May 19th, 3:30 PM - 4:00 PM

When do Correlations Increase with Firing Rates?

Andrea Barreiro
Southern Methodist University, abarreiro@smu.edu

Cheng Ly
Virginia Commonwealth University, cly@vcu.edu

When do Correlations Increase with Firing Rates?

Andrea K. Barreiro, Southern Methodist University, abarreiro@smu.edu
Cheng Ly, Virginia Commonwealth University, cly@vcu.edu

A central question in neuroscience is to understand how noisy firing patterns are used to transmit information. Because neural spiking is noisy, spiking patterns are often quantified via pairwise correlations, or the probability that two cells will spike coincidentally, above and beyond their baseline firing rate. One observation frequently made in experiments, is that correlations can increase systematically with firing rate [1, 2]. Theoretical studies have determined that stimulus-dependent correlations that increase with firing rate can have beneficial effects on information coding [3, 4]; however, we still have an incomplete understanding of what circuit mechanisms do, or do not, produce this correlation-firing rate relationship.

Here, we study the relationship between pairwise correlations and firing rates in asynchronous, recurrent spiking networks. We found that with stronger excitatory coupling, a positive relationship emerges between pairwise correlations and firing rates. To explain these findings, we used linear response theory to predict the full correlation matrix and to decompose correlations in terms of graph motifs. We then used this decomposition to explain why covariation of correlations with firing rate — a relationship previously explained in feedforward networks driven by correlated input [1] — emerges in some recurrent networks but not in others [5]. Furthermore, when correlations covary with firing rate, this relationship is reflected in low-rank structure in the correlation matrix.

References

[1] J. de la Rocha, B. Doiron, E. Shea-Brown, K. Josić, A. Reyes. Correlation between neural spike trains increases with firing rate, *Nature* 448 pp. 802–806, 2007.

[2] D.P.A. Schulz, M. Sahani, M. Carandini. Five key factors determining pairwise correlations in visual cortex, *Journal of Neurophysiology* 114 pp. 1022–1033, 2015.

[3] F. Franke, M. Fiscella, M. Sevelev, B. Roska, A. Hierlemann, R.A. da Silveira. Structures of Neural Correlation and How They Favor Coding, *Neuron* 89 (2) pp. 409–422, 2016.

[4] J. Zylberberg, J. Cafaro, M.H. Turner, E. Shea-Brown, F. Rieke. Direction-selective circuits shape noise to ensure a precise population code, *Neuron* 89 (2) pp. 369–383, 2016.

[5] A.K. Barreiro, C. Ly. When do Correlations Increase with Firing Rate? arXiv:1610.06598v2, 2017.