 0.5 to 4 Hz;
- Theta rhythm –from 4 to 8 Hz;
- Alpha rhythm –from 8 to 13 Hz;
- Beta rhythm - from 13 to 35 Hz;
- Gamma rhythm - above 35 Hz.

# Method of functional tomography (Llinás R.R., Ustinin M.N.)



The method allows, according to MEG and EEG data, to build activity spectra whose sources are located in a particular region of the brain, the so-called partial spectra.

**Llinás R.R., Ustinin M.N.** Frequency-pattern functional tomography of magnetoencephalography data allows new approach to the study of human brain organization // *Front. Neural Circuits*. 2014; 8:43. doi:10.3389/fncir.2014.00043

**Llinás R.R., Ustinin M.N., Rykunov S.D., Boyko A.I., Sychev V.V., Walton K.D., Rabello G.M., Garcia J.** Reconstruction of human brain spontaneous activity based on frequency-pattern analysis of magnetoencephalography data // *Front. Neurosci*. 2015; 9:373 doi:10.3389/fnins.2015.00373

**Rykunov S.D., Ustinin M.N., Polyanin A.G., Sychev V.V., Llinás R.R.** Software for the Partial Spectroscopy of Human Brain// *Math. Biol. Bioinf.* 2016;11(1):127-140

## Types of mental disorders:

- Organic Mental Disorders
- Affective mental disorders
- Schizophrenia Spectrum Disorder
- Autism Spectrum Disorders

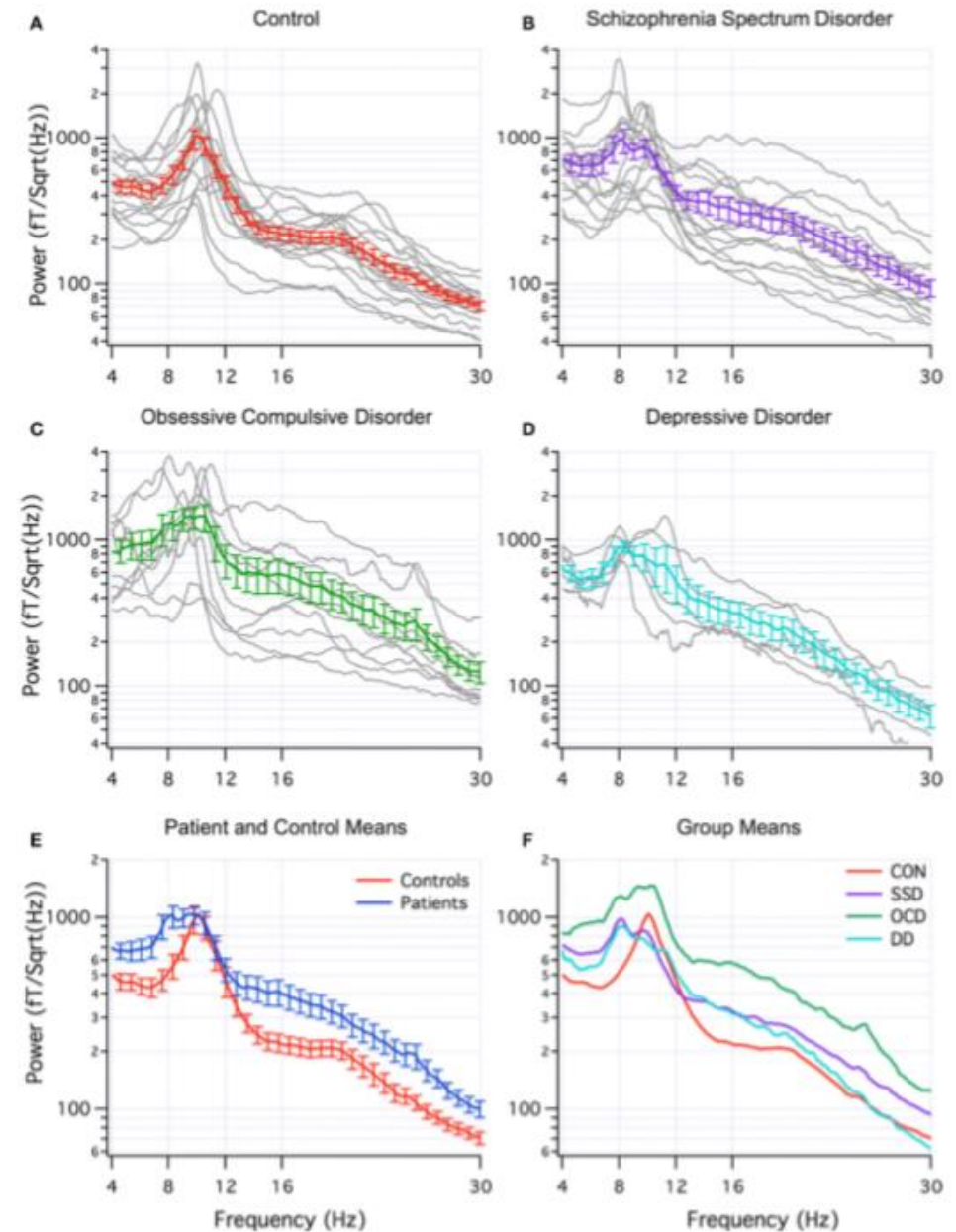
In these disorders, dysfunction of various parts of the brain is observed. This entails a change in the spectra of encephalograms and the localization of current sources of activity of the frequency ranges under study.

Schulman J.J., Cancro R., Lowe S., Lu F., Walton K.D, Llinas R.R.  
 Imaging of thalamocortical dysrhythmia in neuropsychiatry.  
 Frontiers in Human Neuroscience. 2011, V. 5, Article 69.

Spectral analysis of the recording of spontaneous brain activity in the control group and patients:

- Schizophrenia Spectrum Disorder
- Obsessive Compulsive Disorder
- Depressive Disorder

Spectral analysis showed the difference of the spectra from the control for patients of all considered groups.



**FIGURE 1 | Multi-taper power spectra. (A-D)** Individual (grey) and mean ( $\pm$ SEM) spectra for controls (red,  $n=18$ ), schizophrenic spectrum disorder (SSD) (purple,  $n=14$ ), obsessive-compulsive disorder (OCD) patients (green,  $n=10$ ), and depression disorder (DD) (blue,  $n=5$ ). **(E)** Superposition of mean ( $\pm$ SEM) of all patients (blue) and controls (red). **(F)** Superposition of means from **A-D**.

**Organic Mental Disorders** – disturbance of the brain as a result of traumatic brain injury, epilepsy, alcohol or drug addiction.

Accompanied by pathological changes in the encephalograms of the anterior cerebral cortex.

- Aggression and autoaggression: **delta rhythm** - increase in spectral power, **alpha and beta rhythms** – reduction of spectral power.
- Delayed mental development in children : decrease in the frequency of the **alpha rhythm**, its unformed, multiple alpha frequencies.
- Sexual disorders (paraphilia): increase in spectral power **delta, theta and beta ranges**.

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Киренская-Берус А.В., Ткаченко А.А. [Физиология человека](#). 2003. Т. 29, № 3. С. 22-32.

**Affective mental disorders** - excessive manifestation of natural emotions or apathetic attitude to the world around.

**Theta rhythm** - a biomarker of affective disorders, since these states are accompanied by an increase in the power spectrum of this range.

- Stress : increase the power of **theta rhythm** in the prefrontal cortex, frontal asymmetry of the **alpha rhythm**, enhancement of high frequencies of the **beta rhythm** in the posterior sensorimotor cortex.
- Depressive Disorder: increase the power of **theta rhythm** in the temporal lobe, shifting the peak of the **alpha rhythm** to lower frequencies.
- Obsessive Compulsive Disorder: increase the power of **theta rhythm**.

**Schulman J.J., Cancro R., Lowe S., Lu F., Walton K.D, Llinas R.R.** Frontiers in Human Neuroscience. 2011, V. 5, Article 69

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## Schizophrenia Spectrum Disorder

Consequence of thalamocortical dysrhythmia - intermittent thalamocortical paroxysmal activity.

Features of MEG and EEG data:

- an increase in the spectral power of the **delta and theta rhythms** in the frontal areas.
- **Alpha, beta and gamma activity** decreased.
- Sources of **alpha activity** are located in different areas of the brain (in the control group they predominate in the parietal occipital part).
- Decreased **beta activity** is more pronounced in the frontal areas.

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**Князева М.Г., Jalili M., Meuli R., Hasler M., De Feo O., Do K.Q.** Acta Psychiatr. Scand. – 2008. - V.118. - №3. –

P.188-199



## Autism Spectrum Disorders

A disturbance of the thalamocortical bonds and, as a consequence, an increase in high-frequency activity in the cortex sections is assumed.

Features of MEG and EEG data :

- decrease in the spectral power of the **theta rhythm** in the posterior regions.
- **Alpha rhythm** activity is reduced.
- Increasing the power of the spectrum **above 20 Hz**.

[Gregory M., Mandelbaum D.](#) [Research in Autism Spectrum Disorders](#). 2012. № 6.

[Луцкина Е.А., Хаердинова О.Ю., Луцкин В.С., Стрелец В.Б.](#) [Физиология человека](#). 2017. Т. 43. [№ 3](#). С. 32-42.

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# Comparison of the spectral features of encephalograms in schizophrenia and autism

frequency range	Spectral power at	
	Schizophrenia	Autism
Theta rhythm	<b>increased</b>	<b>decreased</b>
Alpha rhythm	<b>decreased</b>	<b>decreased</b>
Beta and Gamma rhythms	<b>decreased</b>	<b>increased</b>

Thus, autism and schizophrenia have different spectral characteristics of the EEG / MEG and are different diseases.

# Conclusion

- Different mental disorders have different spectral features.
- A quantitative study of the spectra is necessary, with the aim of their further use as diagnostic signs.
- The precise localization of various frequency components is important for correlating functional and anatomical maps of the brain.

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