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A study of synchronization between rats ECoG channels under the anesthesia

The continuous wavelet transform:

$$W(s, t_0) = \frac{1}{\sqrt{s}} \int_{-\infty}^{+\infty} x(t) \psi^* \left(\frac{t-t_0}{s} \right) dt,$$

The complex Morlet mother wavelet:

$$\psi(\eta) = (1/\sqrt[4]{\pi}) \exp(j\Omega_0 \eta) \exp(-\eta^2/2)$$

$$\Omega_0 = 2\pi \longrightarrow f = 1/s$$

To measure the degree of coherence between two EEG signals, $x_i(t)$ and $x_j(t)$, we used the corresponding complex-valued wavelet coefficients, $W_i(f; t) = a_i + ib_i$ and $W_j(f; t) = a_j + ib_j$.

mutual wavelet spectrum are calculated:

$$\text{Re} [\sigma_{ij}(f, t)] = \frac{a_i(f, t)a_j(f, t) + b_i(f, t)b_j(f, t)}{\sqrt{a_i^2(f, t) + b_i^2(f, t)} \sqrt{a_j^2(f, t) + b_j^2(f, t)}}$$

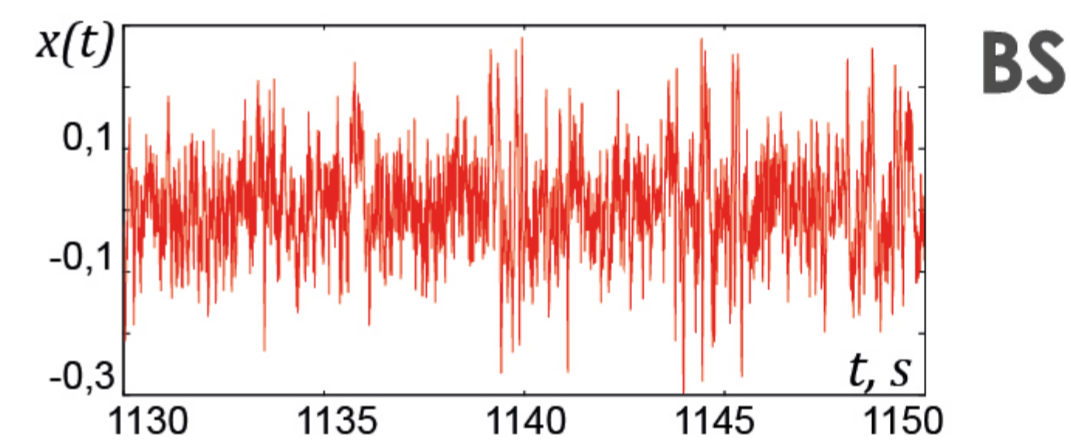
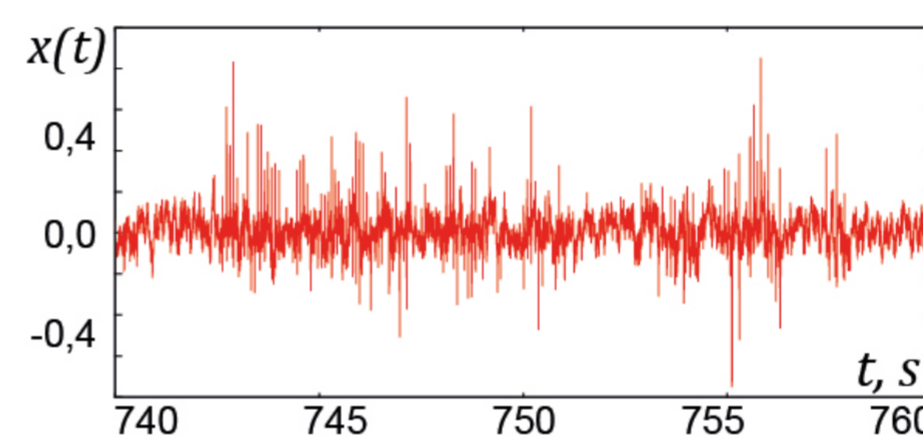
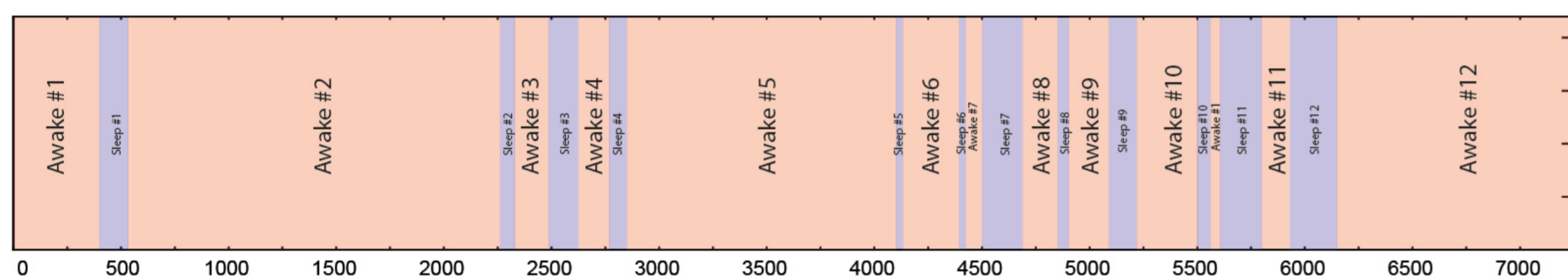
$$\text{Im} [\sigma_{ij}(f, t)] = \frac{b_i(f, t)a_j(f, t) - a_i(f, t)b_j(f, t)}{\sqrt{a_i^2(f, t) + b_i^2(f, t)} \sqrt{a_j^2(f, t) + b_j^2(f, t)}}$$

mutual wavelet spectrum are calculated:

$$\sigma_{ij}(f) = \sqrt{(\text{Re} [\sigma_{ij}(f)]_{T_{mp,m,p}})^2 + (\text{Im} [\sigma_{ij}(f)]_{T_{mp,m,p}})^2}$$

The estimation of the degree of synchronization between the channels was carried out on the basis of calculating the wavelet bicoherence, and the degree of synchronization was estimated in different frequency ranges: Δf_1 [1; 2,5] Hz, Δf_2 [2,5; 4,5] Hz, Δf_3 [4,5; 6,5] Hz, Δf_4 [6,5; 9] Hz, Δf_5 [9; 12] Hz, Δf_6 [12; 14] Hz.

Torresani B., Continuous Wavelet Transform, Savoie, Paris, 1995.
Hramov A.E., et. al. Wavelets in Neuroscience. Springer Heidelberg New York Dordrecht London, 2015



Example of marking up experimental data for rat # 2 for the first EEG record: the pink colour corresponds to wakefulness periods, the blue colour corresponds to sleep state. As part of this recording, 12 episodes of wakefulness and 12 episodes of sleep are identified.

Fragments of EEG signal (The left panel corresponds to the rat's active wakefulness (AW), the right panel corresponds to behavioral sleep (BS))

active wakefulness (AW)

behavioral sleep (BS)

anesthesia

