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 lesion1-3.

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 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

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).

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

Lesioned vs. unlesioned hemisphere

Stroke is known to affect neural dynamics beyond the lesioned area (“diaschisis”4).

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