Estimating sensory delays to primate M1: a comparison of peri-stimulus time histograms and coherence phase-frequency regression

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Introduction

Coherence analysis is widely used to investigate oscillatory phenomena in the nervous system.

Coherence is a measure of correlation in the frequency domain between two signals. Coherence phase indicates the average phase difference between the signals at a given frequency.

For a system with a fixed delay, phase (\(\phi\)) is linearly related to frequency (\(f\)) with a slope related to the delay (\(\tau\)):

\[
\phi(f) = 2\pi f \tau
\]

It is commonly assumed that coherence phase analysis will yield similar delay estimates to response latencies, measured using time-domain methods such as the peri-stimulus time histogram (PSTH).

In this poster, we examine this assumption.

Methods

- Microelectrode penetrations into primary motor cortex of a macaque monkey, sedated using ketamine/medetomidine. Single unit activity isolated.
- Electrical stimulation of median nerve at the arm (ipsilateral stimuli, 0.2ms per pulse, intensity at motor threshold), or digital nerve of index finger (10mA).
- Stimuli delivered as Poisson stimulus trains, mean rate 10Hz.

Experimental Results

Delays estimated from coherence phase-frequency slopes are substantially higher than from PSTH onset latency: in the examples above, 18 vs 10 ms for the median nerve stimulation, and 17 vs 10 ms for the digital nerve stimulation.

We investigated this further using simple computer simulations.

Simulation Methods

- Poisson stimulus train
- Fixed change in spiking probability follows each stimulus
- Probability changes sum to give instantaneous spiking probability
- Spike train simulated as inhomogenous gamma process (order parameter = 4)

Conclusion

Using coherence phase-frequency relationships to estimate delay measures the average delay of the whole response, not just the onset latency. This must be remembered when comparing coherence delays with measurements in the literature, which are usually based on the earliest response to a stimulus.

In some circumstances, coherence delay estimates may be more functionally relevant than those based on onset latency.

References