The Firing Rate-LFP Relation Changes as a Function of Firing Rate in Humans

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Introduction

Single neuron firing rate has been widely correlated with gamma power (30-150 Hz) of the local field potential (LFP). Recent evidence suggests that broadband power (2-150 Hz) is another electrophysiological correlate of single neuron firing rate in humans\textsuperscript{1}.

1. Broadband power (2-150 Hz) is not an oscillation

1/f "pink noise": calculated as mean of Robust-fit line
Correlated with single neuron firing rate

2. Regression framework separates broadband and gamma correlations

\[ R = \beta_0 + \beta_B B + \beta_F F \]

\textbullet Extracellular recordings 20 patients
\textbullet Virtual Navigation Task
\textbullet 2,030 neurons identified
\textbullet Spikes removed from LFP
\textbullet Analyzed in 500ms epochs

Results

3. Sliding window analysis reveals non-linearity in FR-LFP relation

Broadband + Neurons ($n=453$)
Gamma + Neurons ($n=141$)

4. Classifying + correlated neurons with a quadratic fit

Broadband + correlated neurons ($n=453$)
Gamma + correlated neurons ($n=141$)

Concave-Up ($n=285$)
Not Quadratic ($n=128$)
Concave-Down ($n=40$)

Concave-Up ($n=68$)
Not Quadratic ($n=47$)
Concave-Down ($n=26$)

5. Possible model of concave-up neurons

Firing Rate=
Spiking activity of a single neuron
LFP=
Summed activity of all neurons

Conclusions

3 subpopulations of BB+ and gamma+ neurons (fig. 4):
1. Concave-up: Most common; FR-LFP well correlated at high firing rates but not at low firing rates (see fig. 5 “possible model”)
2. Not Quadratic: Positively correlated neurons displaying either linear or higher order FR-LFP relations.
3. Concave-down: Least common; FR-LFP well correlated at low firing rates but not at high firing rates. Previously described in monkey literature\textsuperscript{3}.

References