

Isolating Single Cycles of Neural Oscillations in Population Spiking

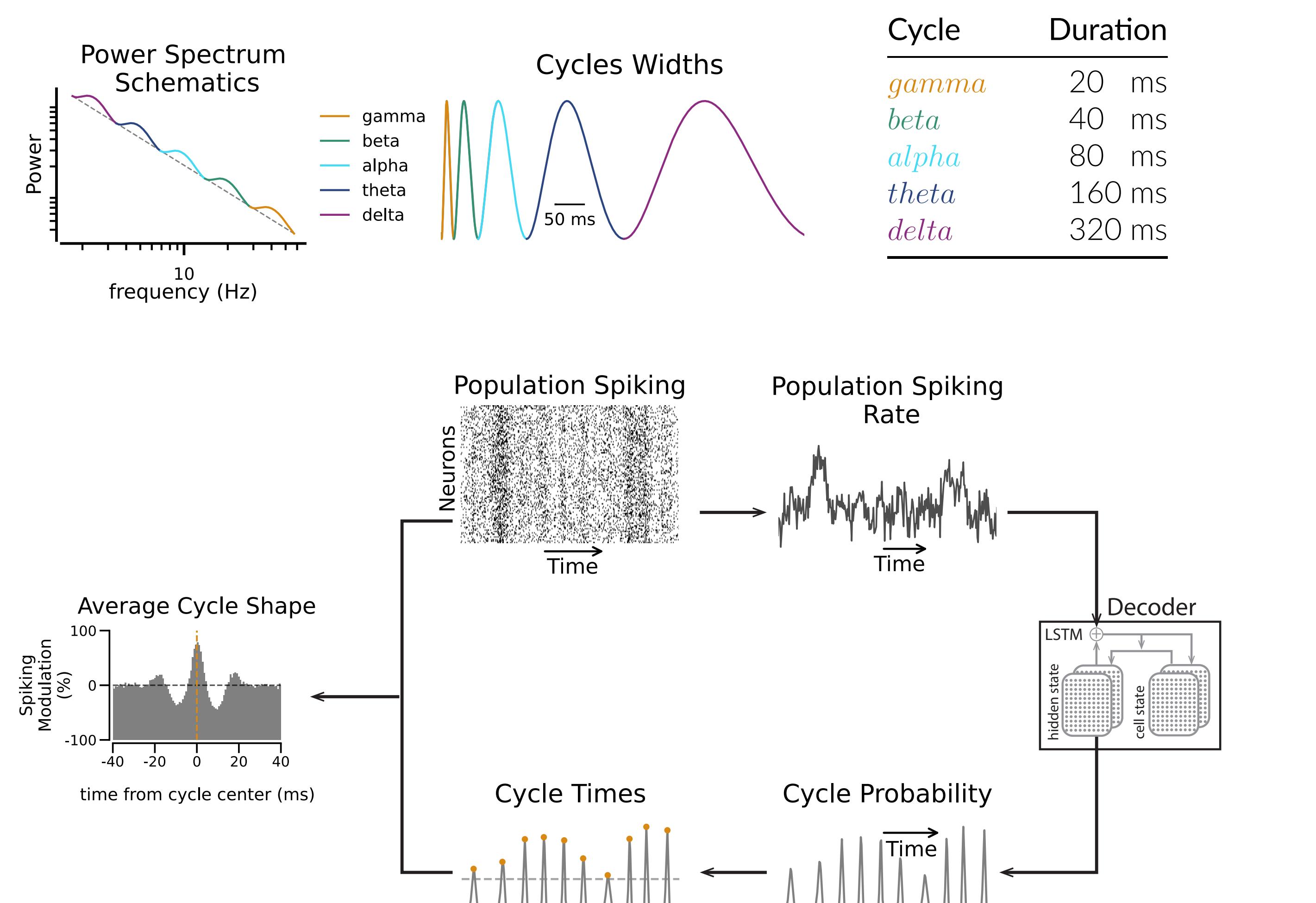
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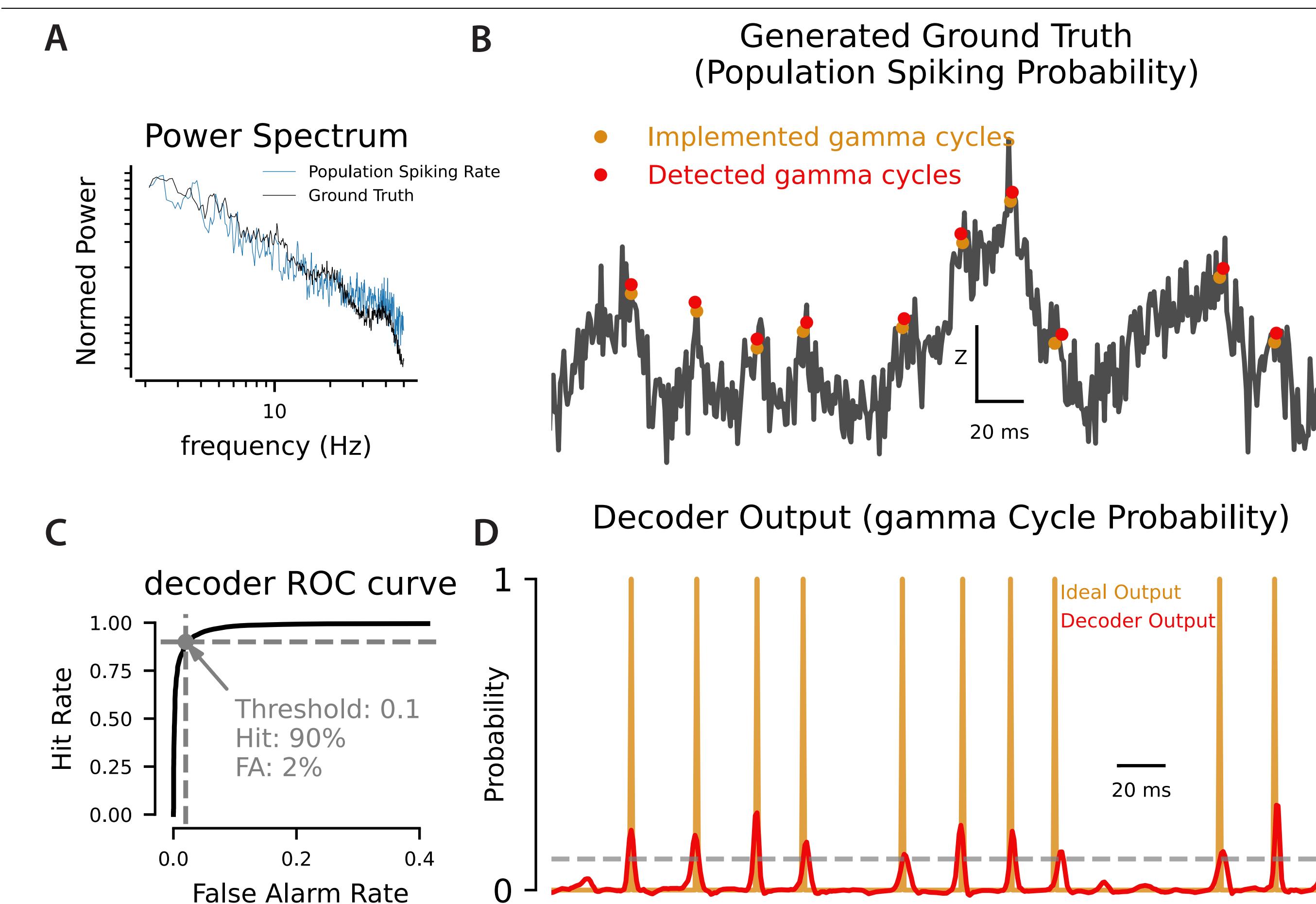
Abstract

Although the identification of neural oscillations has primarily relied on EEG and LFP, the intrinsic relation between neural oscillations and neuronal spiking is noteworthy. We investigate the potential to detect individual cycles of neural rhythms solely through the spiking activity of neurons, using recent advances in densely recording large populations of neurons within a local network. Numerous spikes from neurons within a local network estimate the network's activity over time, enabling us to identify cyclic patterns. Here, we employ a multilayer network of long-short-term memory (LSTM) units to effectively isolate and align individual cycles of neural oscillations from the spiking of a densely recorded population of neurons. This isolation occurs in the temporal domain, where cycles from different time scales may combine in various ways to shape the network's spiking probability.

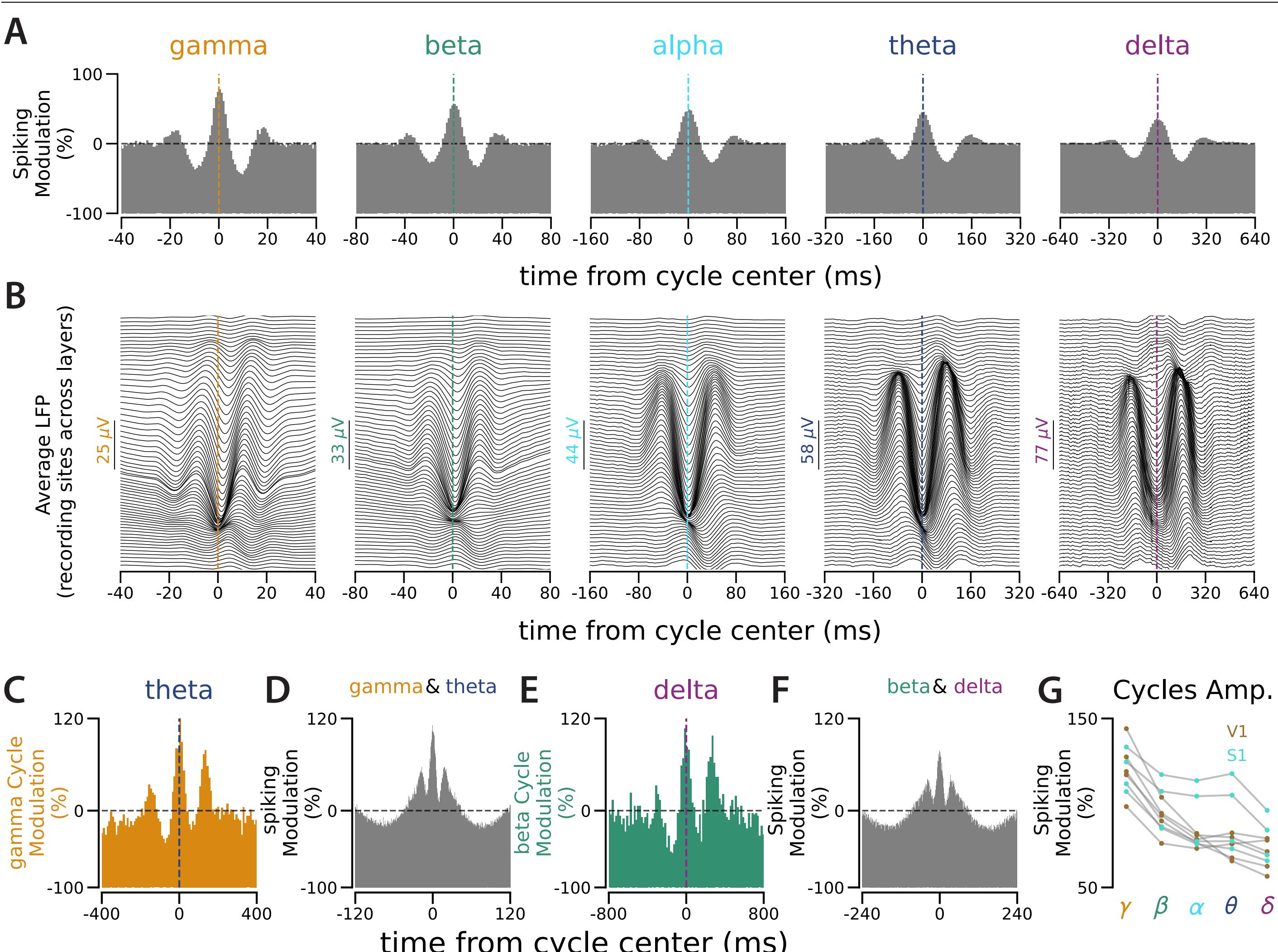
Introduction



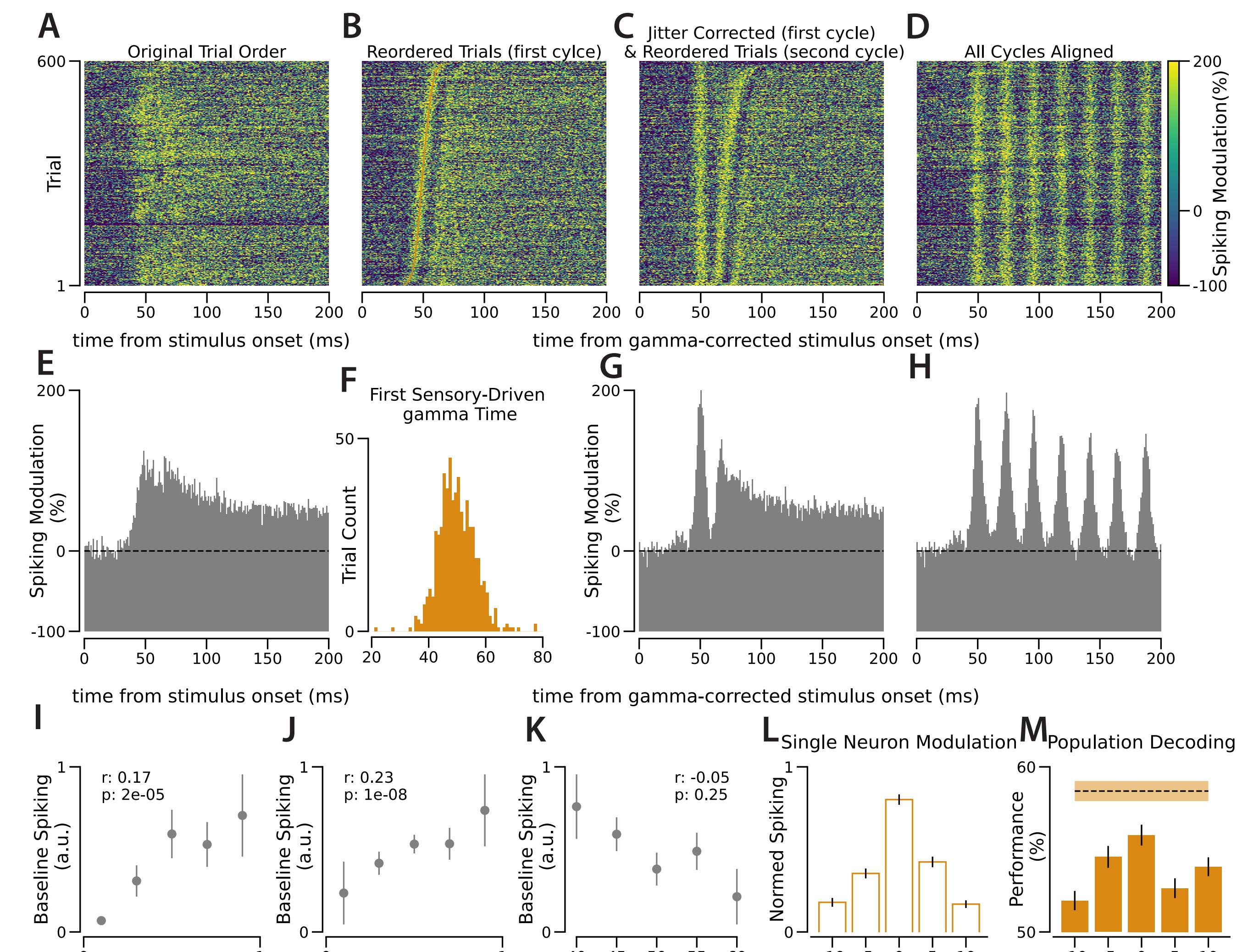
Decoder Characteristics



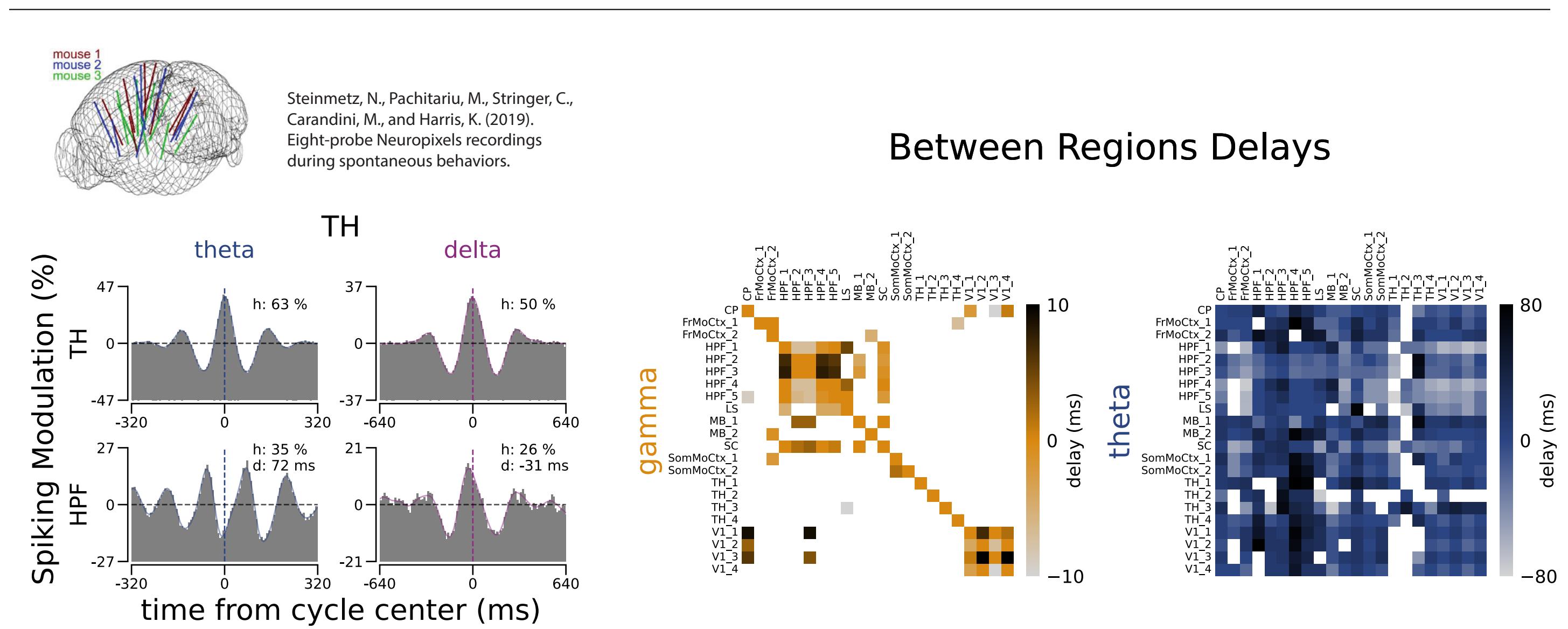
Cycle Detection in Population Spiking of Mouse Primary Sensory Cortex



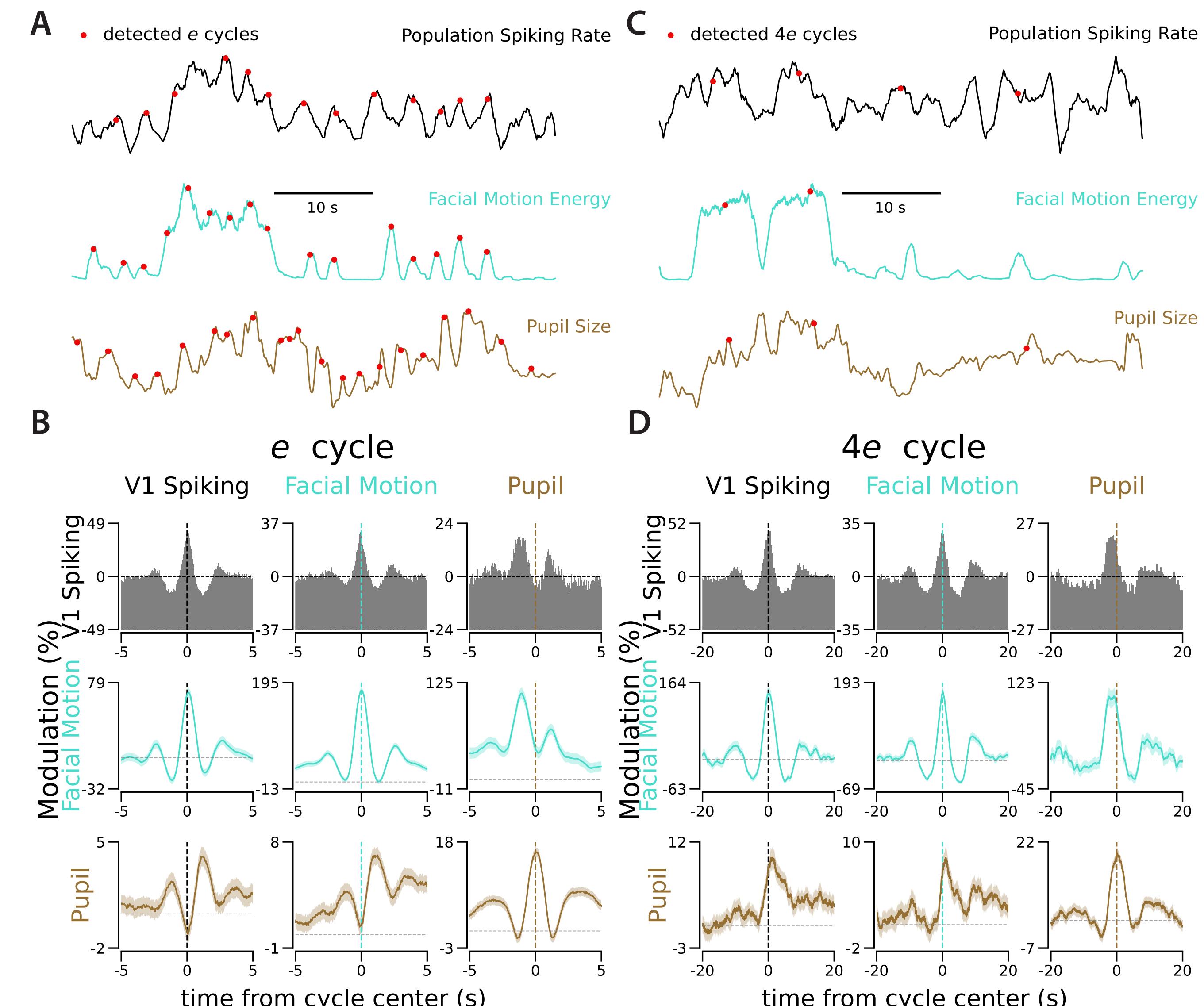
Aligning Sensory Stimulation Trials Using the Sensory-Driven gamma Cycles



Correlated Activity across Brain Regions in Different Time Scales



Ultra Slow Cycles in Population Spiking, Pupil Size, and Facial Motion: Similar Basis Functions?



Summary

- Using an LSTM decoder in the time domain, we isolated and aligned the individual cycles of neural oscillations from densely recorded population spiking.
- The cycles captured in population spiking reflect the rhythmic patterns of LFP and their cross-frequency couplings.
- In visual stimulation experiments, isolated sensory-driven gamma cycles can compensate for variations in signal transfer time between the retina and V1.
- By isolating cycles of different neural oscillations across brain regions, we observed correlated dynamics that are time-scale dependent between these regions.
- Multi-second cycles, identifiable from population spiking, pupil size changes, and facial movements, revealed correlated dynamics between them.