Sharif University of Technology

Advanced Topics in Neuroscience

Simulation 03 (Noise correlation)

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1 Neurons Tuning curves

At first, I use the script code to set the spike time, remove the neuron with a low SNR or neuron with a low firing rate, and count spikes in a 200 ms time bin for each neuron. I find the PSTH in each condition and plot it.

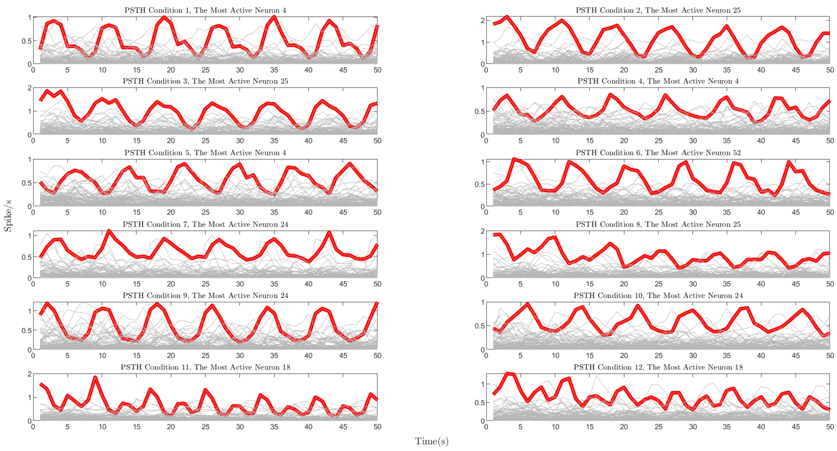


Figure 1: PSTH of all neurons in 12 conditions. The most active neuron is shown in red, Monkey 1.

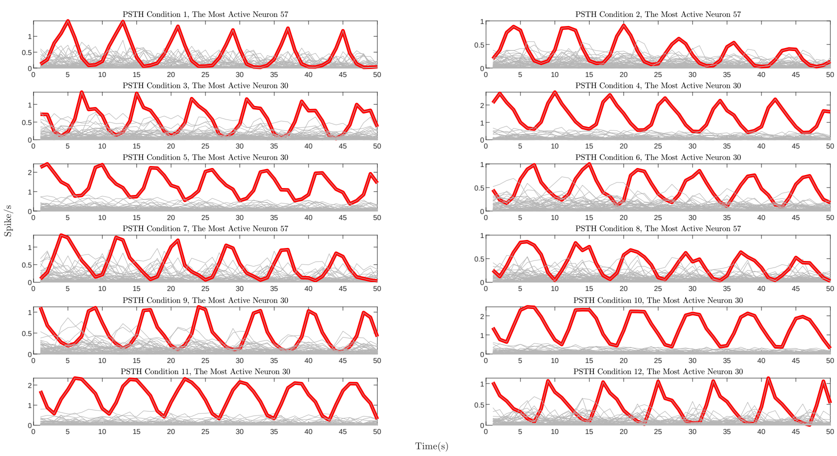


Figure 2: PSTH of all neurons in 12 conditions. The most active neuron is shown in red, Monkey 2.

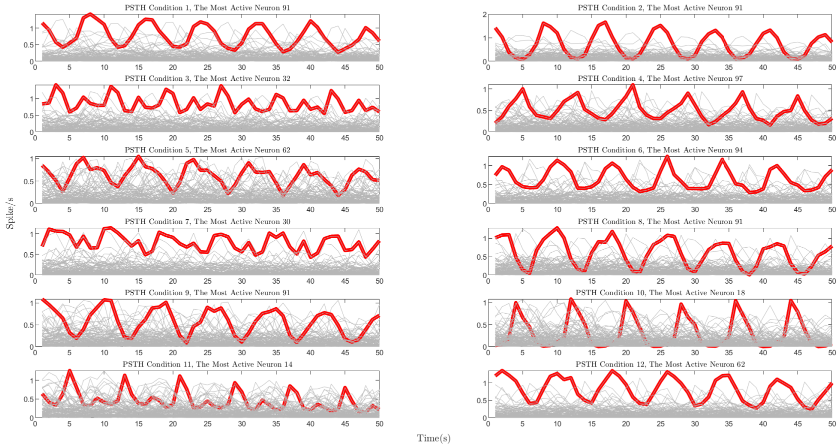


Figure 3: PSTH of all neurons in 12 conditions. The most active neuron is shown in red, Monkey 3.

PSTH has sinus periodic. It maybe because the stimulus has a temporal frequency of 6.25 Hz. Almost in all neurons, we can see six picks during these 50-time bins last 20 ms.

I average spikes in a 200 trial and 12 stimulation, find the 12 more active neurons in each array and plot their tuning curve. We can see different neuron responses more in a specific orientation and direction and are quiet in some others. Some of them are directly based, which fires more in one direction. We have two picks with a 180-degree difference in their tuning curve.

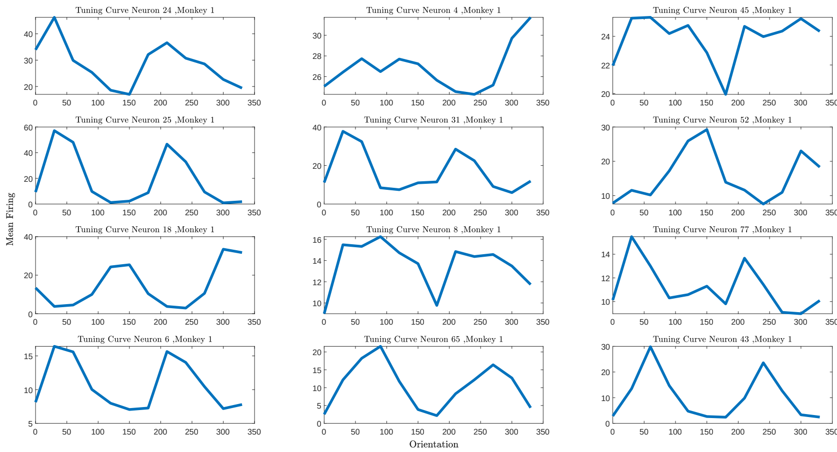


Figure 4: Tuning curve of 12 active neurons, Monkey 1.

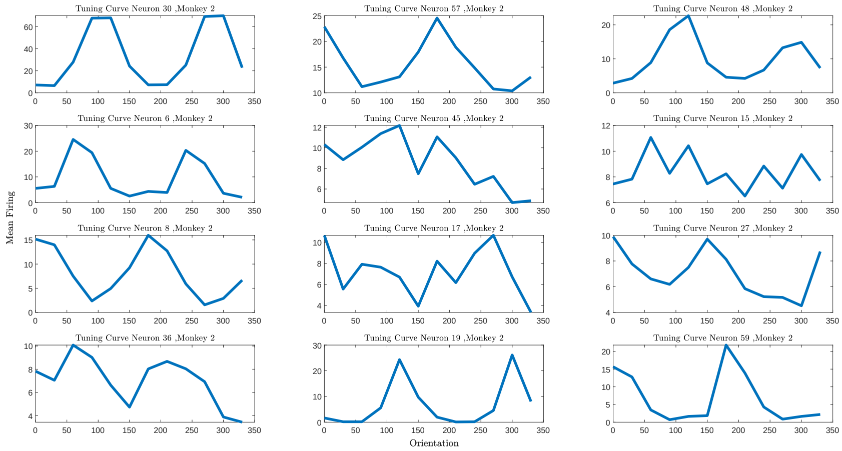


Figure 5: Tuning curve of 12 active neurons, Monkey 2.

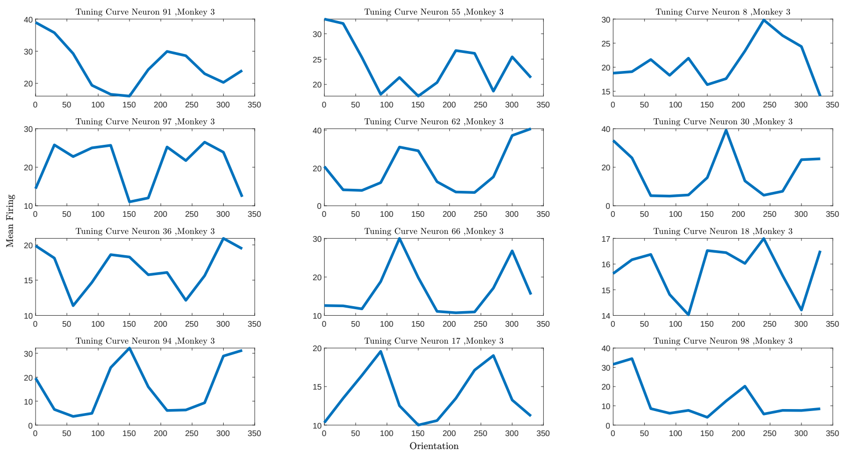
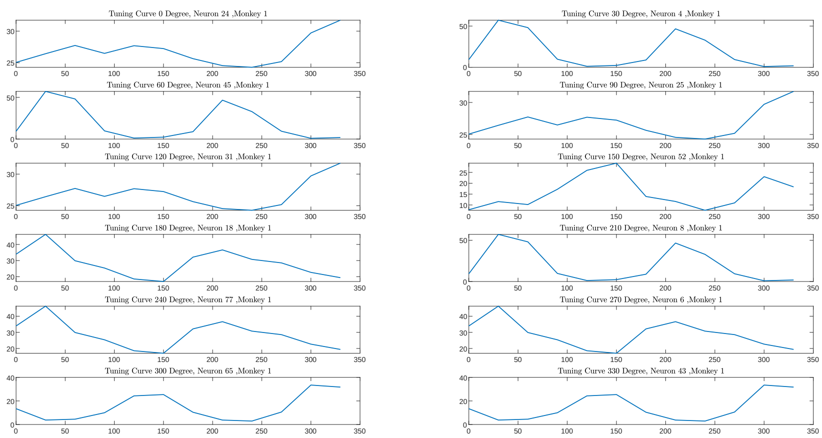
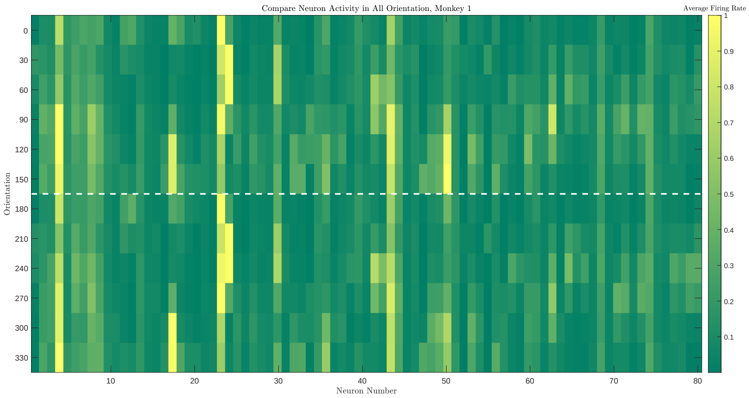


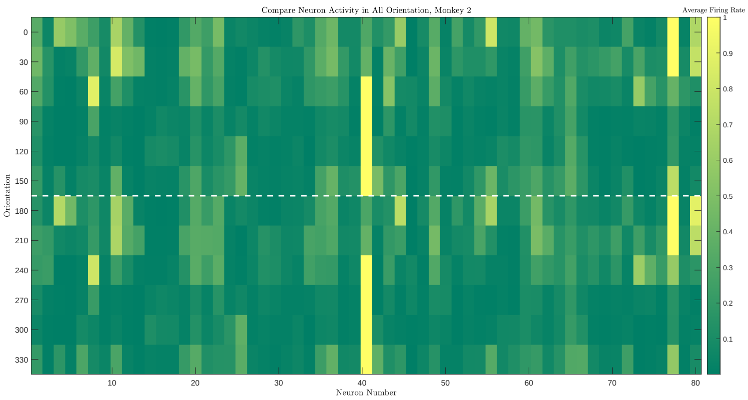
Figure 6: Tuning curve of 12 active neurons, Monkey 3.

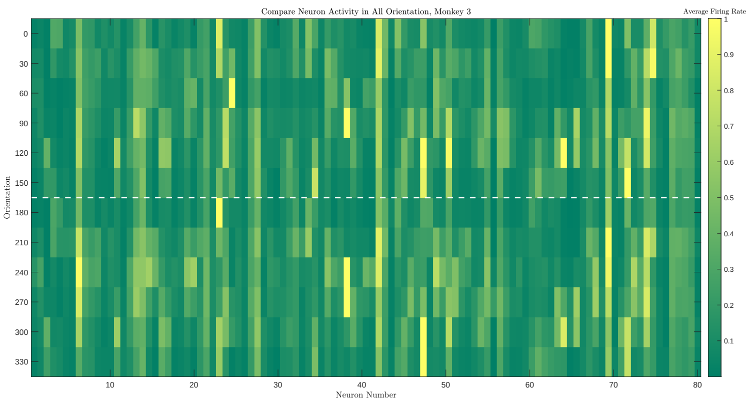
I plot the tuning curve of the most active neuron in each condition and suppose to see picks in tuning curve in that orientation, but I don't see it in all orientation! Because I plot the tuning curve of the most active neuron. It doesn't mean this orientation is the neuron preferred.



Also, I plot all neuron activity in all orientation (average firing rate is normalize with maximum FR in that direction). You can see some neuron response in more than one direction. Some neuron activity has same pattern in 0 to 150 and 180 to 330. It means these neurons response in specific direction (compare above and below white dashed line).

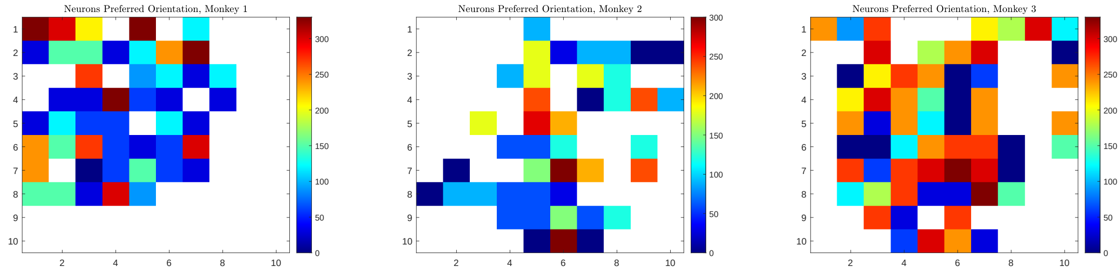






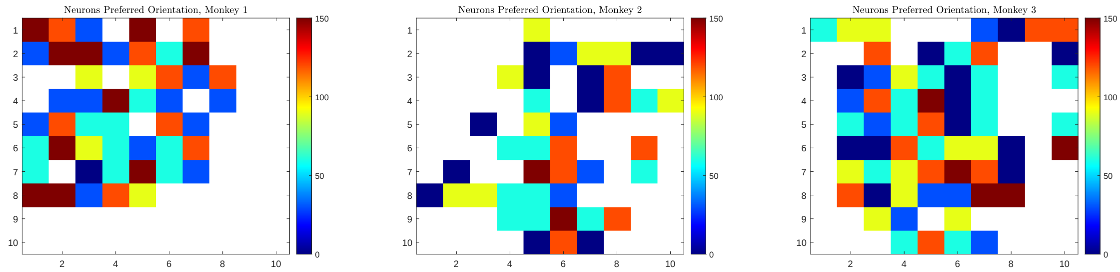
2 Pinwheel Organization of Orientation

In the MAP file, we have an array of the location of each channel. They contain some neurons. CHANNELS file gives the index of these neurons. I plot this array by different colors that show the neurons with similar preferred orientations.

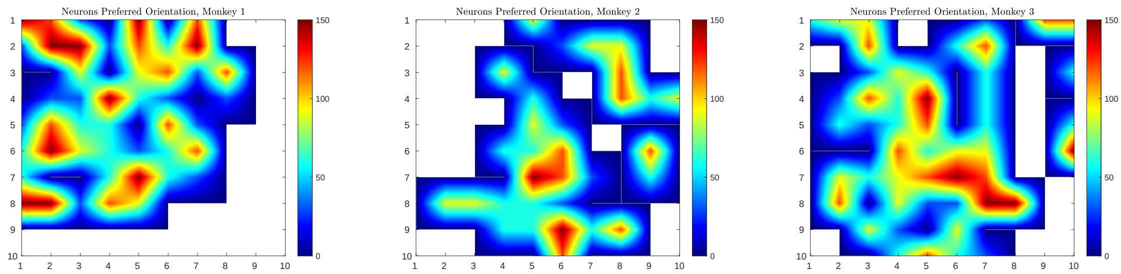


Pinwheel is orientation columns that extend vertically down from the cortical surface, containing cells with receptive fields responsive to lines or edges at a particular angle. We expect to see some regions have all colors in their neighborhoods, but we don't, Because we have a small number of neurons and are too far from each other (400 nm). Spatial resolution is not enough to see this result in this dataset.

I also limit orientation between 0 and 150 degree.



To be sure there is any pinwheel, I interpolate the colors.



3 Dependence of Noise Correlation on Distance and Tuning Similarity

In this part, we want to see the dependency of noise correlation, distance and signal correlation. Signal correlation is correlation between each pairs of neuron tuning curve. The distance of each pairs of electrode is measured. We know the distance of each neighbor electrode is 400 nm. Noise Correlation is found by article method: 'The r_{sc}, or spike count correlation, is the Pearson correlation coefficient of the evoked spike counts of two cells to repeated presentations of a particular stimulus: it captures shared trial-to-trial variability. For each stimulus orientation, we normalized the response to a mean of zero and unit variance (Z-score), and calculated r_{sc} after combining responses to all stimuli.'

At first, I group the neuron base on their signal correlation and plot the average noise correlation base on distance. 'The distance bins start at 0.25 mm and extend to 4.25 mm in 0.5 mm increments.'

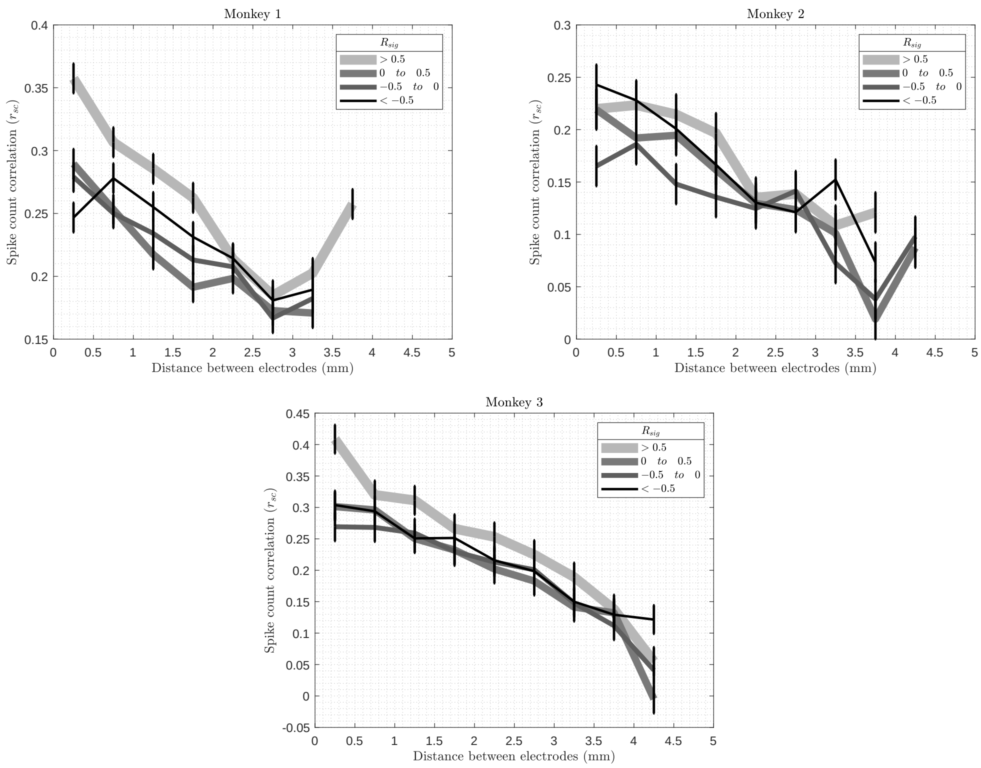


Figure 7: The dependence of r_{sc} on distance for pairs grouped based on their orientation tuning similarity

As you see, the neurons have less noise correlation if they are far apart, especially when they have more signal correlation (we see this result better foe group of neuron with signal correlation more than 0.5)

Now, I group the neuron base on their distance and plot the average noise correlation base on signal correlation.

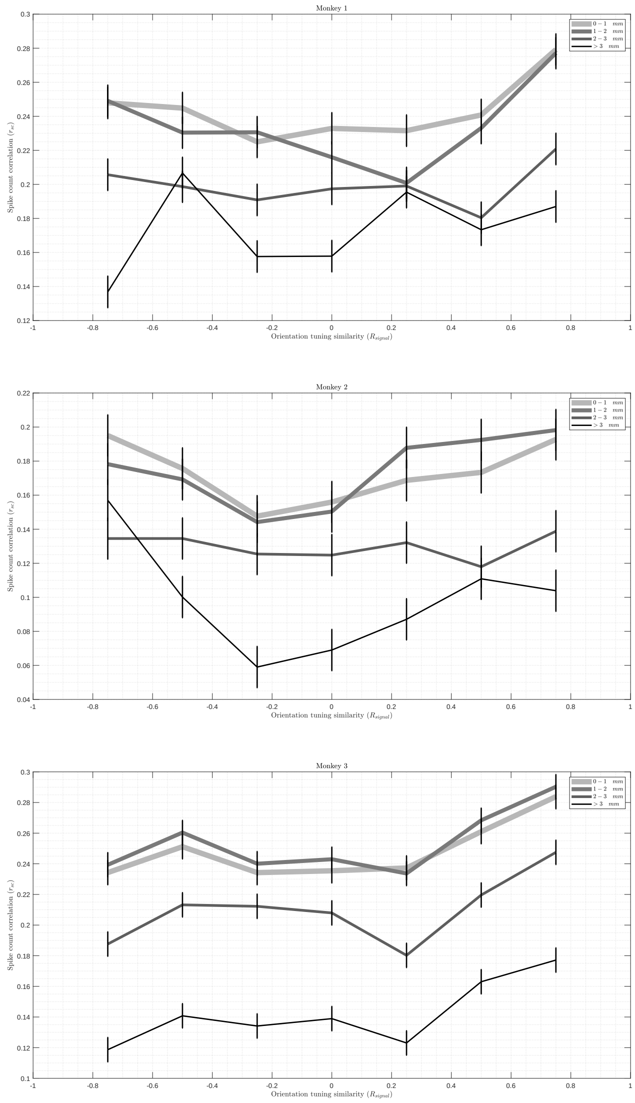


Figure 8: The dependence of r_sc on distance for pairs grouped based on their orientation tuning similarity.

Finally, I show the relationship between r_{sc}, distance and tuning similarity.

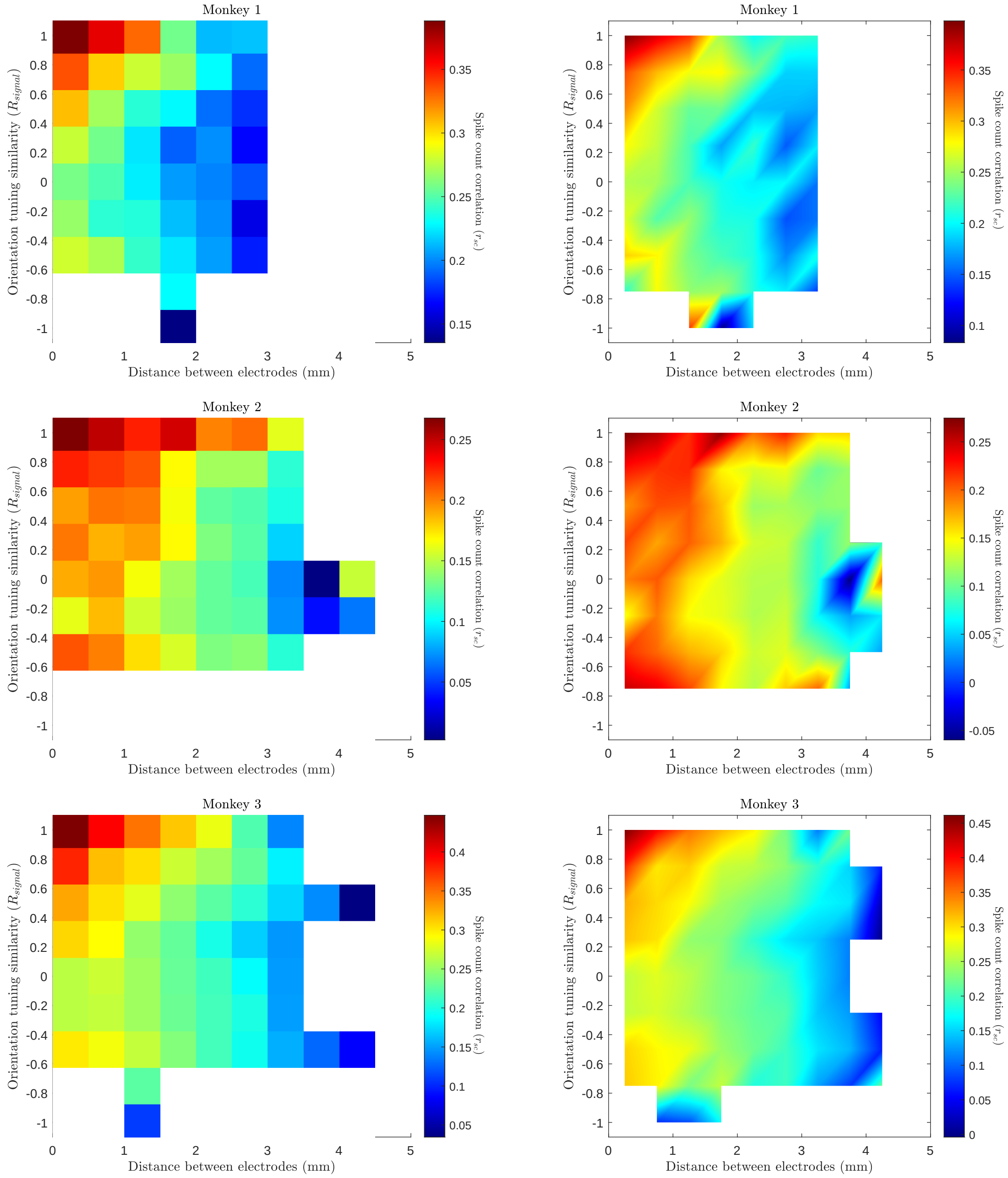
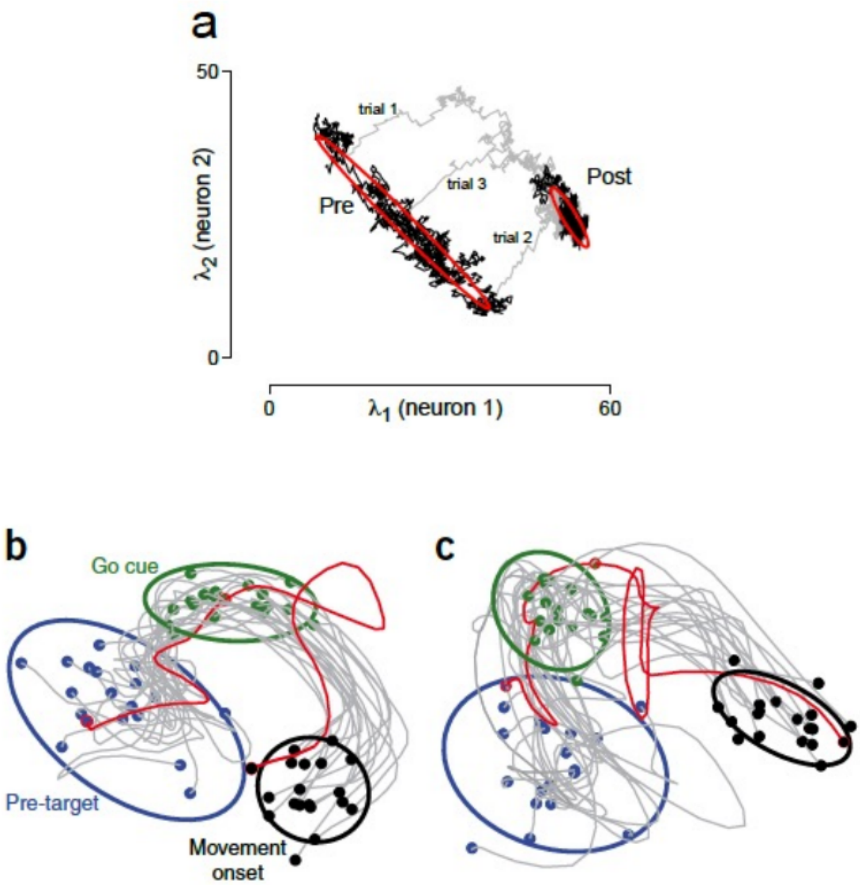


Figure 9: The dependence of r_{sc} on both distance and tuning similarity.

4 Part 4

Based on the Churchland article, noise correlation decrease after stimulus onset. If we consider neurons as a network, the system goes to a more stable point in phase space after the stimulus. So neurons behave similarly, and the noise correlation decrease.

In spontaneous activity, neuron fire differently, and the noise correlation is high. But in evoked activity, neurons respond in a specific manner.



5 Part 5

In spontaneous activity, we don't have a tuning curve. I think we could find the correlation between each neuron's spike time (or spike count) and keep only a high correlation. Then plot the figure (question 2) again with color based on the number of connections between each neuron and others.