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

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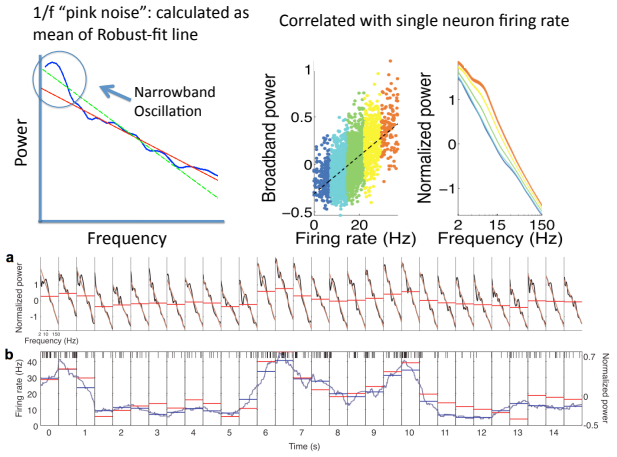
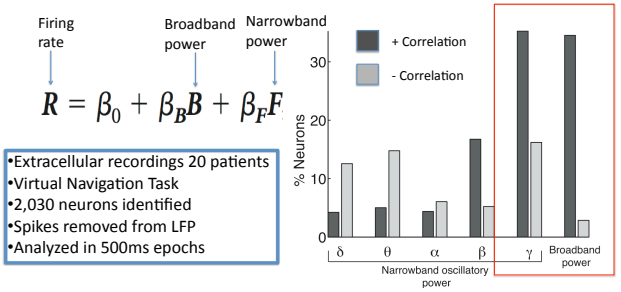
Introduction

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

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



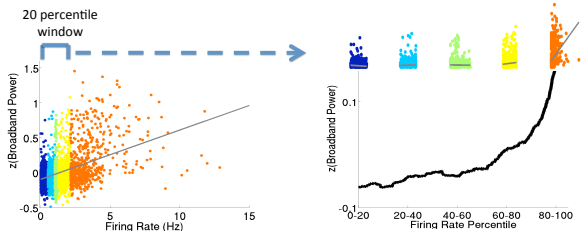
2. Regression framework separates broadband and gamma correlations



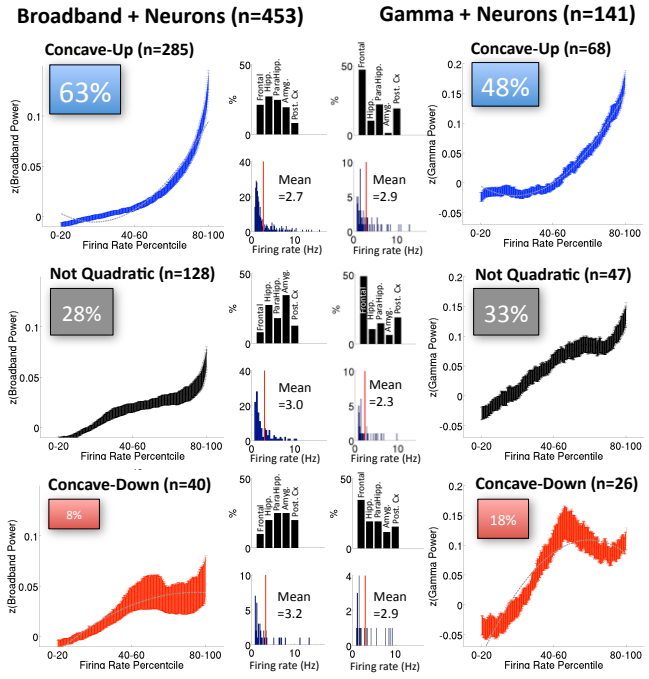
- Extracellular recordings 20 patients
- Virtual Navigation Task
- 2,030 neurons identified
- Spikes removed from LFP
- Analyzed in 500ms epochs

Results

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



4. Classifying + correlated neurons with a quadratic fit

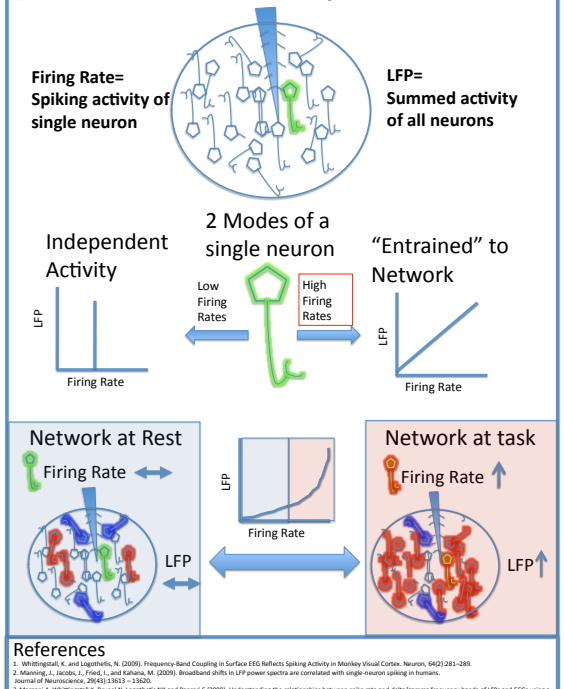


Conclusions

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[3].

5. Possible model of concave-up neurons



References

1. Whittingstall, K. and Logothetis, N. (2009). Frequency-Band Coupling in Surface EEG Reflects Spiking Activity in Monkey Visual Cortex. Neuron, 64(2):281–289.
2. Manning, J., Jacobs, J., Fried, I., and Kahana, M. (2009). Broadband shifts in LFP power spectra are correlated with single-neuron spiking in humans. Journal of Neuroscience, 29(43):13613 – 13620.
3. Mazzoni A, Whittingstall K, Brunel N, Logothetis NK and Panzeri S (2009). Understanding the relationships between spike rate and delta/gamma frequency bands of LFPs and EEGs using a local cortical network model. Neuroimage, 52(3):956-972