Neural dynamics revealed by power-law analysis of sEEG across brain regions

Abstract

We present the effectiveness of non-linear analysis techniques in capturing the complexity of neurophysiological signals.

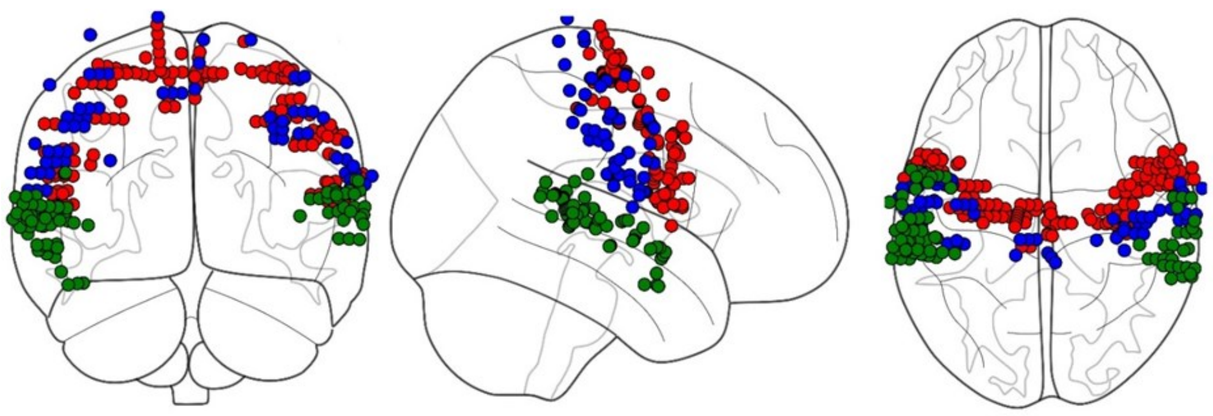
- We found that the power spectral density (PSD) power law behaviour in low and high frequency ranges, express a scale-free properties and can differ in three cortical parcels.
- These differences extends to other brain regions, including the subcortical parcels.
- The scale-free activity does not change across wake-sleep stages.

Methods

Dataset

We analysed the stereo-tactical intracranial encephalography (sEEG) recordings from superior temporal, postcentral and precentral gyri in wakefulness and three sleep stages of Montreal Neurological Institute (MNI) data.

We further extended the analysis by analysing other 33 brain parcels from cortical and subcortical regions.

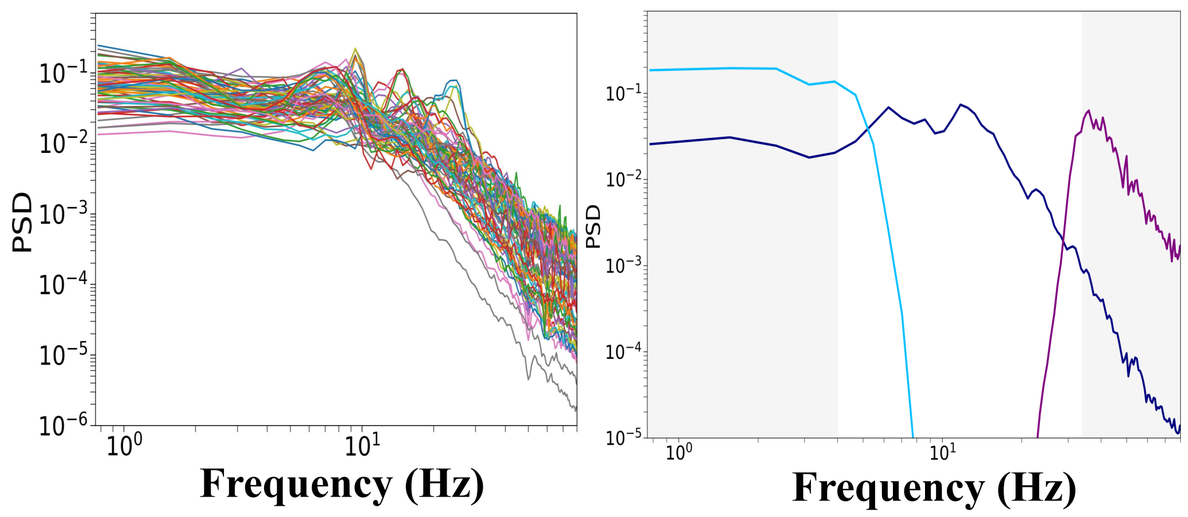


Power-law of PSD

Scale-free property: a PSD on a log-log scale expressed a negative slope, different in two frequency ranges, δ and γ.

Oscillatory activity: we removed the oscillations in sEEG signals below (above) a certain frequency threshold ω_c by applying a Butterworth filter of order 7.

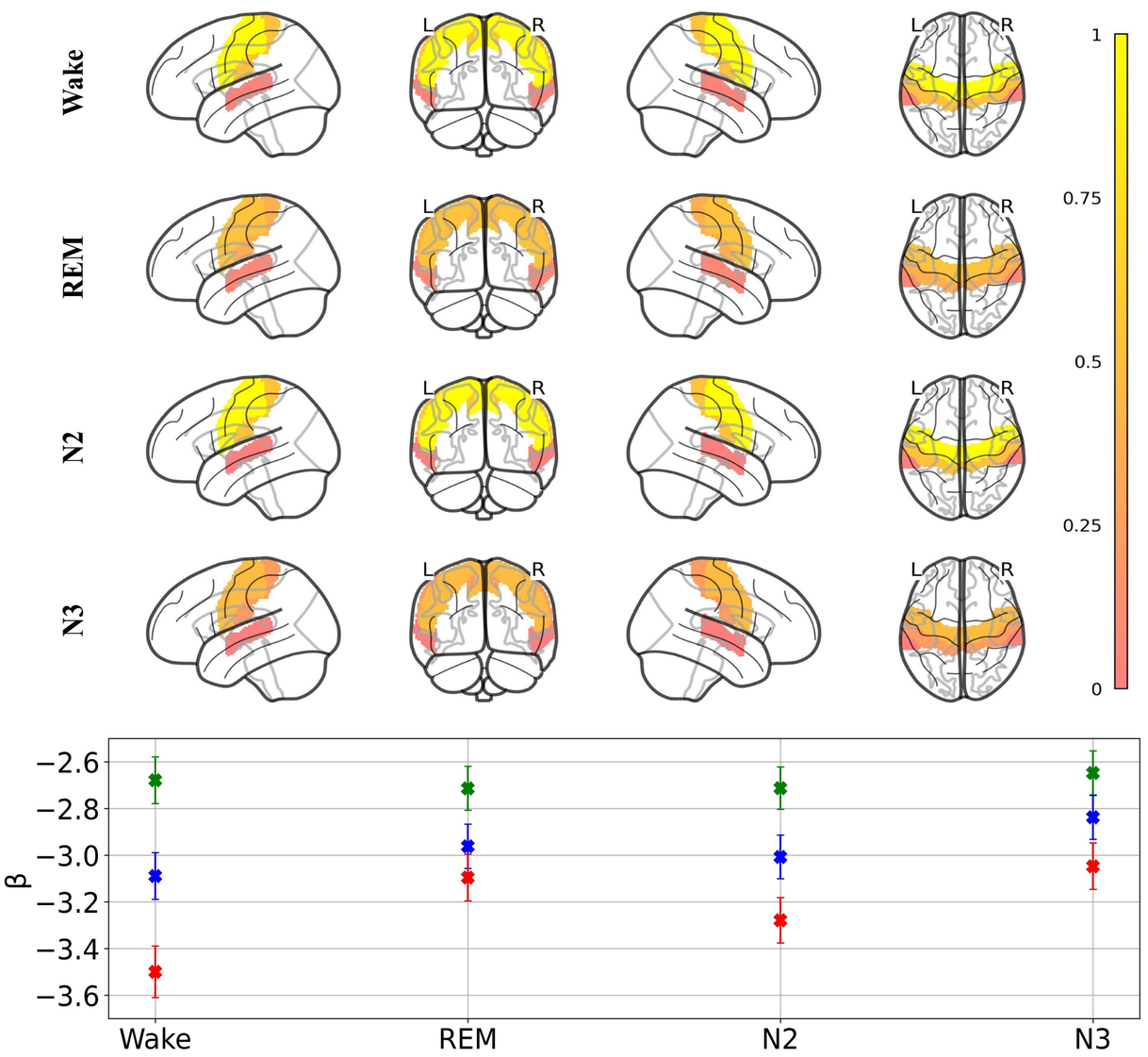
Fitting: δ (0.29—4 Hz), γ (34—80 Hz). The linear fit was calculated by using the weighted least square method, where to each ordinate $y_i = log(PSD(f_i))$ is associated the weight $w_i = 1/\Delta y_i^2$ with Δy_i the uncertainty on y_i, which is the standard deviation (σ_i) for each i-frequency across population.



Results

Power-law properties of three cortical parcels

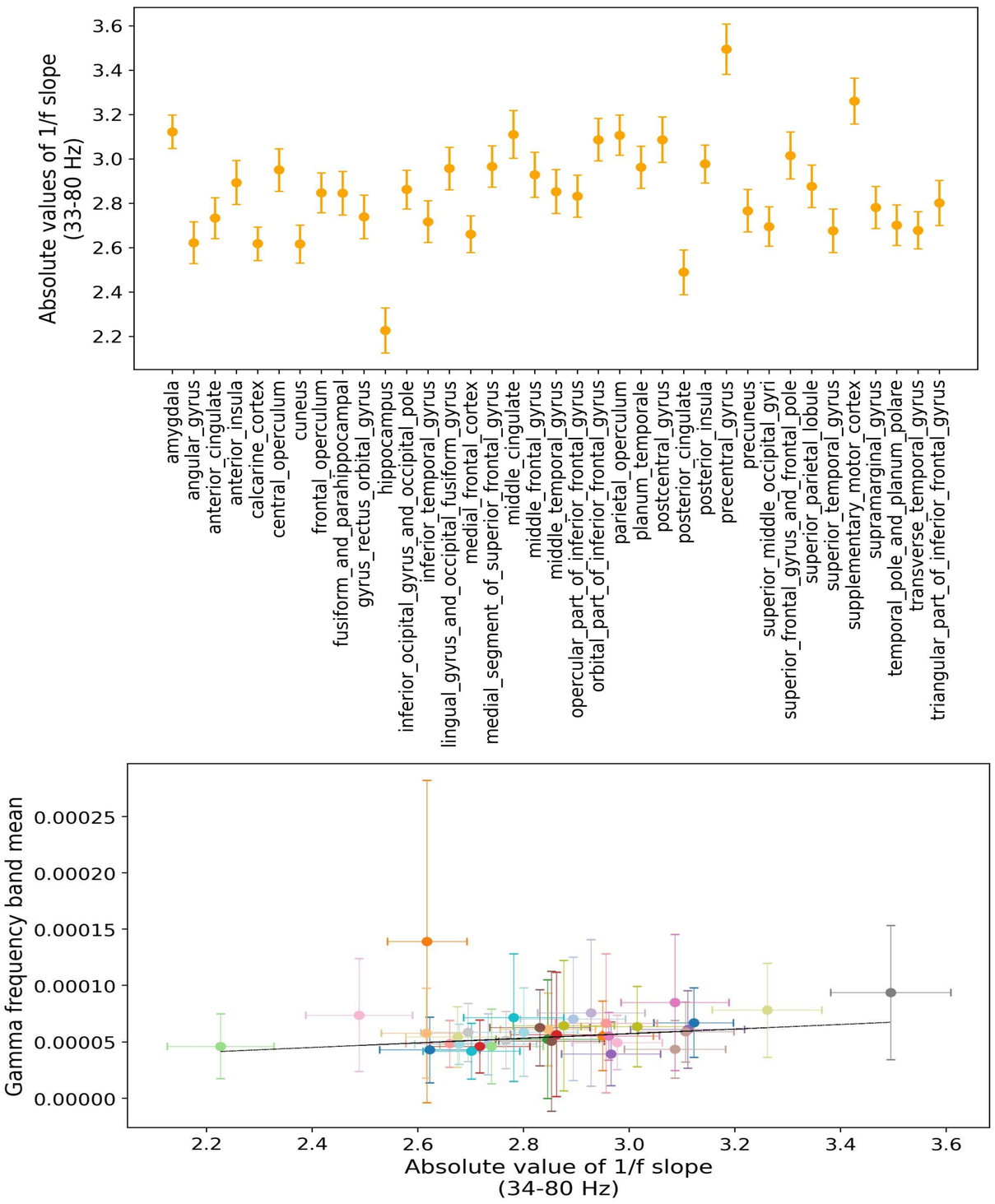
- Across population, β value was different across the three gyri in γ band;
- We did not detect the differences of β value across states in each of the three gyri.



- β value in γ band is a good index to see the differences of the cortical neurodynamics at a population level.
- β does not indicate the change between states.

Power-law properties of other 33 brain regions

- β value was also different across other parcels in γ band; There was no correlation between scale-free activity and band amplitude.



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