Introduction:

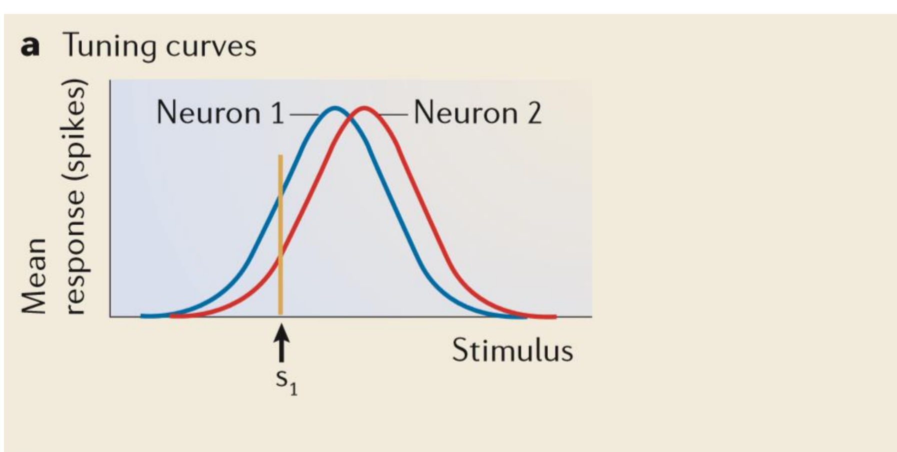
Irregular spontaneous activity, i.e., activity that is not related in any obvious way to external stimulation, and trial-to-trial variations in neuronal responses are often considered as noise. The origin of this irregularity of neuronal dynamics in vivo is poorly understood[3]. For instance, trial-to-trial fluctuations in response strength are shared between neurons, and spikes often occur synchronously. Understanding the properties and mechanisms that generate these forms of correlation is critical for determining their role in cortical processing[2]. Matthew Smith and Adam Kohn have investigated the spatial extent and functional specificity of correlated spontaneous and evoked activity[2]. In this exercise, we are going to replicate some part of their research and manipulate neuronal data.

Data description[5]:

Information about the data including cells, stimuli and format of the data are in crcns_pvc-11_data_description file. For further details on how the data were obtained, see the reference 2.

Tuning curve and noise correlation:

Tuning curve represents the average response of a neuron to a set of stimuli, with the average taken across many presentations of each stimulus, and the noise refers to the trial-to-trial variability in the responses. In panel a, tuning curves are shown for two neurons that have slightly different preferred stimuli. In panel b, we show two hypothetical scatter plots of the single trial responses for this pair of neurons, in response to the repeated presentation of a single stimulus s1 (arrow in panel a). Ellipses represent 95% confidence intervals. The example on the left illustrates positive noise correlation and the example on the right illustrates negative noise correlation. Responses also show a second sort of correlation known as signal correlation. These are correlations in the average response. Neurons with similar tuning curves (panel a) typically have positive signal correlations, because when s increases, the mean responses of both neurons tend to increase, or decrease, together. Conversely, neurons with dissimilar tuning curves typically have negative signal correlations[1].

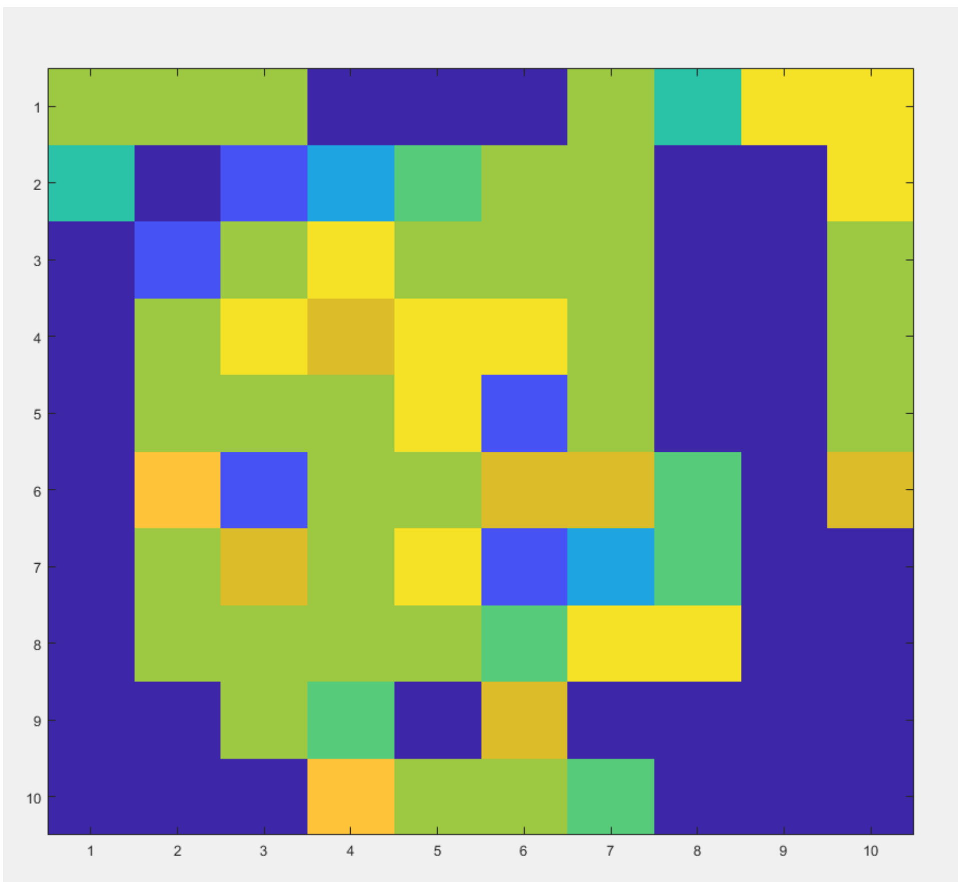


Questions:

First you have to read the reference 2 (just read the abstracts and go through the figures and read the captions to get an idea) and download their data

1. As mentioned in data_description file, evoked data set ('spikes_gratings') comprises spiking activity from 44 to 104 neurons collected from 3 arrays (data_monkey1_gratings, up to 3). So you need to find data_monkey1_gratings, 1, 2 and 3 files; and then find the most active neuron in each array. Then plot their Tuning curves.

2. Use MAP file and CHANNELS files; to Plot 3(10×10) color mesh for these 3 arrays and use same color for neurons with similar preferred orientation. (as shown below). Is your results similar to pinwheel organization of orientation in the cortex? Why or whynot?



3. You need to find the dependence of r_{sc} (noise correlation) on distance for pairs grouped based on their orientation tuning similarity. In other word, you should find most populated group of

neurons with similar orientation preferences, and investigate the relation of correlation and distance of pair neurons. Is your answer similar with paper's conclusion?

4. As mentioned earlier in the paper, the spatial structure of correlation was similar between spontaneous and evoked activity, there was a striking difference in its strength: the average r_{sc} value for spontaneous activity was 0.299, nearly twofold higher than the average correlation of evoked activity (0.176) in dataset. How can you explain his difference in correlation between evoked and spontaneous periods?

5. [Additional Score question not mandatory] So we know that the neurons with similar orientation preferences are highly correlated with each other. Can we use this fact and compute color mesh (in question2) from spontaneous activity of neurons? Explain your approach

References:

1. Averbeck, Bruno B., Peter E. Latham, and Alexandre Pouget. "Neural correlations, population coding and computation." *Nature reviews neuroscience* 7.5 (2006): 358.
2. Smith, Matthew A., and Adam Kohn. "Spatial and temporal scales of neuronal correlation in primary visual cortex." *Journal of Neuroscience* 28.48 (2008): 12591-12603.
3. Gerstner, Wulfram, et al. *Neuronal dynamics: From single neurons to networks and models of cognition*. Cambridge University Press, 2014.
4. Mainen, Zachary F., and Terrence J. Sejnowski. "Reliability of spike timing in neocortical neurons." *Science* 268.5216 (1995): 1503-1506.
5. Kohn, A., Smith, M.A. (2016) Utah array extracellular recordings of spontaneous and visually evoked activity from anesthetized macaque primary visual cortex (V1). CRCNS.org http://dx.doi.org/10.6080/K0NC5Z4X