Relationships between phase coupling, signal power, and distance in V4 and PFC

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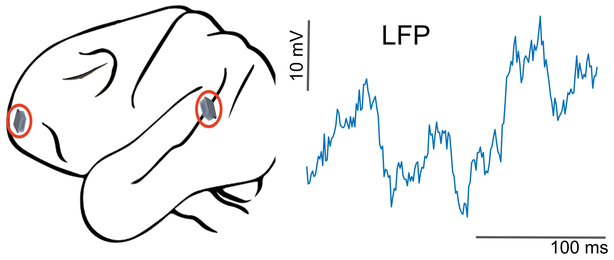
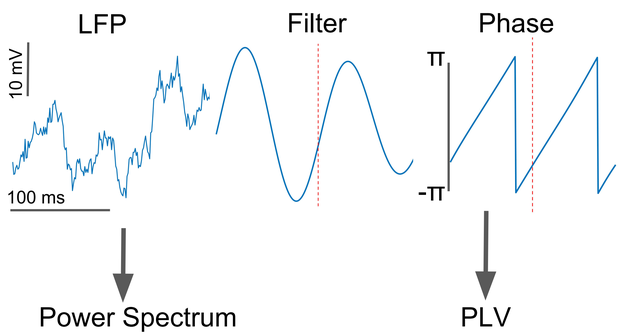
Introduction

- Phase coupling measures how synchronous neural oscillations are. It can be an indicator of how well two regions are communicating.
- Phase coupling, signal strength, and distance are all related to neural communication, however, the relationship is not understood.
- **Goal: Explore the relationships between phase coupling, signal strength, and distance.**
- Data: Local field potentials (LFP) are recorded simultaneously within V4 and prefrontal cortex (PFC) using UTAH arrays over 1742 trials.



Methods

- To measure phase coupling, we used phase locking value (PLV) which lies between 0 and 1.
- LFPs are bandpass filtered to 15Hz and 10Hz. Phases were then found using the Hilbert transformation and at a fixed time point.



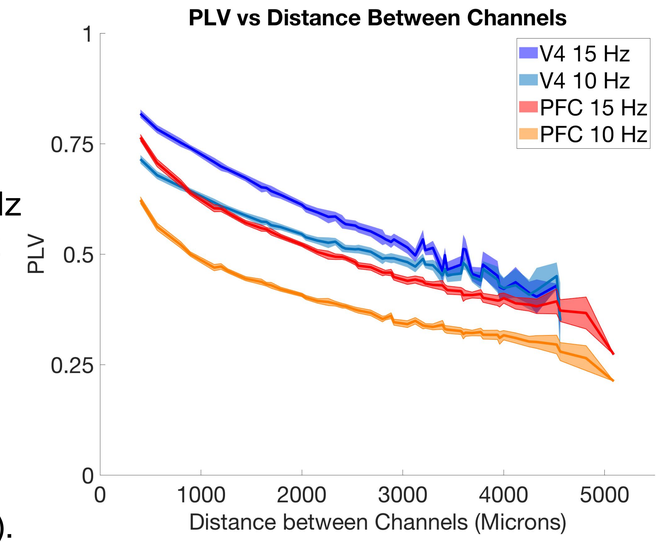
$$PLV_{j,k} = \frac{1}{N}\left|\sum_{n=1}^{N} e^{i(\phi_n^{(j)} - \phi_n^{(k)})}\right|$$

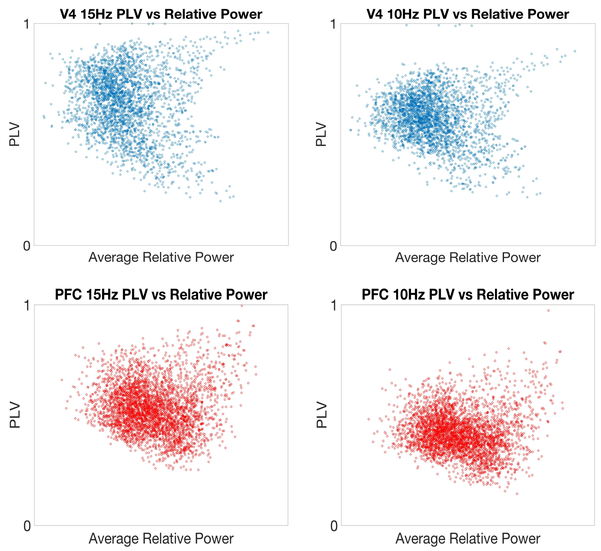
- Frequency analysis involved the use of the Fast Fourier Transform, an algorithm that implements the Discrete Fourier Transform to find the power of each frequency in the LFP.
- "Bad" channels were eliminated if there were no spiking activity present in the channels during the trial periods.

Results

PLV decreases as distance increases in both brain regions and both frequencies.

- On average, PLV of the 10Hz signal is lower than its 15Hz counterparts.
- Plot depicts the mean PLV value and its standard error at each distance.
- Regions are plotted in a similar color scheme V4 (blue) and PFC (red/orange).



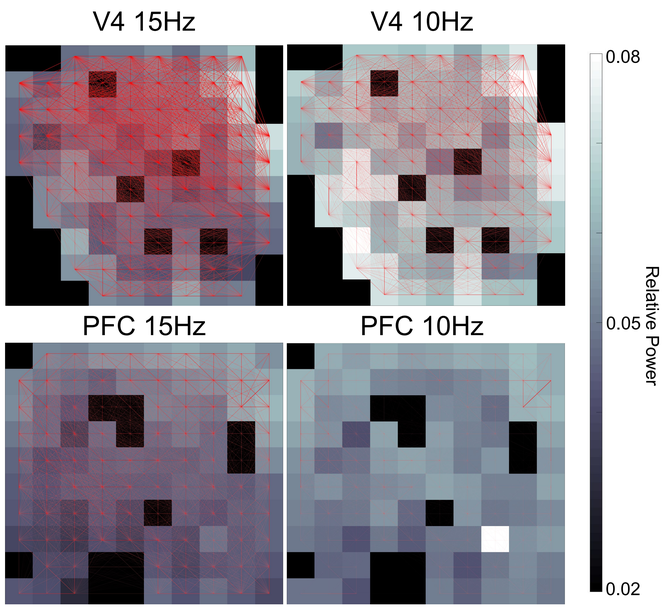


No direct relationship between PLV values and relative power of the target signal strength.

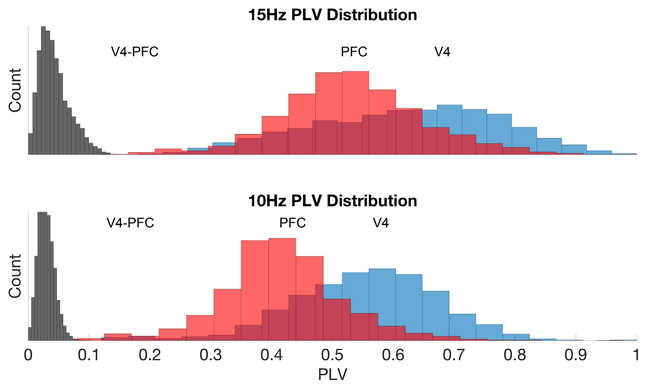
- Each signal in each region had a differently shaped scatter plot for PLV vs relative power of the signal
- No large changes across experimental conditions
- Phase locking value is plotted versus the average relative power of its channels

15Hz signal exhibits, on average, higher phase locking than the 10Hz signal in both regions.

- Red lines that are more opaque indicate higher PLV values and thus stronger phase locking
- Brighter pixels indicate stronger relative power and signal fidelity



Phase coupling between V4 and PFC was low.



Discussion

PLV decreases as distance increases, has no direct relationship with relative power of a signal, and is higher in the 15Hz signals. V4 and PFC lack phase coupling in the two recorded regions.

- Verification of the existence of the signals was done by comparing a filtered signal to a smoothing at the target frequencies
- Poor communication between V4 and PFC because their signals were poorly coupled
- V4 is more phase coupled to itself, perhaps it must conduct computations on the signals to find various features of the stimulus

Future Plans

- Explore the relationship between coherence and PLV. PLV is only based on phase values while coherence also includes the power of the signal
- Explore how well gamma waves phase lock between these regions especially during attention experiments
- Check more brain regions to see if the trends still appear

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