SpectraVis: A web app for analyzing dynamic, task-related functional networks

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Summary: Functional network analysis is a growing area of research, but as technology improves and recordings include more sensors, the dimensionality of the networks can make analysis unwieldy and hard to interpret. Dimensionality is particularly problematic with increasing network size, because the number of possible connections in a network scales quadratically with the number of sensors, and the networks can vary over time and frequency. Additionally, researchers may be interested in several spatial scales such as analyzing connectivity within and between brain regions. While careful statistical models and strong hypotheses are important for reducing dimensionality, interactive visualizations are an often neglected tool for coping with high-dimensional analyses.

Visualizations allow us to make multiple simultaneous comparisons, easing the cognitive burden on working memory by efficiently encoding properties of the data into features salient to the human visual system. Adding interactivity can allow the user to change perspectives and modify analyses on demand, further facilitating comprehension and hypothesis generation.

Here we present an interactive web-based visualization application, SpectraVis, that: (1) displays task-related functional networks over time and frequency, (2) compares individual and associative measures on electrode pairs (e.g. spectra and coherences), (3) compares different measures of association (e.g. correlation vs. coherence, binary vs. weighted networks), and (4) views networks at two spatial scales (sensor- and region-of-interest-level). The different modules of SpectraVis are dynamically linked, highlighting relationships between the metrics in response to user interaction. We demonstrate its capabilities on an electrocorticography (ECOG) dataset collected during a overt reading task. We believe this application will be of interest to the COSYNE audience because visualization is an essential tool for understanding these datasets at all stages of analysis and current practices for visualization of brain networks do not reflect their richness and complexity. Additionally, SpectraVis is open-sourced and therefore open to use and development by the community.

Network View for Edge Statistic
Shows the network at a particular time and frequency. The view can be updated from the control panel or via mouseover of a time-frequency bin in the single electrode pair view.
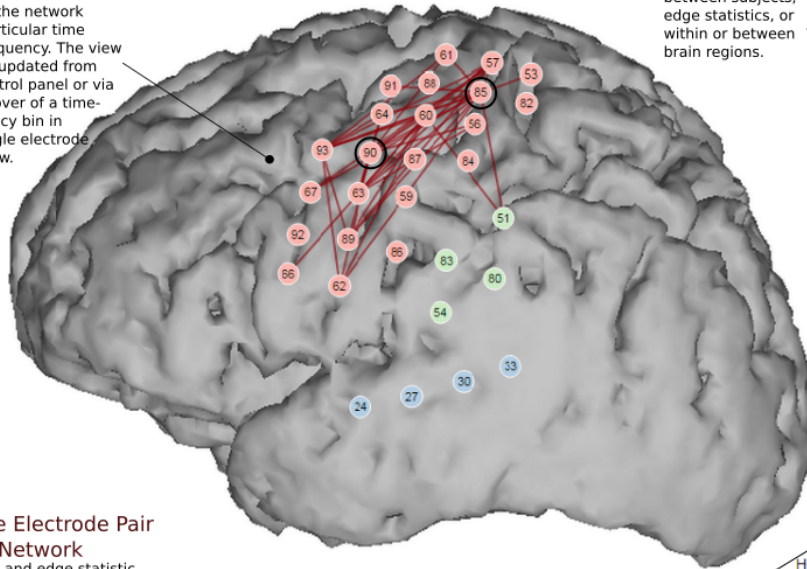
Controls
Compare networks between subjects, edge statistics, or within or between brain regions.

Subject	D▾
Edge Statistic	Two-sided bin
Edge Area	All▾
Network View	⦿ Anatomical
	○ Topological
Time	187.5 ms
Frequency	10 Hz
Play	Reset

Legend

Brain Areas
- Rolandic
- Auditory
- aSMG

Edge Statistic
Two-sided binary coherence
-1.0   0.0   1.0

Spectra
Difference in Power
-1.1   0.0   1.1

HOLD

Single Electrode Pair from Network
Spectra and edge statistic for all times and frequencies for one pair of electrodes. Can be dynamically updated by selecting electrodes.
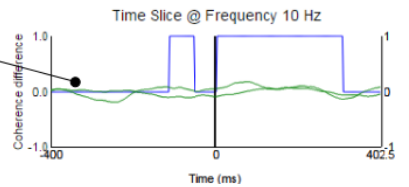
Dynamic Legend
Legend automatically updates based on the type of edge statistic selected.

Spectra: Ch85

Two-sided binary coherence: Ch85-Ch90

Spectra: Ch90
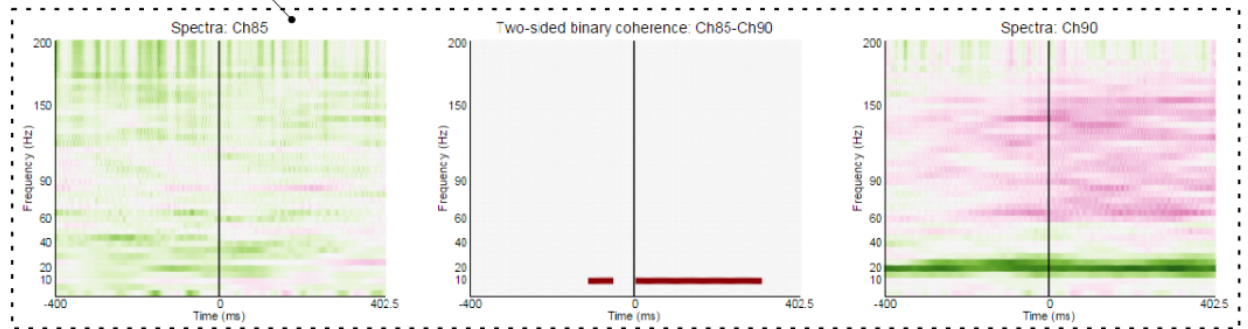
Electrode pair over time at a particular frequency
Same electrode pair as above. Offers simultaneous comparison of edge statistic and spectra.

Time Slice @ Frequency 10 Hz

Detail: