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Student ID: 99102189
Subject: Noise Correlation

Advanced Topics in Neuroscience - Dr. Ali Ghazizadeh
Assignment 3

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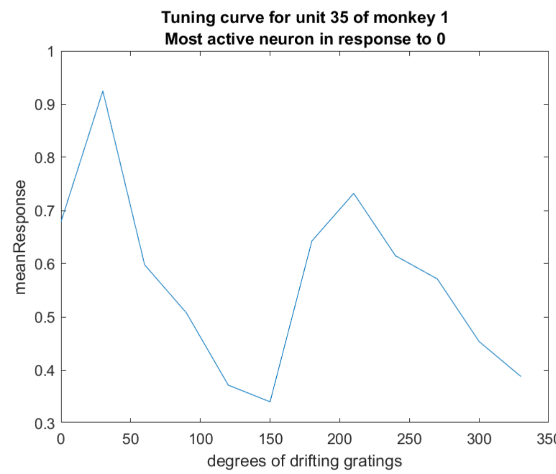
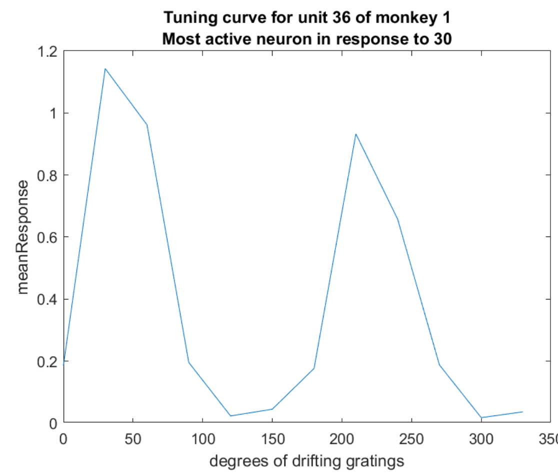
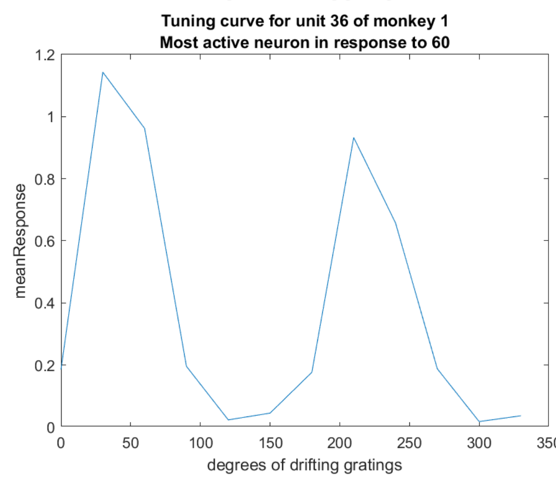
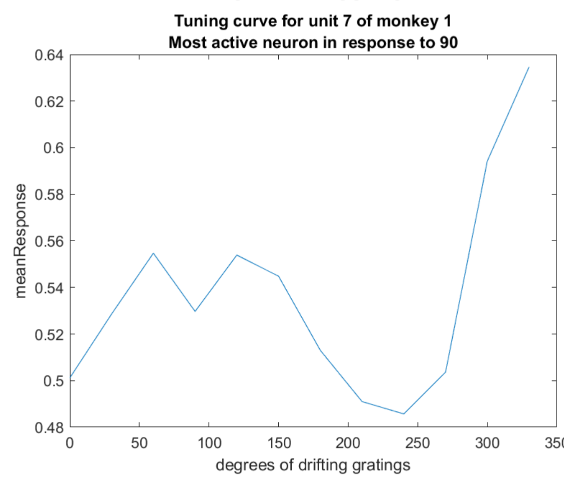
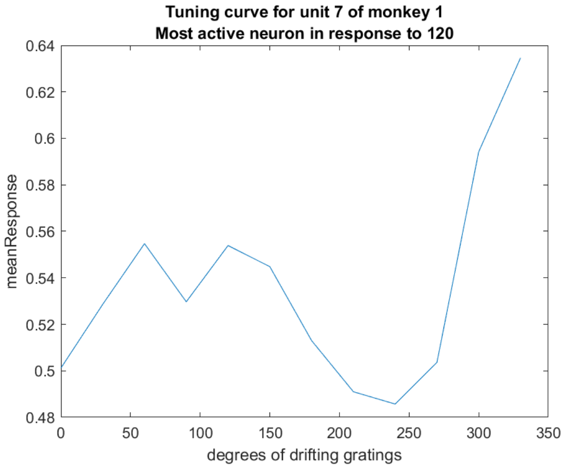
1. First we dismiss neurons which have SNR less than 1.5 and firing rate 1.0 spikes/sec. Then for each monkey we find 12 unit. Each unit is the most active unit in response to a specific stimulus.

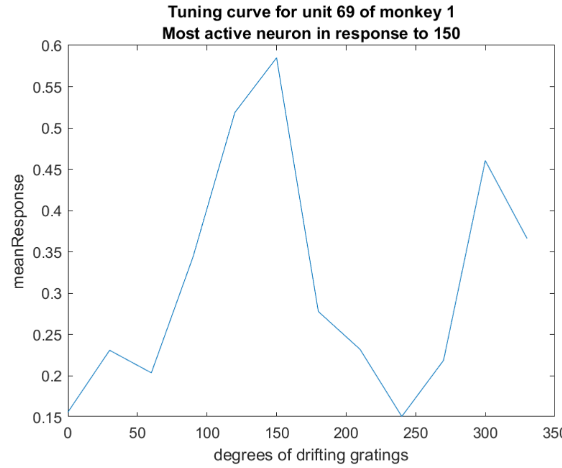


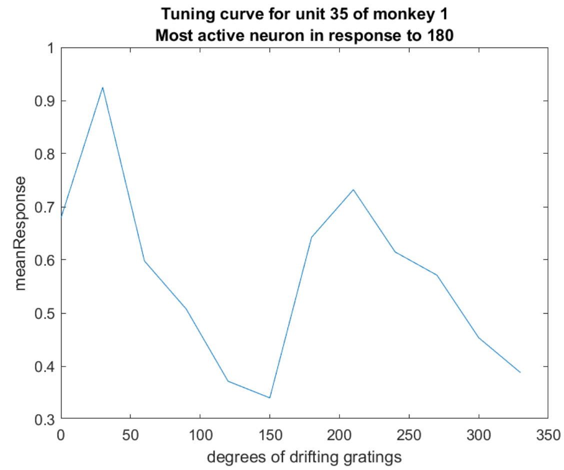


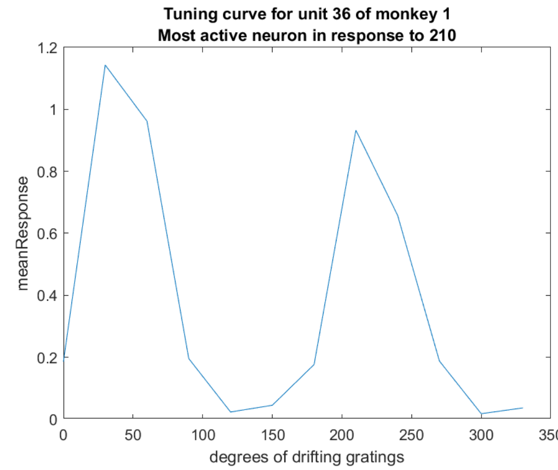


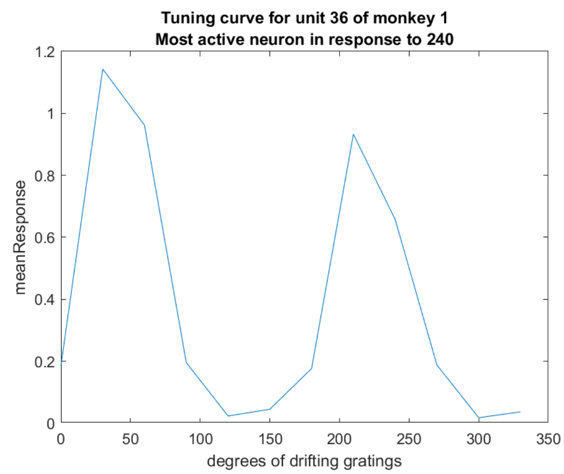


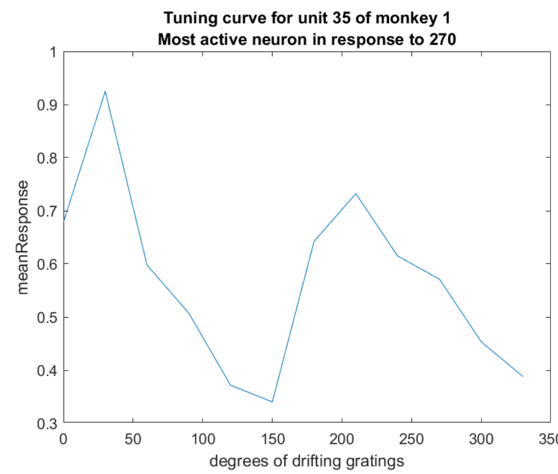

Tuning curve for unit 7 of monkey 1
Most active neuron in response to 120
meanResponse
degrees of drifting gratings
0.48 0.5 0.52 0.54 0.56 0.58 0.6 0.62 0.64
0 50 100 150 200 250 300 350

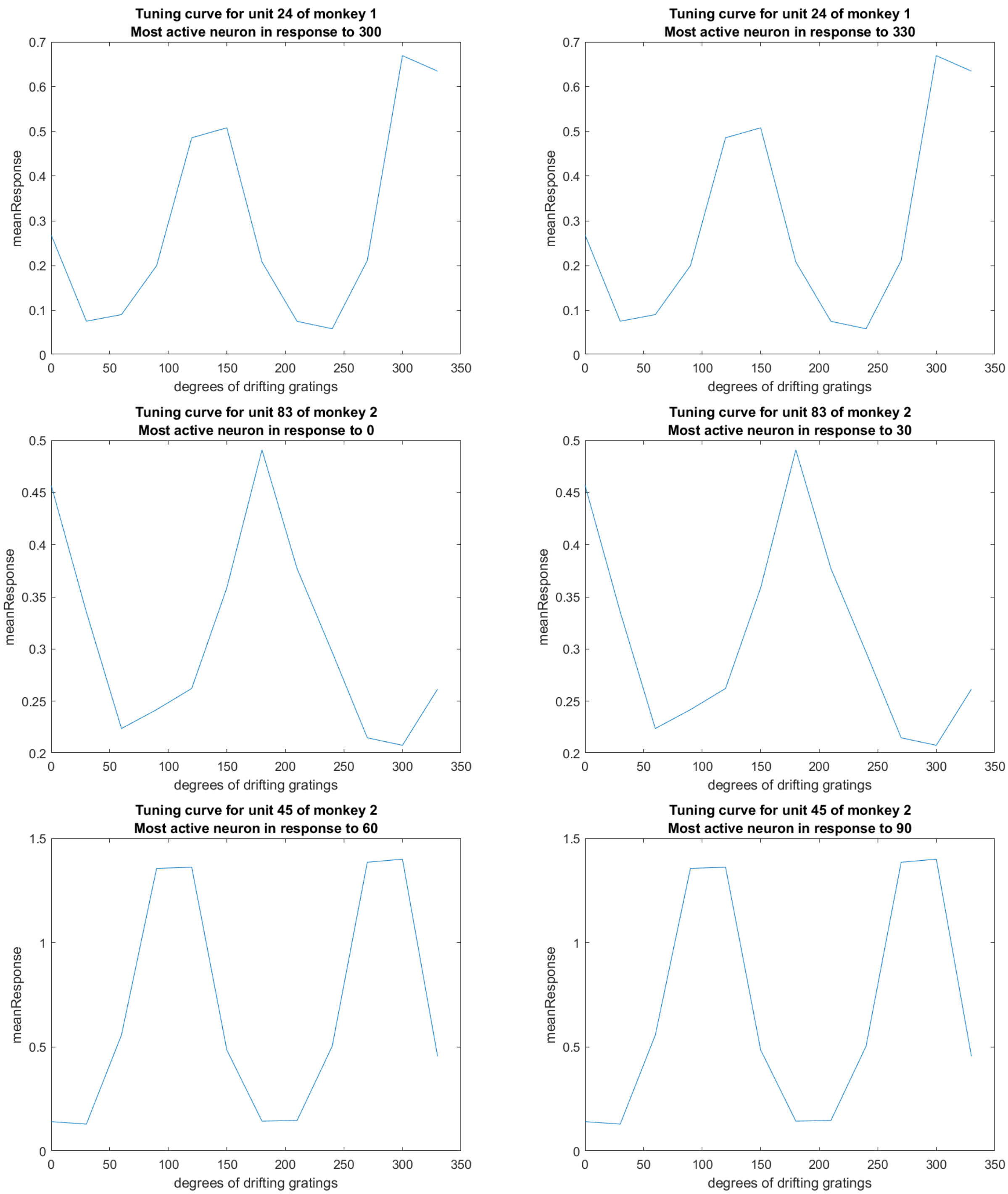

Tuning curve for unit 69 of monkey 1
Most active neuron in response to 150
meanResponse
degrees of drifting gratings
0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6
0 50 100 150 200 250 300 350

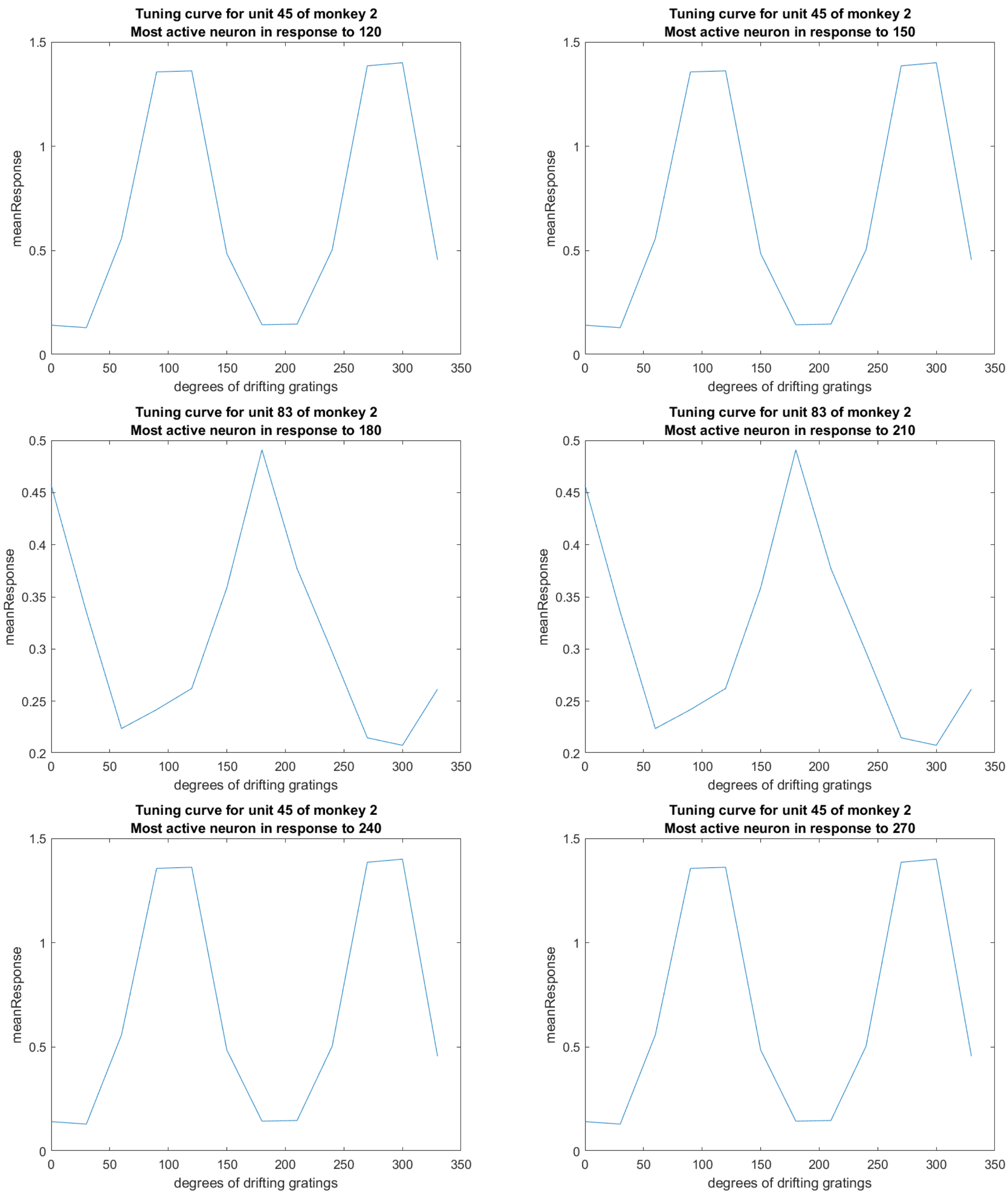

Tuning curve for unit 35 of monkey 1
Most active neuron in response to 180
meanResponse
degrees of drifting gratings
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 50 100 150 200 250 300 350

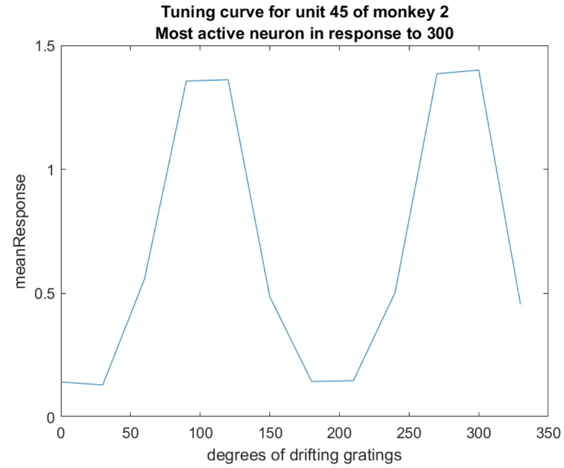

Tuning curve for unit 36 of monkey 1
Most active neuron in response to 210
meanResponse
degrees of drifting gratings
0 0.2 0.4 0.6 0.8 1 1.2
0 50 100 150 200 250 300 350

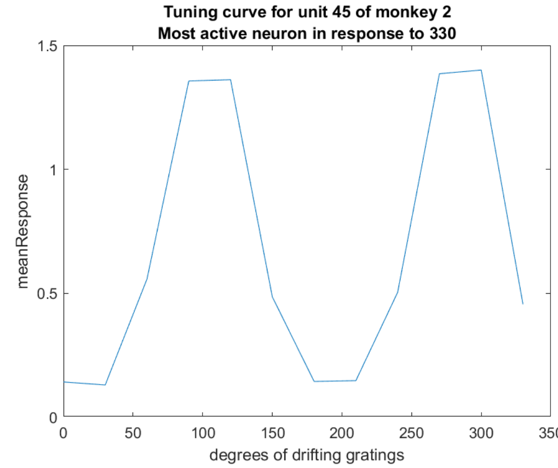

Tuning curve for unit 36 of monkey 1
Most active neuron in response to 240
meanResponse
degrees of drifting gratings
0 0.2 0.4 0.6 0.8 1 1.2
0 50 100 150 200 250 300 350

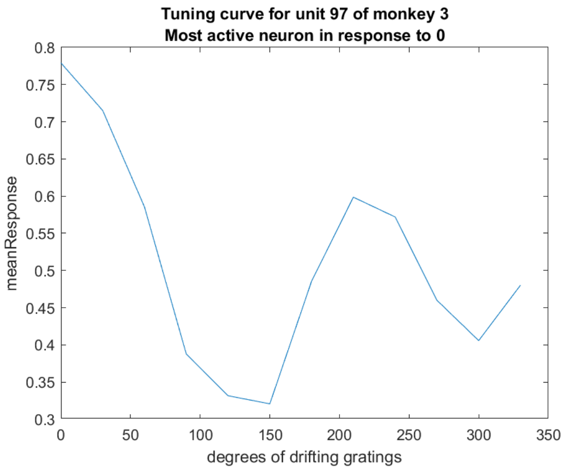

Tuning curve for unit 35 of monkey 1
Most active neuron in response to 270
meanResponse
degrees of drifting gratings
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
0 50 100 150 200 250 300 350

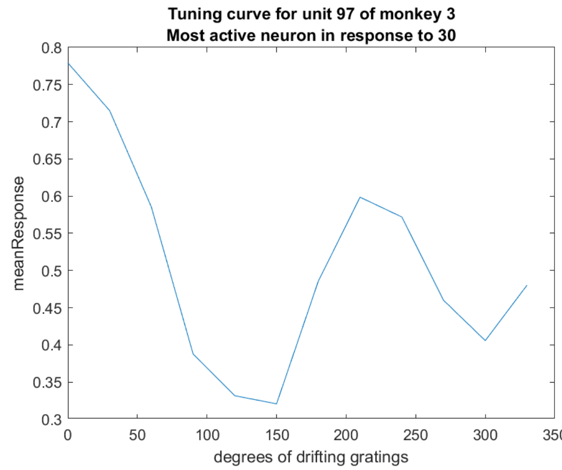

Tuning curve for unit 24 of monkey 1
Most active neuron in response to 300
Tuning curve for unit 24 of monkey 1
Most active neuron in response to 330
Tuning curve for unit 83 of monkey 2
Most active neuron in response to 0
Tuning curve for unit 83 of monkey 2
Most active neuron in response to 30
Tuning curve for unit 45 of monkey 2
Most active neuron in response to 60
Tuning curve for unit 45 of monkey 2
Most active neuron in response to 90
meanResponse
degrees of drifting gratings

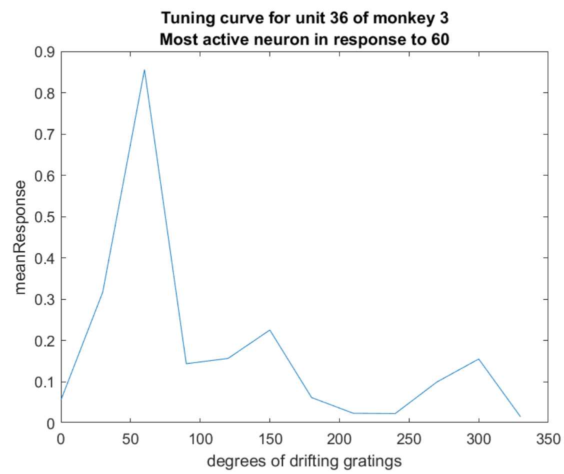

Tuning curve for unit 45 of monkey 2
Most active neuron in response to 120
Tuning curve for unit 45 of monkey 2
Most active neuron in response to 150
Tuning curve for unit 83 of monkey 2
Most active neuron in response to 180
Tuning curve for unit 83 of monkey 2
Most active neuron in response to 210
Tuning curve for unit 45 of monkey 2
Most active neuron in response to 240
Tuning curve for unit 45 of monkey 2
Most active neuron in response to 270
meanResponse
degrees of drifting gratings
0
50
100
150
200
250
300
350
0.5
1
1.5
0.2
0.25
0.3
0.35
0.4
0.45

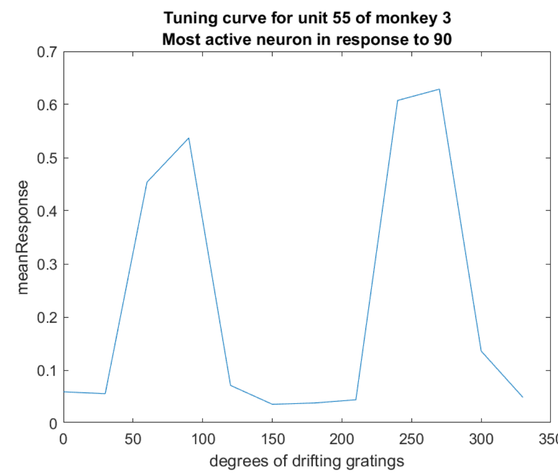

Tuning curve for unit 45 of monkey 2
Most active neuron in response to 300
meanResponse
degrees of drifting gratings

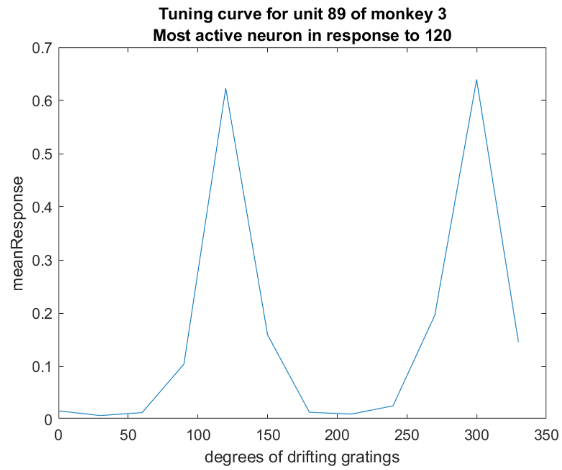

Tuning curve for unit 45 of monkey 2
Most active neuron in response to 330
meanResponse
degrees of drifting gratings

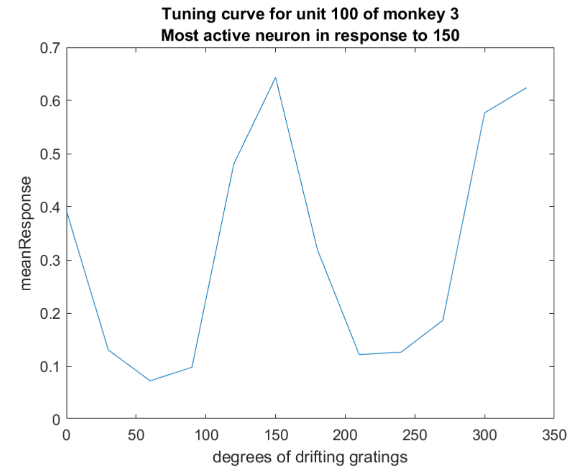

Tuning curve for unit 97 of monkey 3
Most active neuron in response to 0
meanResponse
degrees of drifting gratings

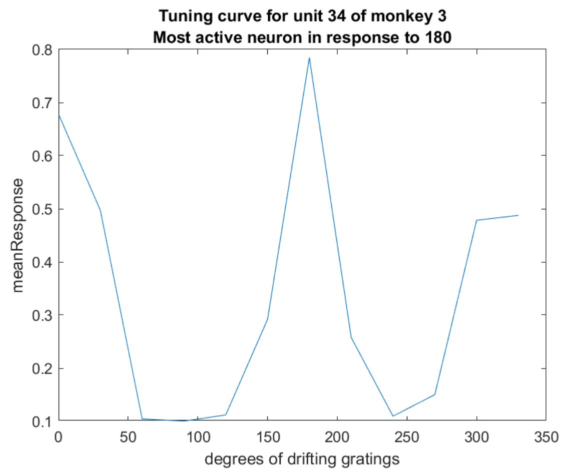

Tuning curve for unit 97 of monkey 3
Most active neuron in response to 30
meanResponse
degrees of drifting gratings

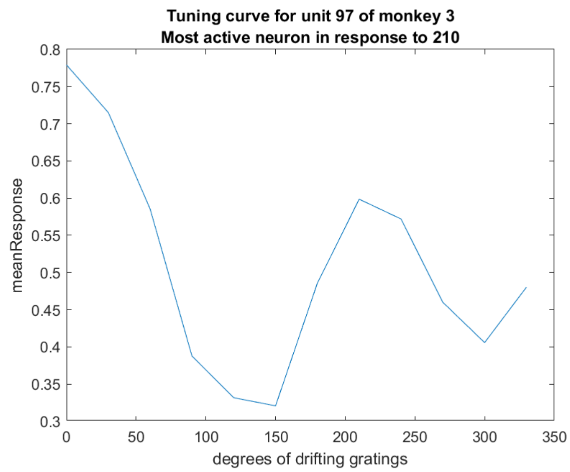

Tuning curve for unit 36 of monkey 3
Most active neuron in response to 60
meanResponse
degrees of drifting gratings

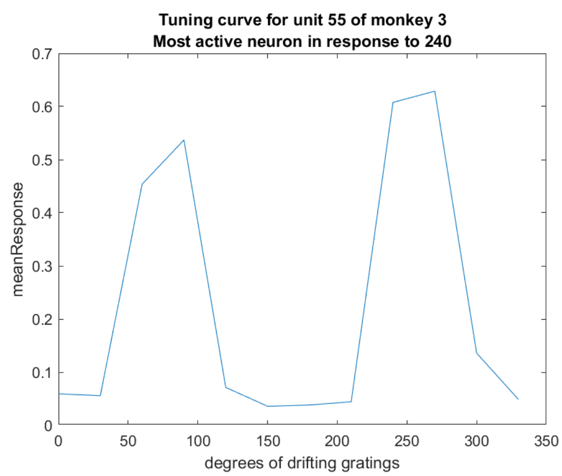

Tuning curve for unit 55 of monkey 3
Most active neuron in response to 90
meanResponse
degrees of drifting gratings

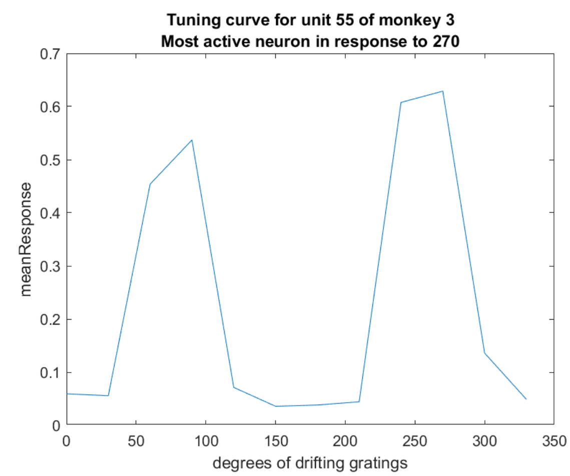

Tuning curve for unit 89 of monkey 3
Most active neuron in response to 120
meanResponse
degrees of drifting gratings

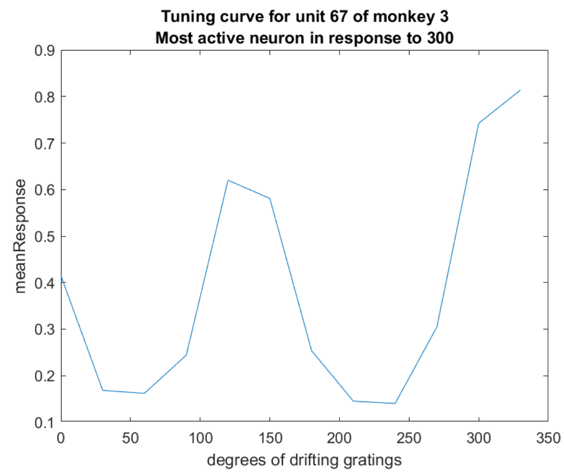

Tuning curve for unit 100 of monkey 3
Most active neuron in response to 150
meanResponse
degrees of drifting gratings

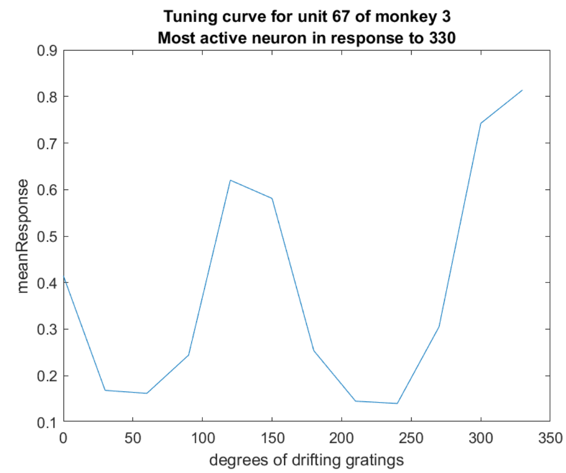

Tuning curve for unit 34 of monkey 3
Most active neuron in response to 180
meanResponse
degrees of drifting gratings


Tuning curve for unit 97 of monkey 3
Most active neuron in response to 210
meanResponse
degrees of drifting gratings


Tuning curve for unit 55 of monkey 3
Most active neuron in response to 240
meanResponse
degrees of drifting gratings

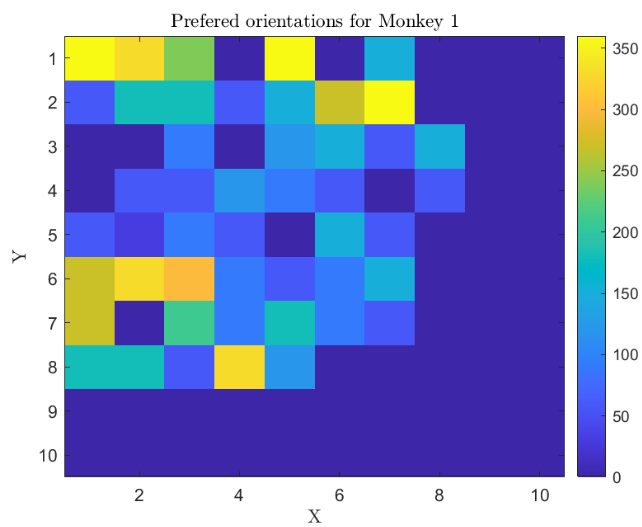

Tuning curve for unit 55 of monkey 3
Most active neuron in response to 270
meanResponse
degrees of drifting gratings

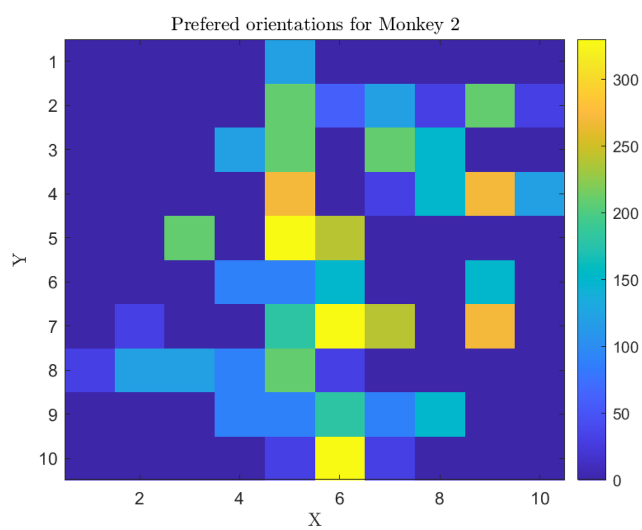


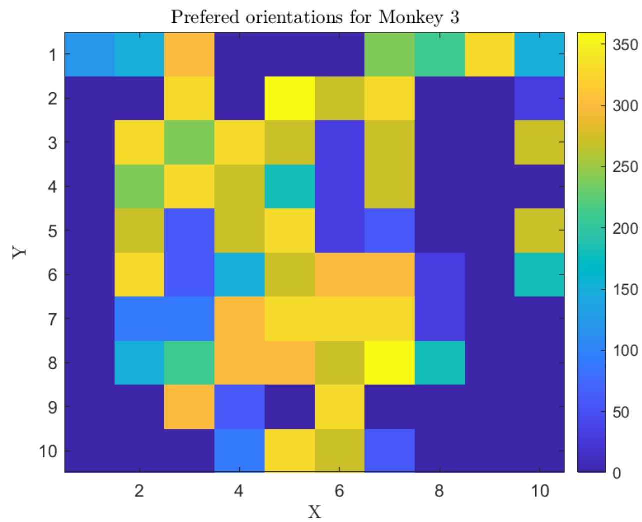


As you see some units are the most active one for more than 1 type of stimulus.

2. In this part we find place of remaining neurons in Utah array by using .MAP and .CHANNELS matrices. Then find the most active neuron in each cell of the new map. Now we use same color for neurons with similar preferred orientation and image the map.



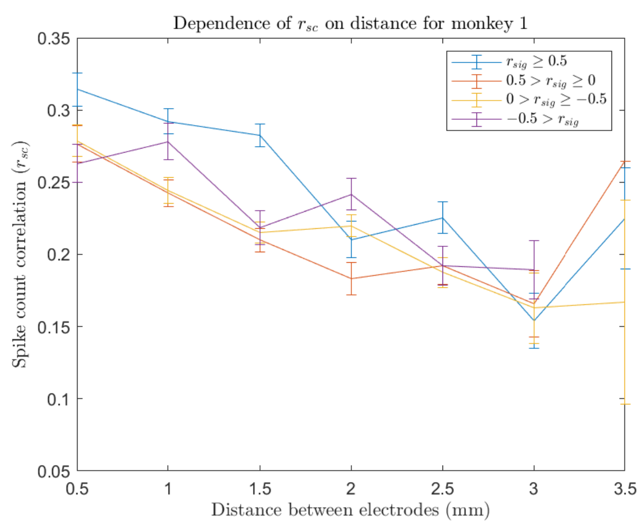


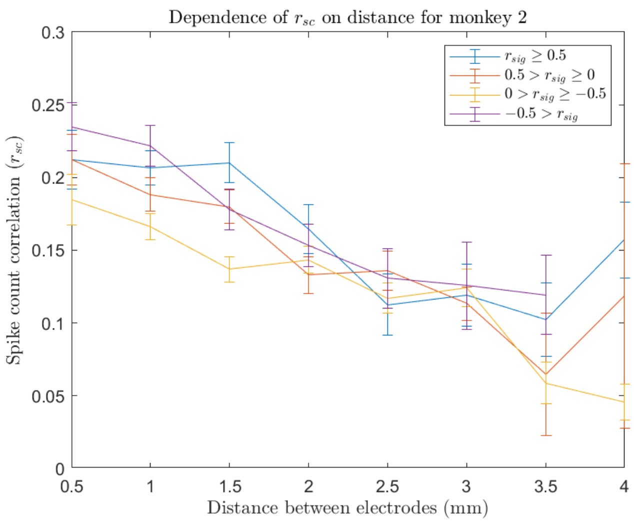


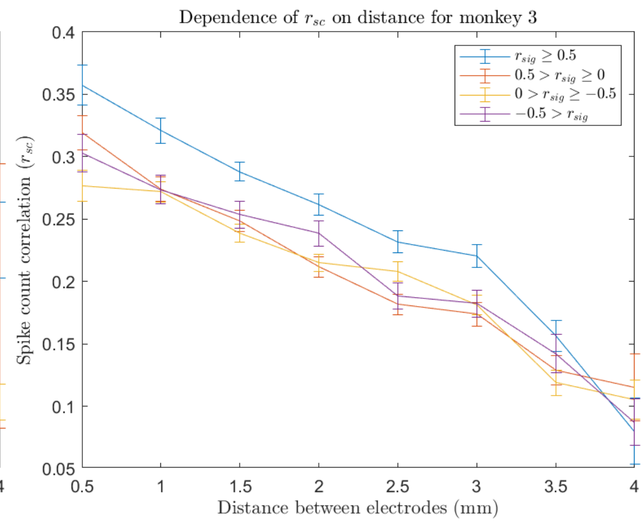
Our result is not similar to pinwheel organization of orientation in the cortex because we don't have enough neurons and our resolution is not as high as we need for observing pinwheel organization. So we need more neurons and bigger array.

3. Now we will find the dependence of r_{sc} (noise correlation) on distance for pairs grouped based on their orientation tuning similarity. In other word, we will find most populated group of neurons with similar orientation preferences, and investigate the relation of correlation and distance of pair neurons.

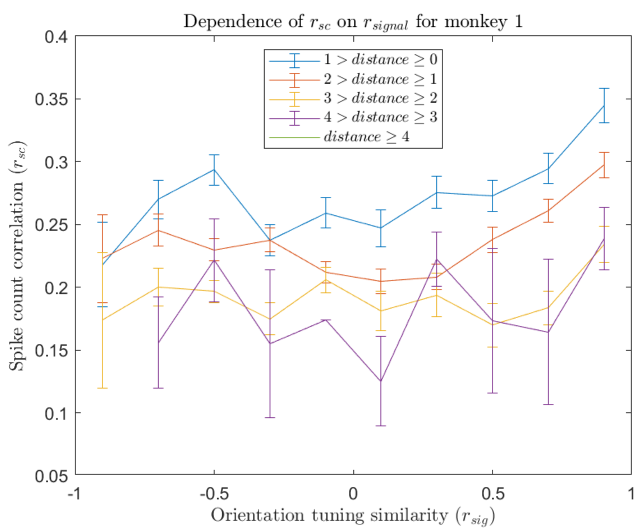
   First we plot the dependence of r_{sc} on distance for pairs grouped based on their orientation tuning similarity (r_{signal}). The distance bins start at 0.25 mm and extend to 4.25 mm in 0.5 mm increments. The average of all the data are plotted at the center value of each bin. Error bars onthis and allsubsequent plots indicate ±1 SEM;

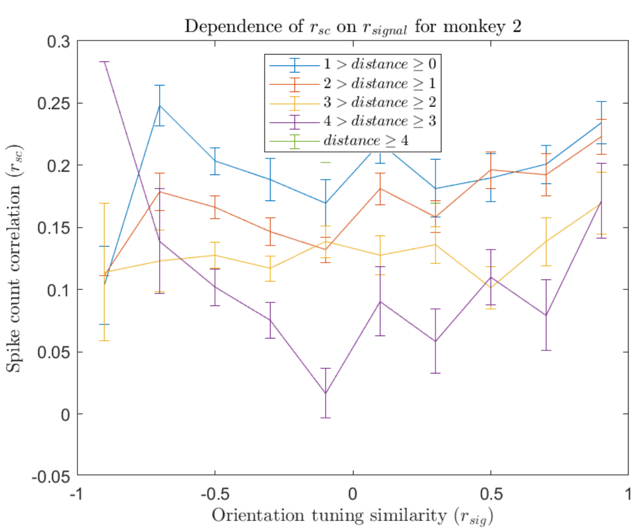


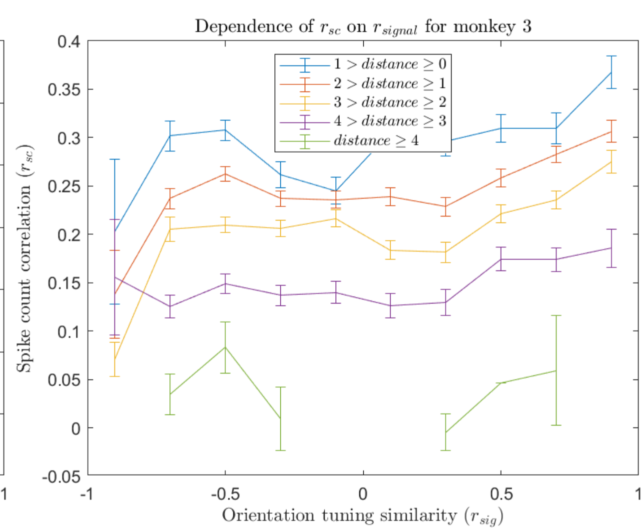




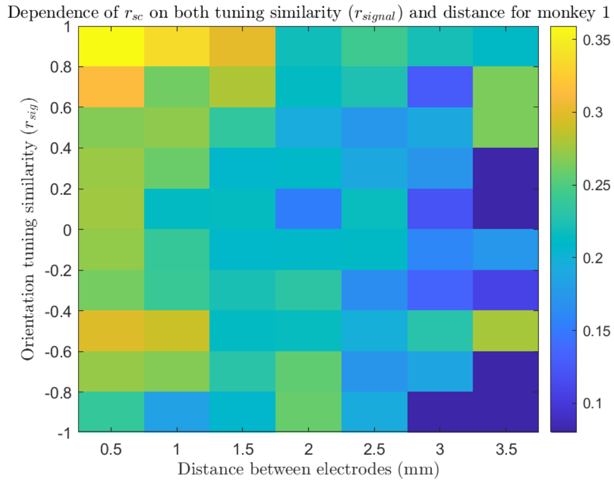
Now the dependence of r_{sc} on r_{signal} for pairs grouped by their separation will be shown. The average of all the data are plotted at the center value of each bin.

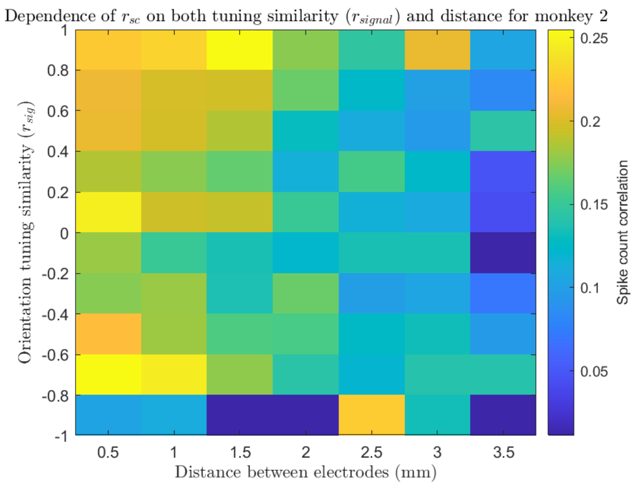


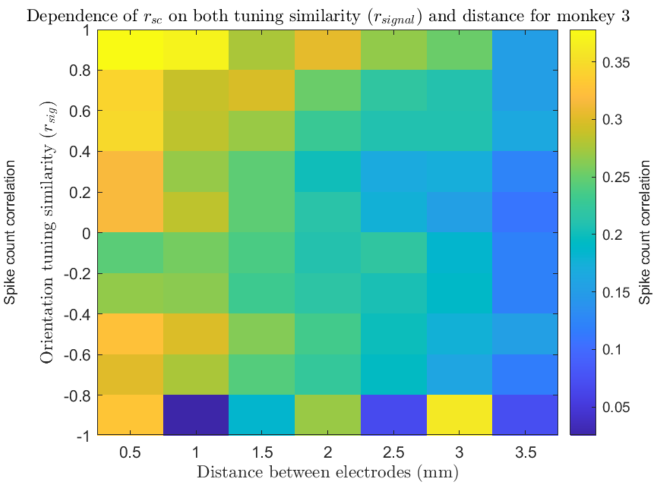




Now The dependence of r_{sc} on both distance and tuning similarity:







We can see that our answer is similar with paper of Smith, Matthew A., and Adam Kohn conclusion.

4. Based on the information provided, it seems that the correlation values for spontaneous and evoked activity are different. The average spike count correlation value for spontaneous activity is nearly twofold higher than the average correlation for evoked activity.

   One possible explanation for this difference in correlation is that spontaneous neural activity is characterized by more synchronous firing of neurons compared to evoked activity. Spontaneous activity is generated by ongoing neural processes in the brain without any external input, while evoked activity is generated in response to a specific sensory stimulus. The synchronous firing of neurons during spontaneous activity could contribute to the higher correlations compared to evoked activity, which may involve a more distributed pattern of firing across neurons.

   In fact during spontaneous activity, it is common for neurons to fire in synchronous bursts, which can result in higher levels of correlation compared to evoked activity where neurons may fire more independently. This synchronous firing can result in the formation of functional networks in the brain and may play a role in various cognitive processes such as perception, attention, and memory.

   Another possibility is that the difference in correlation reflects differences in the underlying network structure or connectivity between neurons for spontaneous versus evoked activity. Spontaneous activity may involve stronger or more consistent connections between neurons, leading to higher correlations, while evoked activity may involve weaker or more variable connections, resulting in lower correlations.

5. To compute color mesh from spontaneous activity of neurons based on their preferred orientation preferences, we first need to understand how the correlation between the neurons' spontaneous activity reflects their similarity in preferred orientation.

   Typically, neurons in the visual cortex have a preference for a particular orientation of a visual stimulus. Neurons with similar preferred orientations tend to have higher correlation in their activity patterns, whereas neurons with different preferred orientations tend to have lower correlation in their activity patterns. This is known as the orientation tuning curve.

   To capture this relationship between correlation and preferred orientation, we can use techniques such as principal component analysis (PCA) or independent component analysis (ICA) to extract the underlying patterns of correlated neural activity.

   We would record the spontaneous activity of a population of neurons over a period of time. Then, we would calculate the correlation matrix between all pairs of neurons in the population. We can then perform PCA or ICA on the correlation matrix to identify the underlying patterns of correlated neural activity.

   Another way is to compute correlation between all pairs of neurons and then filter neurons with respect to SNR and P-Value and finally for each neuron find the neuron which is correlated with it more than others.

   Overall, by leveraging the fact that neurons with similar preferred orientation preferences are highly correlated, we can use techniques such as PCA or ICA to extract the underlying patterns of correlated neural activity and create a color mesh that represent the neural population's orientation preferences.