Spectral Slowing in Chronic Stroke Comprises Both Periodic and Aperiodic Components

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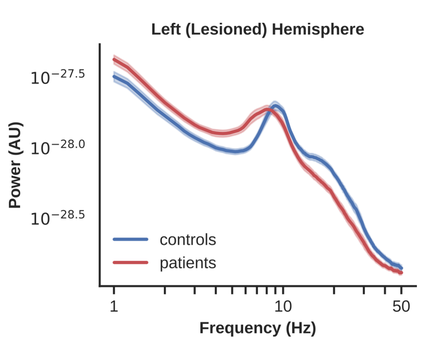
Motivation

Chronic stroke patients exhibit **a shift in the electrophysiological power spectrum towards lower frequencies** ("spectral slowing"), particularly near the lesion[1,2,3]:



This is typically assumed to reflect changes in the amplitude of neural oscillations, but **a change in the aperiodic (non-oscillatory) component of the spectrum could also produce this effect.**

Quantifying resting-state neural dynamics in both the **frequency domain and time domain** allows us to disentangle the periodic and aperiodic components and address the question:

Does spectral slowing in stroke reflect abnormal periodic or aperiodic activity?

Methods

Participants

- 23 patients with chronic left hemisphere (MCA) stroke (34-84 y.o., mean = 63.4 y.o.)
- 23 age- and education-matched controls (45-88 y.o., mean = 66.0 y.o.)

Data

- 5 minute eyes-open resting state
- 151-Channel MEG (CTF) and structural MRI
- 90 non-cerebellar ROIs of the AAL atlas registered to T1 MRI
- Time series localized to spheres (10 mm diameter) at each ROI with SAM beamforming

Frequency domain analysis

- Power spectral densities (PSDs) computed for each 5s epoch with smoothed FFT (*neurodsp),* then averaged across epochs
- Average PSDs at each ROI modelled with *specparam*[4] to estimate spectral parameters (fitting range 1-50 Hz, max 4 peaks, no knee)

Time domain analysis

- Lagged coherence applied to each epoch (frequency range 1.5-50 Hz), then averaged across epochs to quantify rhythmicity at each frequency[5]

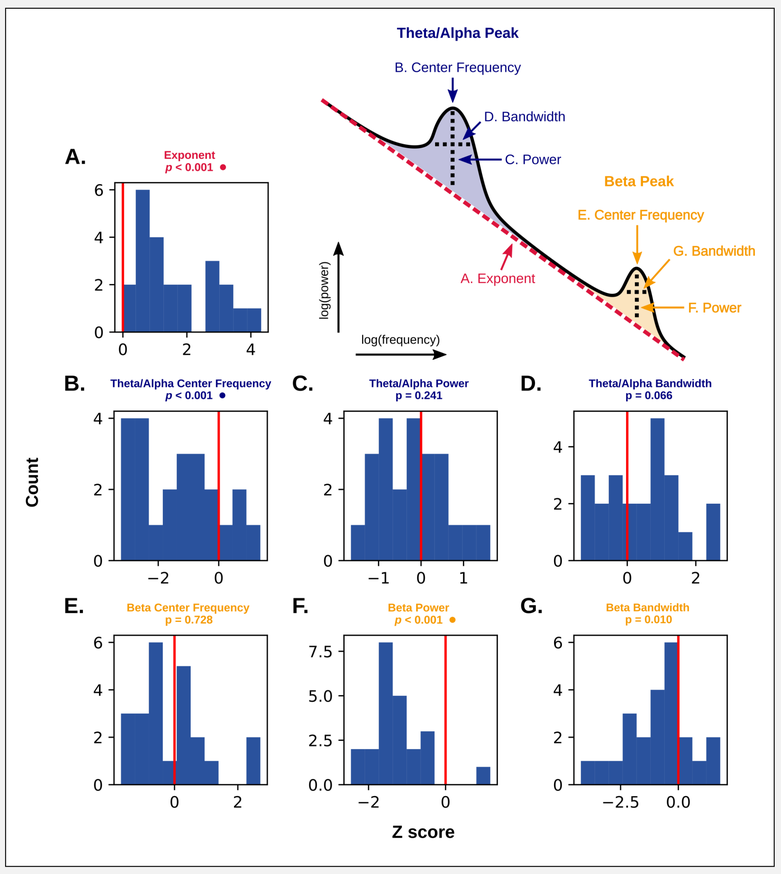
Results

Perilesional tissue

Tissue adjacent to the lesion itself holds significant interest as a potential site of intervention, and is known to show prominent electrophysiological abnormalities.

For each patient, parameters were averaged across perilesional ROIs and compared to the same subset of ROIs drawn from controls (red line).

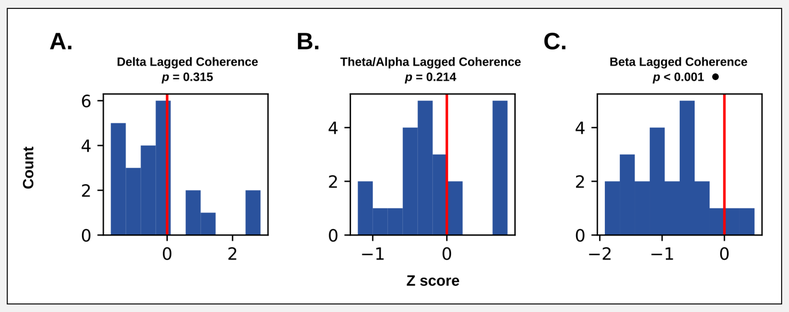
Frequency domain results



Perilesional tissue exhibits **three frequency domain abnormalities** compared to controls:

1. Higher **aperiodic exponent** (steeper slope)
2. Lower **theta/alpha center frequency** (alpha slowing)
3. Lower **beta power**

Time domain results



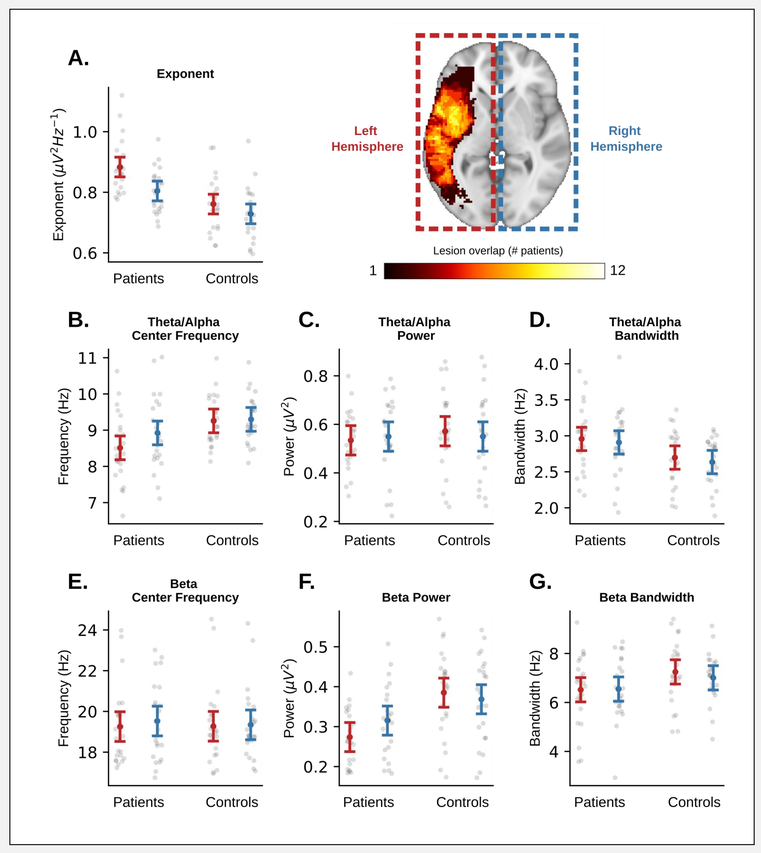
Perilesional tissue exhibits **two time domain findings** that complement the frequency domain results:

1. Lower **beta rhythmicity**
2. No significant difference in low frequency (delta/theta) rhythmicity

Lesioned vs. unlesioned hemisphere

Stroke is known to affect neural dynamics beyond the lesioned area ('diaschisis'[6]).

Parameters were averaged across the entire left (lesioned) and right (unlesioned), hemispheres and compared between patients and controls.



The right (unlesioned) hemisphere exhibits:

1. Higher **aperiodic exponent** compared to controls (but lower than lesioned hemisphere)
2. Possible **alpha slowing** and **beta power decrease** (n.s., intermediate between lesioned hemisphere and controls)

Conclusions

- Spectral slowing in stroke reflects **abnormalities in *both* periodic and aperiodic components**
- Contrary to typical interpretation, increased power in delta/theta bands is due to changes in aperiodic exponent and alpha slowing, *not* increased power of delta/theta oscillations
- The unlesioned hemisphere exhibits abnormalities similar to the lesioned hemisphere, but less pronounced

References

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