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Investigating endogenous delta oscillations in human MEG

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1. Introduction

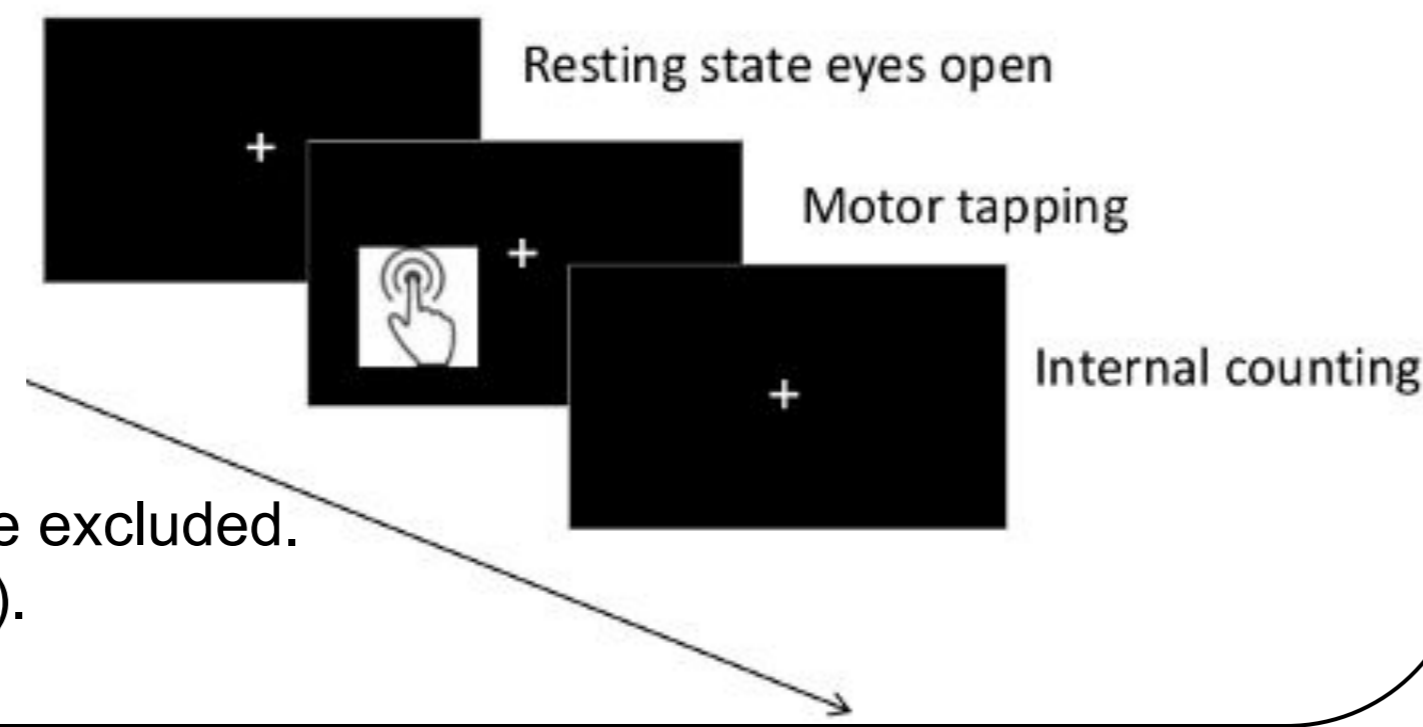
- Evidence from non-human primate studies supports the functional role of endogenous delta oscillations (0.5 - 4 Hz) in cognition [1,2].
- Recent lines of research have suggested that temporal predictions could be implemented through the entrainment of slow neural oscillations (e.g. delta, 0.5 - 4 Hz) [3,4].
- However, it is difficult to assess whether entrainment truly results from an a priori endogenous delta oscillation, or whether oscillatory brain dynamics merely reflect the exogenous rhythmic input [5].
- Research question asked:** Can we see delta oscillations in spontaneous human brain activity measured with MEG?
- Working hypothesis:** Endogenous delta oscillation will be reflected in the self-paced rhythmic behaviours such as the motor tapping and the internal counting.

2. Materials

- To establish whether endogenous delta oscillations can be seen in human brain activity with non-invasive recordings, we re-analyzed an MEG dataset (N = 22) collected for a different experiment. We chose three conditions devoid of external stimulation, yet varying in the amount of internal rhythmic behavior:

- Resting state (no rhythmic behavior)
- Motor tapping (overt rhythmic behavior)
- Internal counting (covert rhythmic behavior)

- 120 seconds of continuous MEG recording (Elekta Neuromag, 102 Magnetometers)
- 4 participants had noisy MEG recordings and were excluded.
- Sampling rate: 1000 Hz (i.e., 1 ms time resolution).



3. Methods and data analysis

MEG Analysis pipeline

Pre-processing

- Bad channel identification (manual) and signal-space separation (SSS) & Maxwell filtering.
- Low pass filtering (DC - 100 Hz) & down sampling to 250 Hz (allows to have $f_{\max} = 125$ Hz).
- Epoching into 10 s segments (allows to have $f_{\text{res}} = 0.1$ Hz) with overlap.
- Baseline correction averaged across the entire epoch duration (10 s)
- Automatic noise rejection (Jas et al., 2017) and manual rejection of noisy epochs based on GFP.
- Eye-blink and heart artefacts rejection using independent component analysis (ICA).

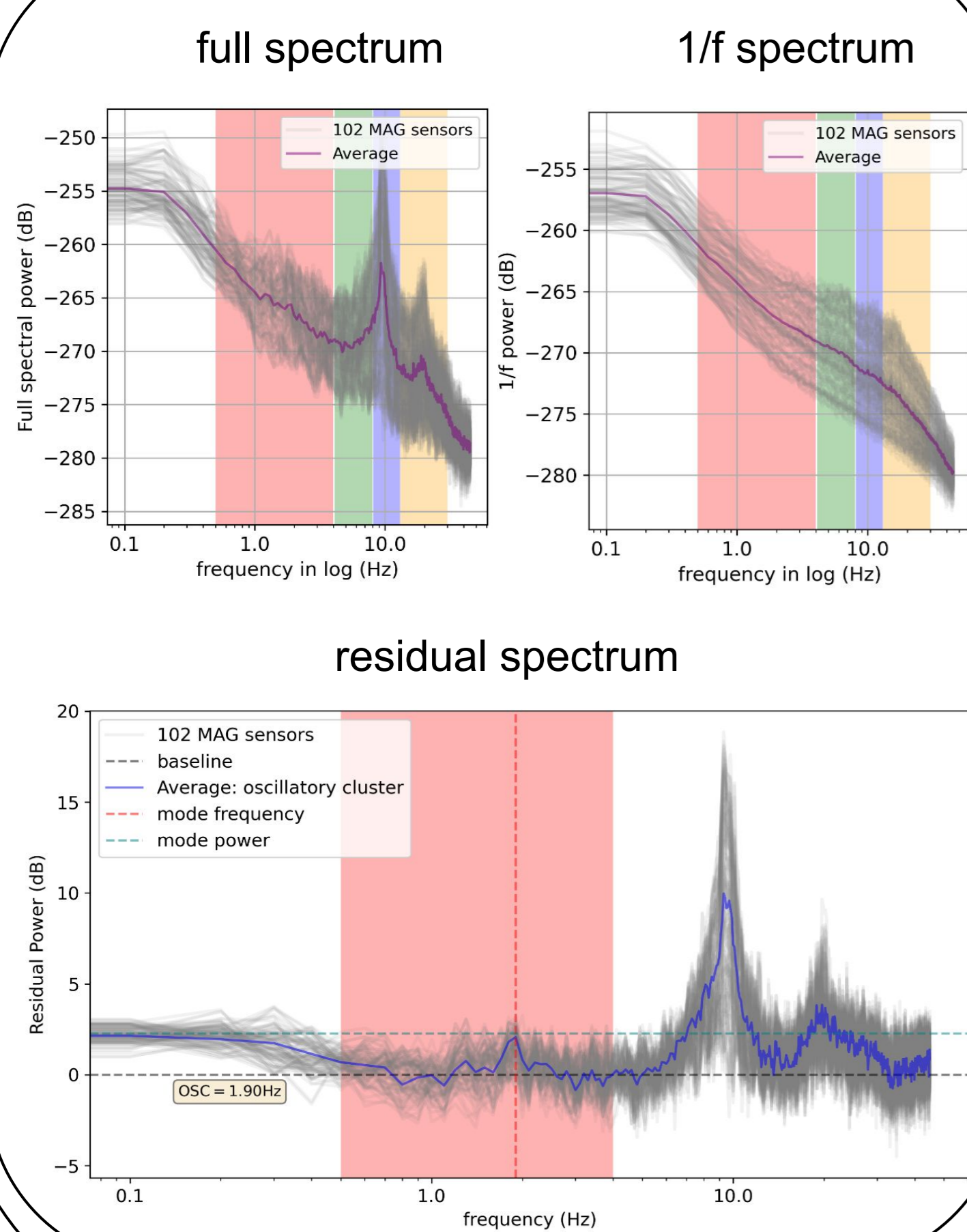
Analysis of delta activity

- Welch power spectral density (PSD) estimation using FFT (frequency resolution - 0.1 Hz).
- Oscillatory and $1/f$ components separation by IRASA (irregular resampling auto-spectral analysis) (Wen and Liu, 2016).
- Peak frequency estimation using topographic prominence peak detection.
- Clustering based on statistical modes.

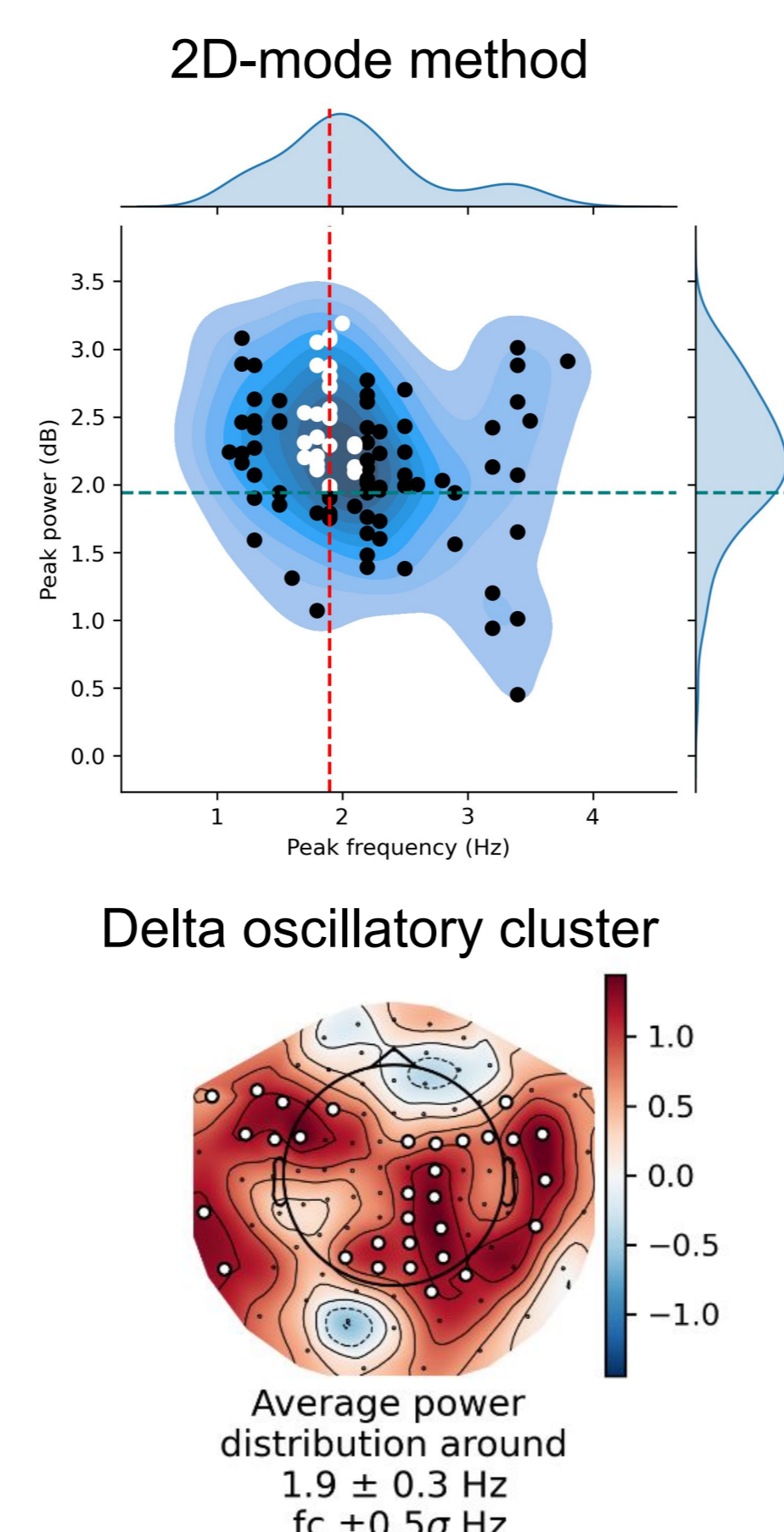
4. Single subject results

SUB 11: Tapping condition

4a. Removal of $1/f$ activity using IRASA method (Wen and Liu, 2016)



4b. Delta peak detection using novel 2D method

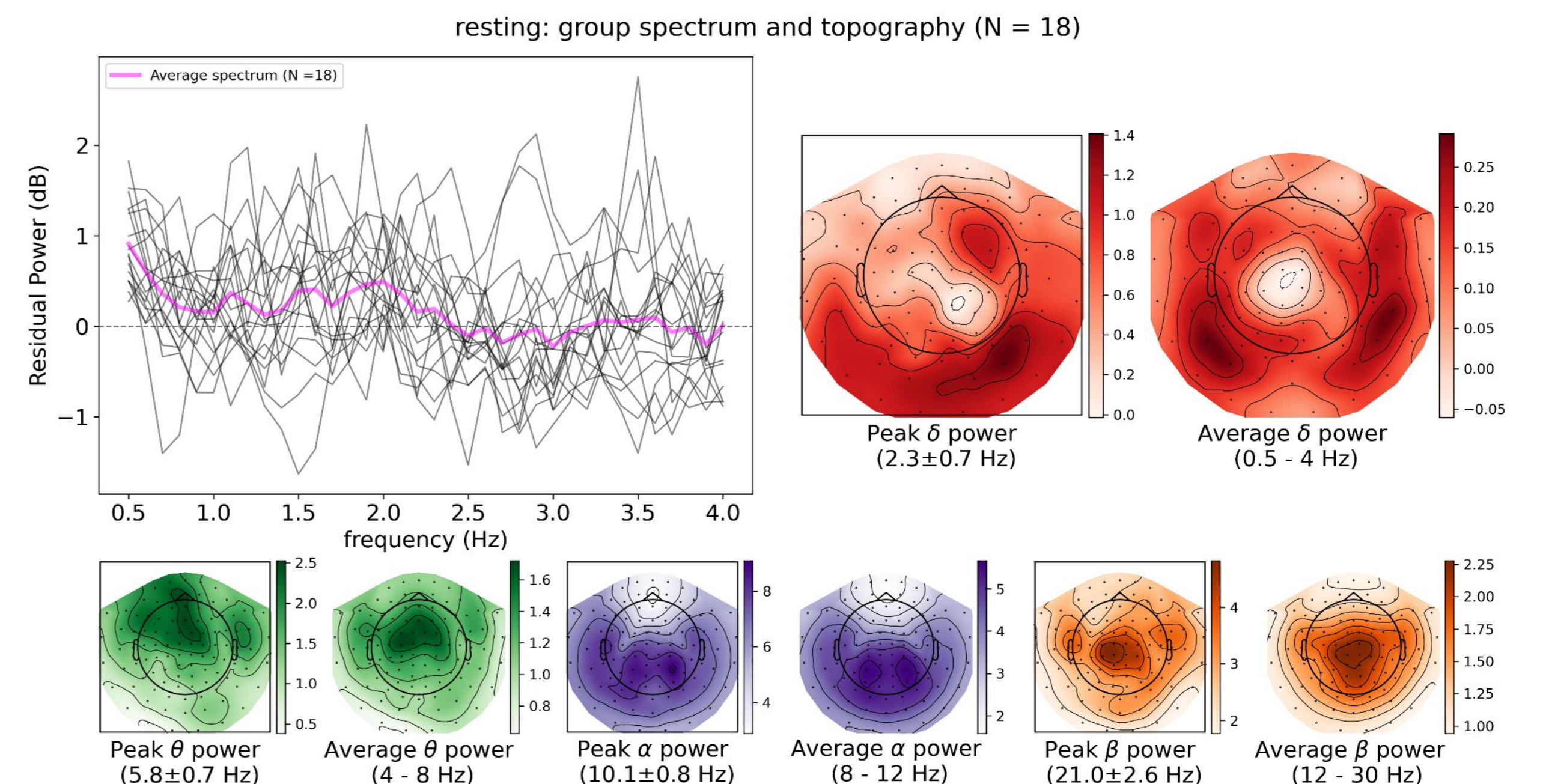


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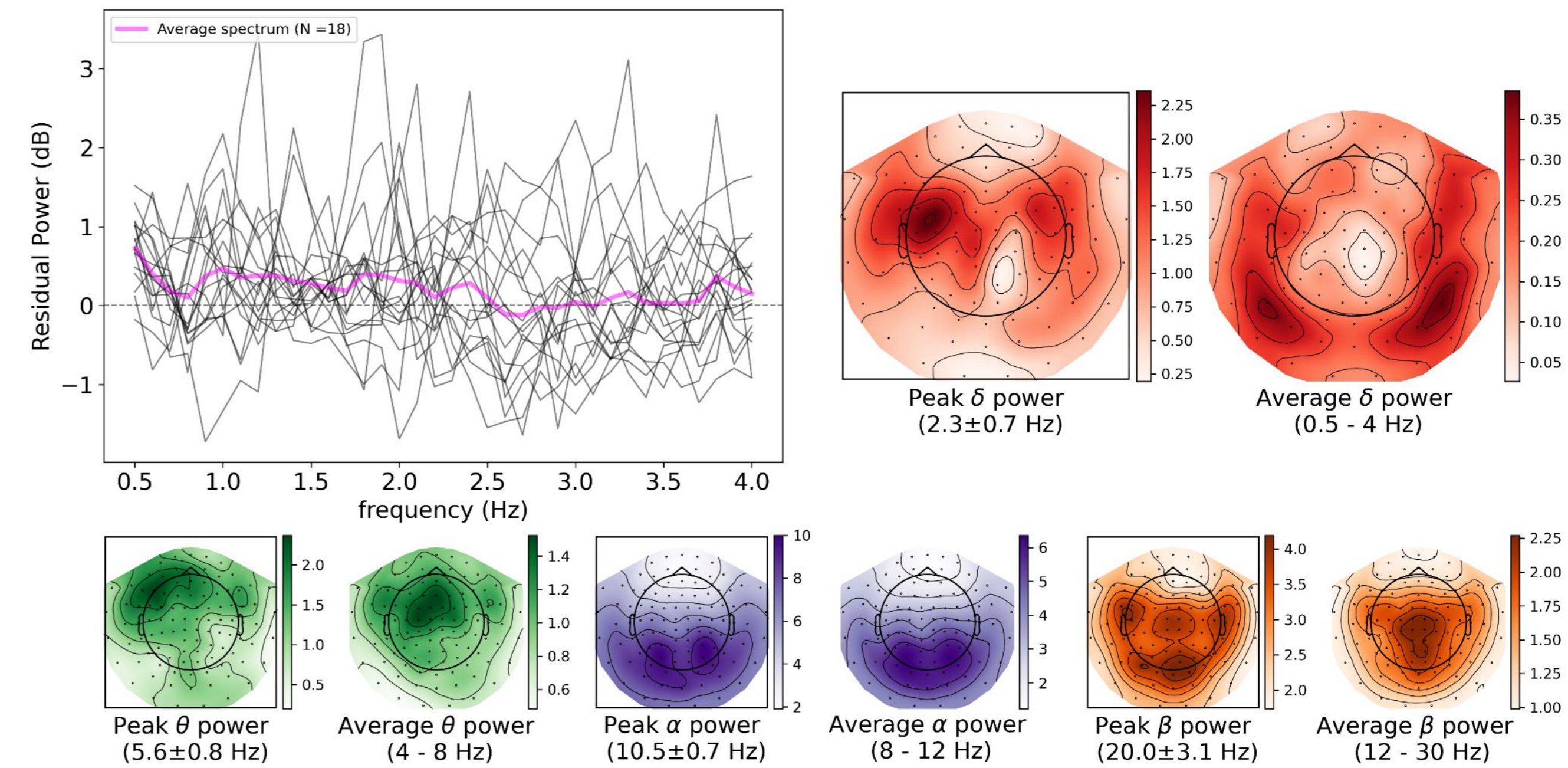
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5. Group results

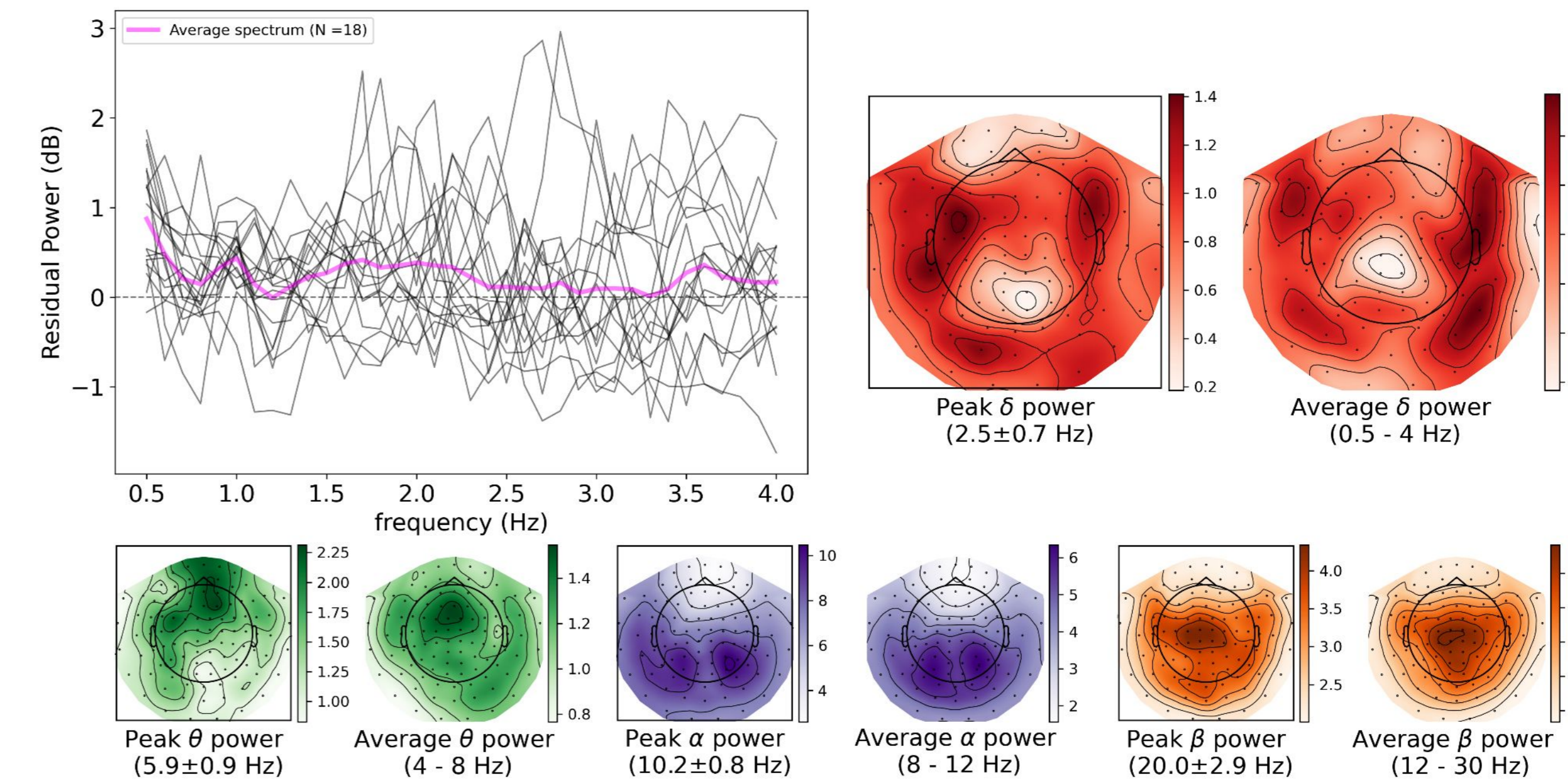
5a. Average power spectrum and average topography across subjects (N = 18)



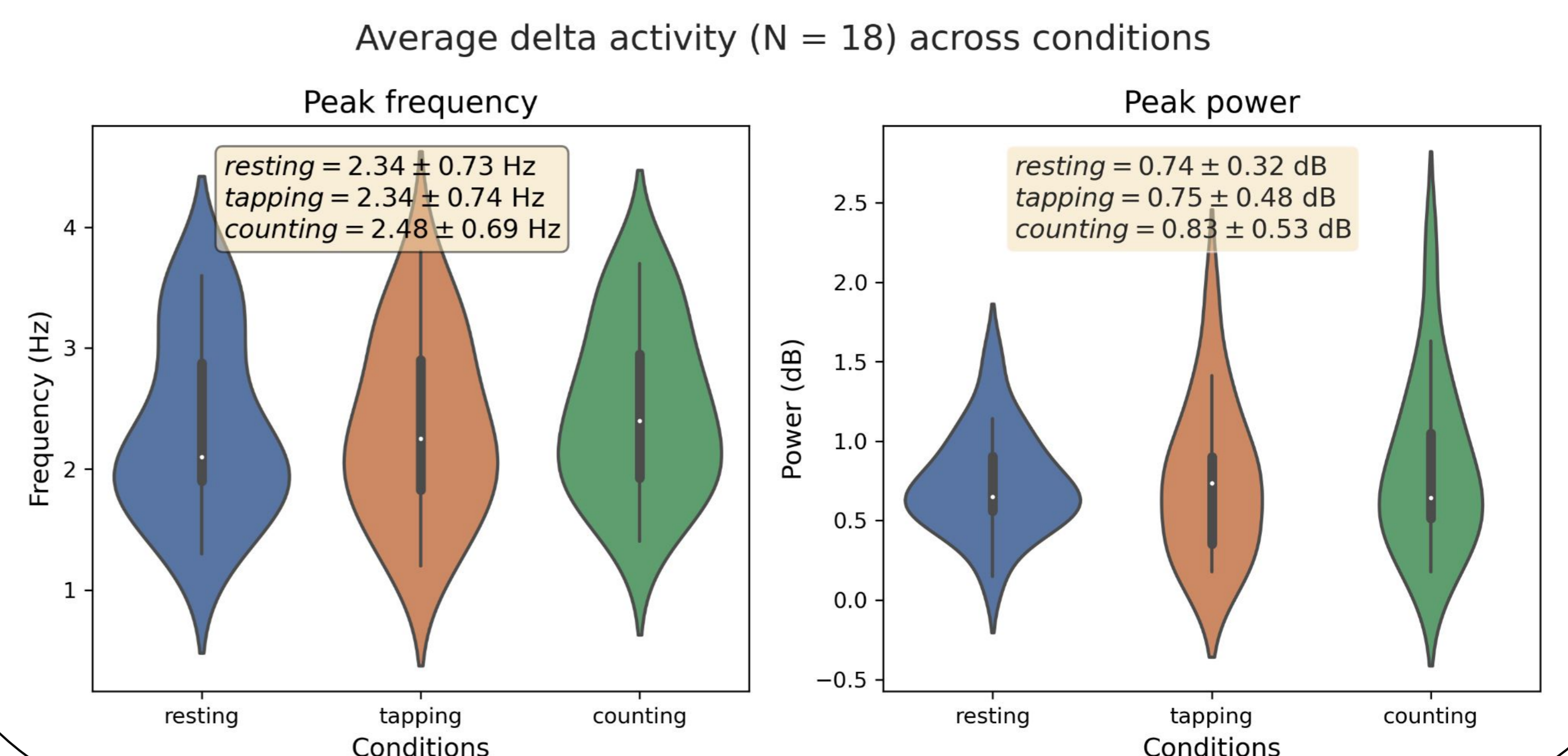
tapping: group spectrum and topography (N = 18)



counting: group spectrum and topography (N = 18)



5b. Average delta peak frequency and power across subjects



6. Discussions

- Evidence of the existence of **delta activities** in human MEG is shown for three conditions: resting, motor tapping, and internal counting.
- The novel method is validated against the other "known" **oscillatory** sources such as theta, alpha, and beta.
- Tapping condition: The clear-cut distinction between endogenous oscillations vs. evoked activities in is still not evident. More analysis in time domain is to be done.

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