Advance Neuroscience HW2

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Part 1 - PSTH and Tuning Curves

The data is preprocessed using included script and electrodes with SNR of less than 1.5 and neurons with firing rate of less than 1.0Hz are removed from the dataset.

For each monkey the two most active neurons are found by taking the mean activity over time and the PSTH is plotted for each grating in order to decide what neurons is the most active by inspection. Figures 1, 2 and 3

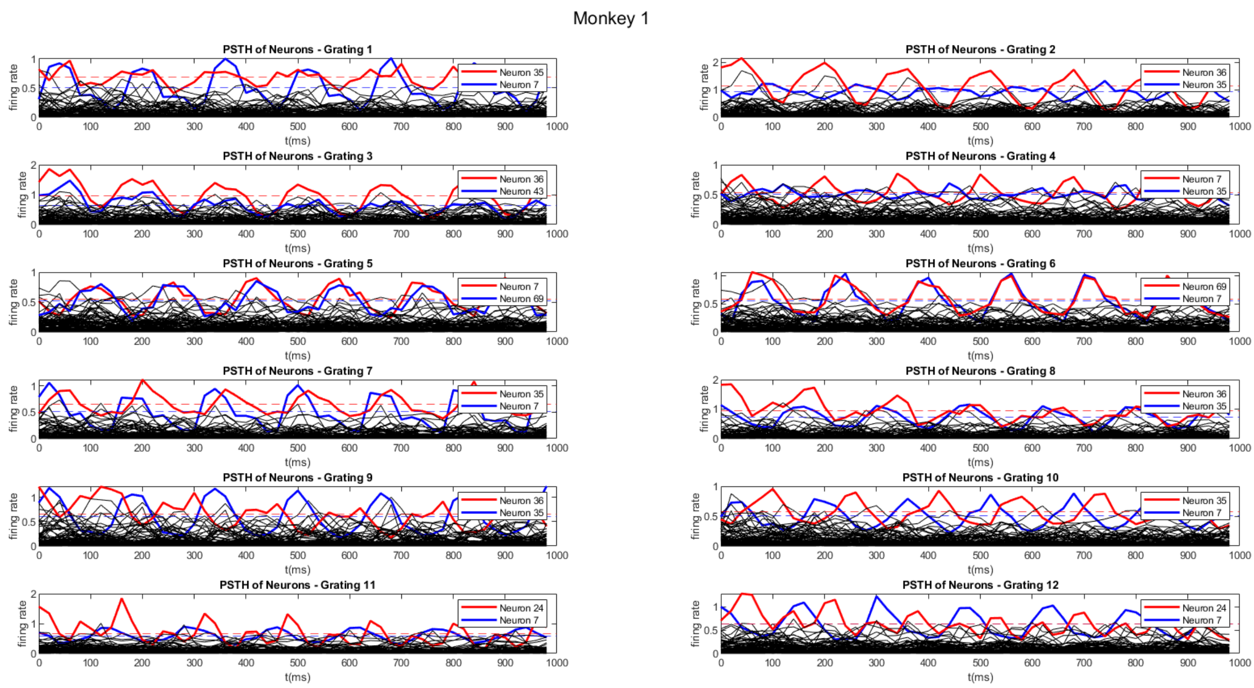

Figure 1: Monkey 1 - PSTH plots of units for each grating. Two most active neurons are chosen by taking the PSTH average over time. The red curve is the first most active neurons and the blue curve is the second most active neuron.

By looking at the figure 1 there are fluctuations in each plot. These fluctuations are as a result of the stimuli. The stimuli are a set of similarly oriented white lines with black lines between and they move in a directions. So as each white line comes in the focus of the monkey the neurons in the area V1 start firing. Later we will see raster plots and the explained dynamic will be understood better. For monkey 1, neuron 35 is chosen as the most active and well behaved neuron.

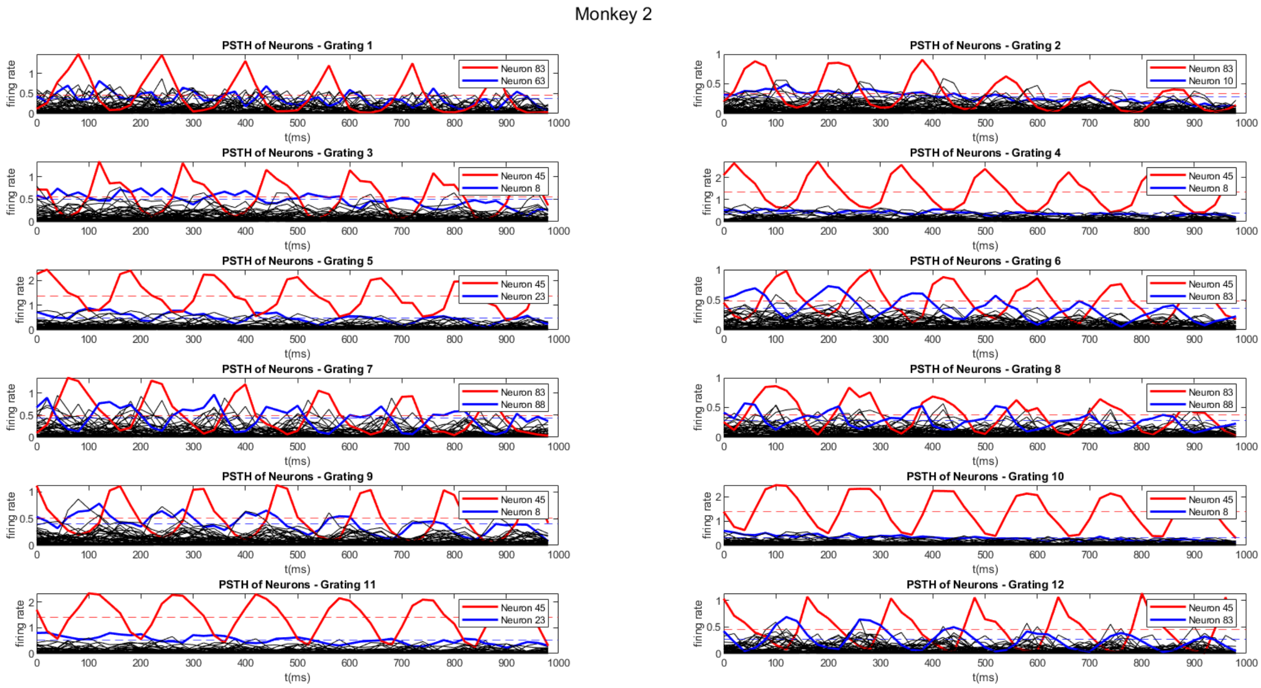

Figure 2: Monkey 2 - PSTH plots of units for each grating. Two most active neurons are chosen by taking the PSTH average over time. The red curve is the first most active neurons and the blue curve is the second most active neuron.

By looking at the activity of neurons in each grating, clearly neuron 45 is most active neuron for monkey 2.

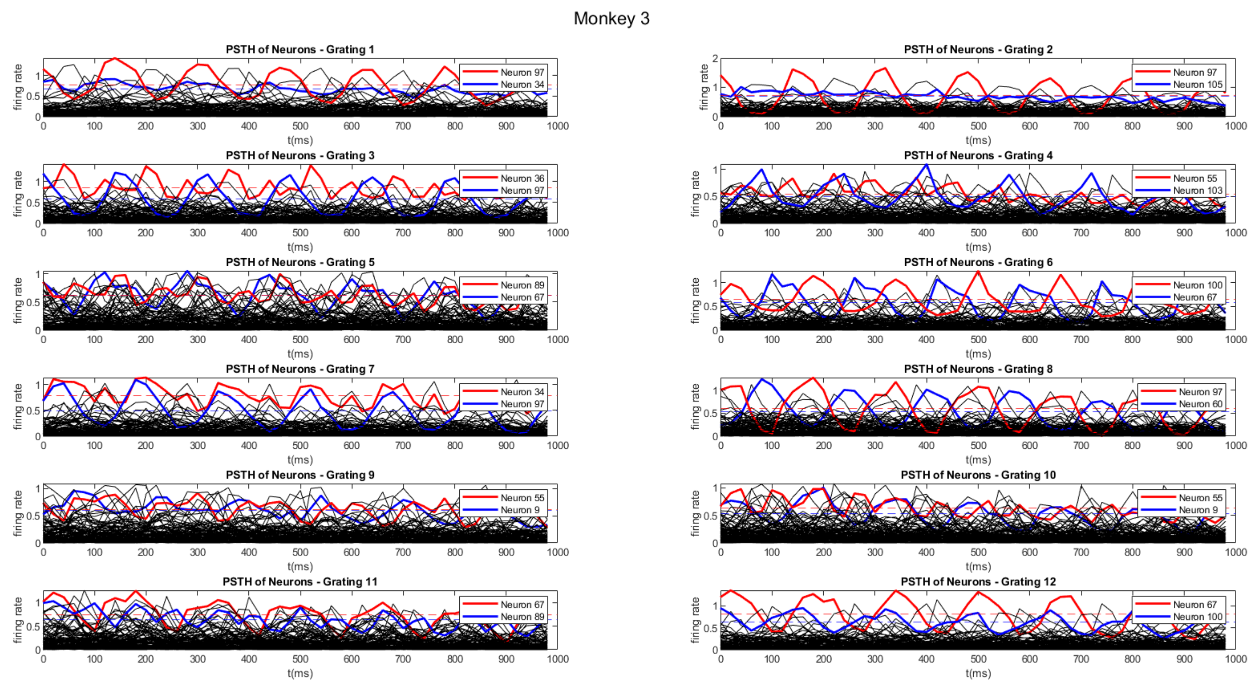

Figure 3: Monkey 3 - PSTH plots of units for each grating. Two most active neurons are chosen by taking the PSTH average over time. The red curve is the first most active neurons and the blue curve is the second most active neuron.

For monkey 3, neuron 97 is chosen as the most active neuron.

Figure 4 shows is the raster plot of neuron 25 of monkey 1 in each grating. grating 2 has the most activity so we can tell that the perferred orientation of neuron 25 is 60 degree.

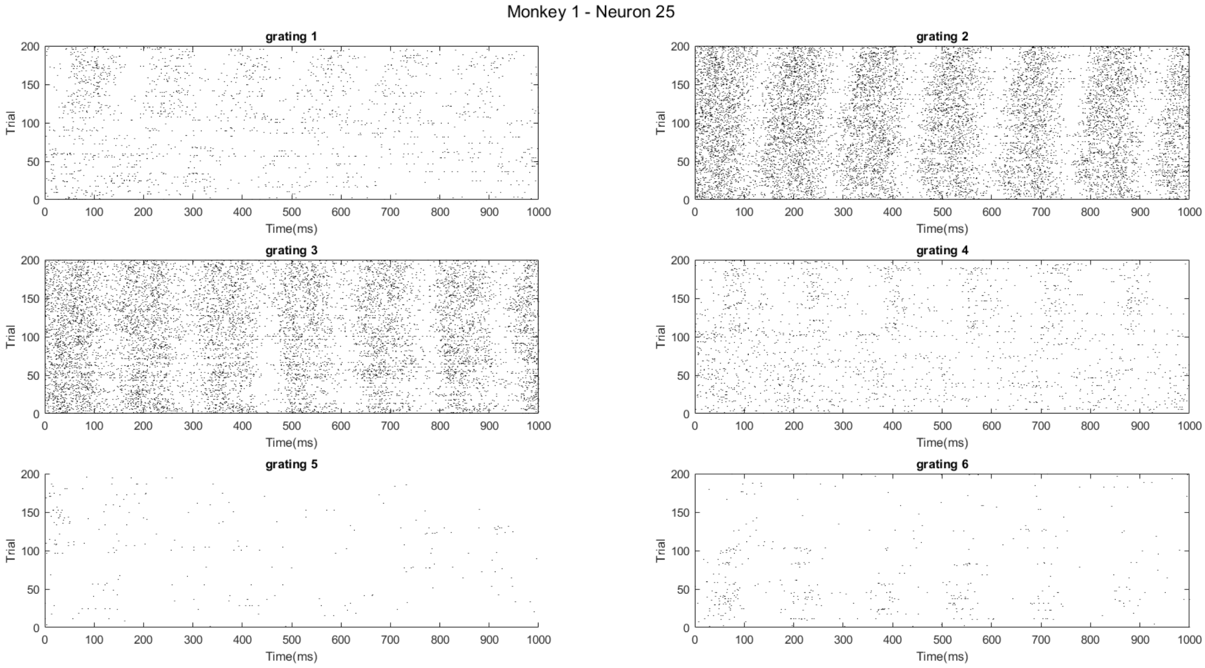

Figure 4: Monkey 1, neuron 25 raster plot. Grating 2 (60 degree) is the preferred stimulus

Figure 5 is the tuning curve of most active neuron in each monkey.

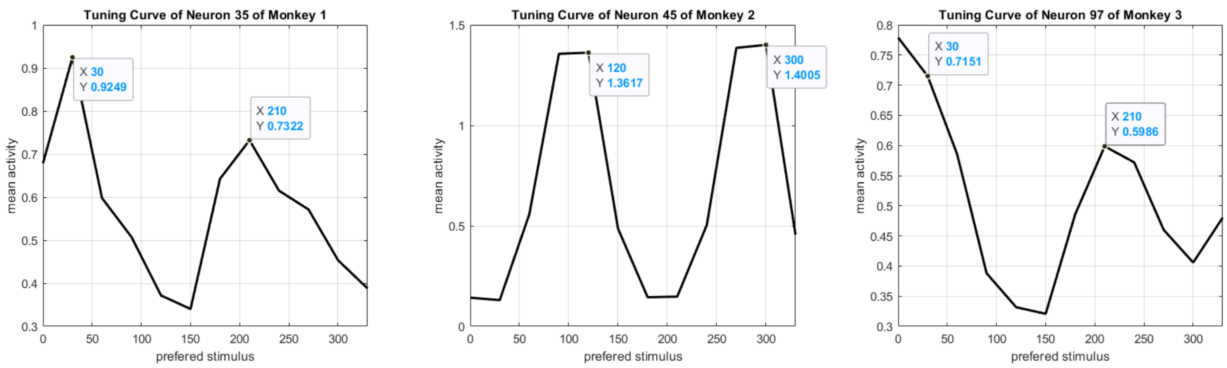

Figure 5: Tuning curve of the most active neuron in each monkey.

In the top figure we can see that we have two peak in the tuning curves. This is because the orientations of gratings are from 0 to 360 degrees and every 180 degree the orientation is repeated. In the left plot, the pereferred orientation is 30 degree or 210 = 180 + 30. Similar thing also happens for other monkeys. But for monkey 3 the first preferred oriention is 0 degree but it could be happening due an error in the begining of the data acquision so we get 30 degree as the preferred orientation.

Part 2 - Area V1 Orientation Preference

For each monkey the preferred orientations of neurons are calculated and displayed as a color matrix. The same colors show the same orientations. Figure 6 shows a found pattern of area V1 [ref: Predicted contextual modulation varies with distance from pinwheel centers in the orientation preference map 2011] that we try to use as a reference to compare with our figure.

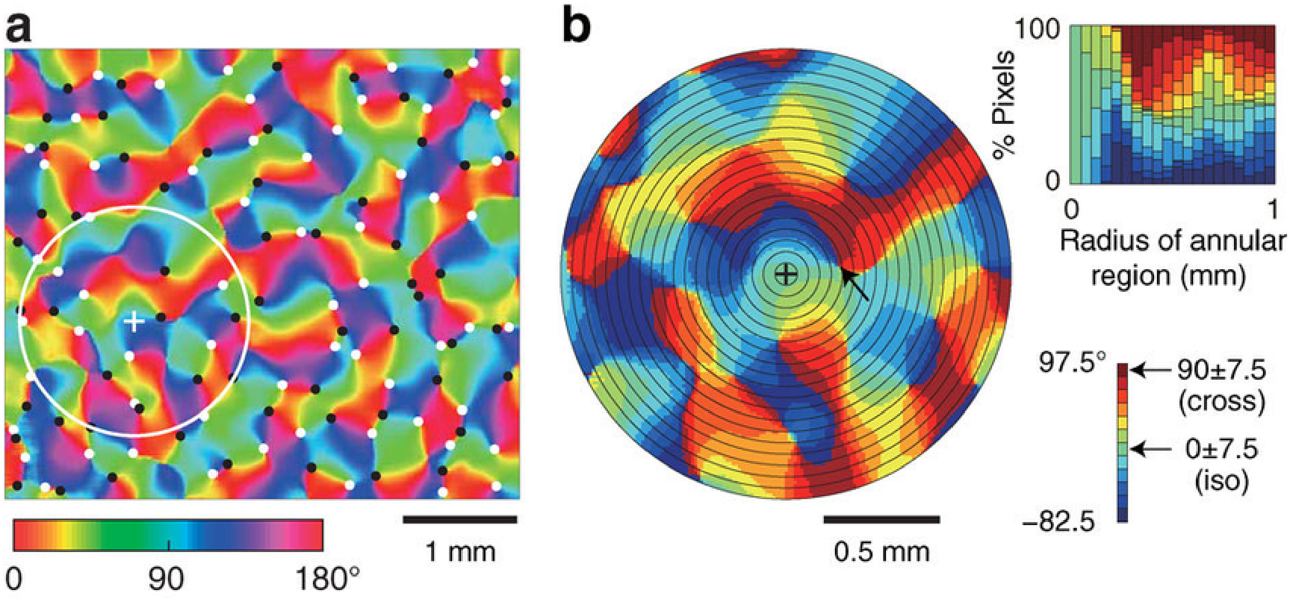

Figure 6: Reference area V1 orientation preference.

Figure 7 is the orientation preference of the area that was recorded from each monkey.

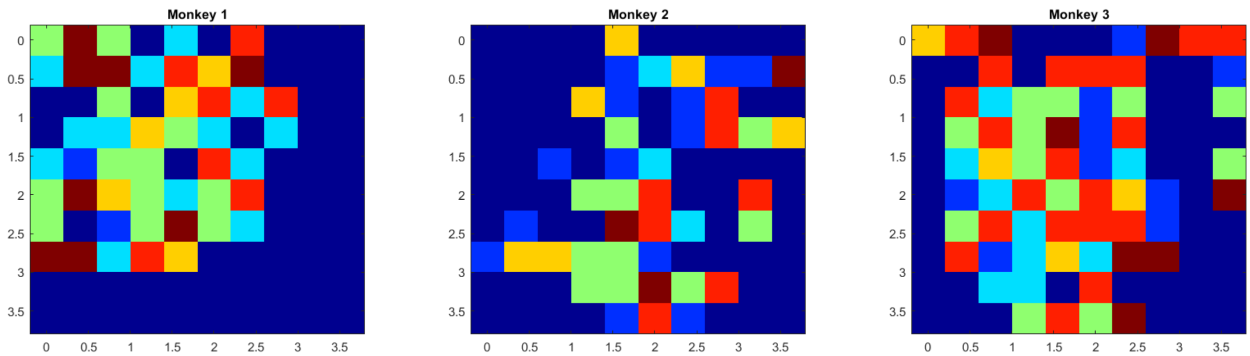

Figure 7: Area V1 orientation preference of monkey 1,2 and 3. Dark blue areas are either bad channels which are removed, or NaN channels that were not included in the data from the begining.

It is worhty to mention that right figure is quite similar to the figure that is brought in the problemset. But actually in this resolution the pinwheel pattern can not be seen properly. If you look at the figure 6, almost every 0.5mm we have a color shift. So we can expect from our low resolution figures to change colors every block. So there will not be any special connected patterns. Yet there are also similar color blocks which are close and they represent the connected color patterns. In order to check the result of removing channels on the figure, we make figure 8 that no bad channel is removed from.

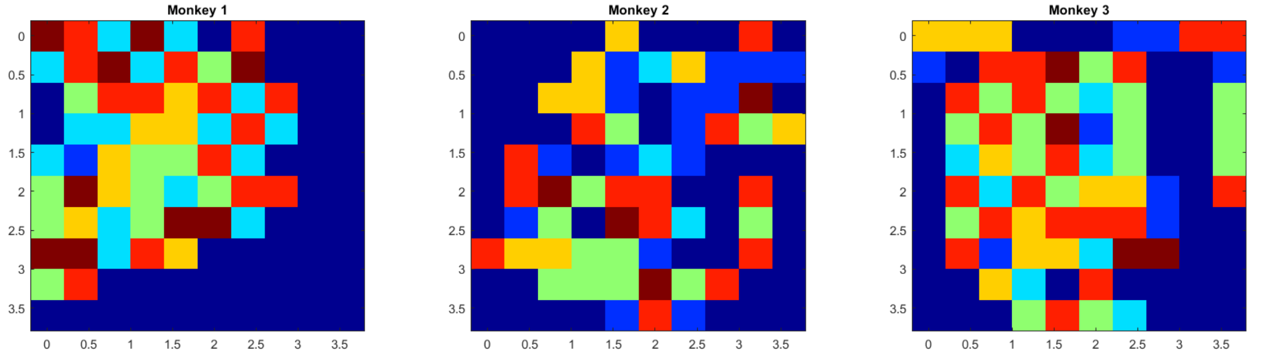

Figure 8: Area V1 orientation preference of monkey 1,2 and 3. Dark blue areas are NaN channels that were not included in the data from the begining. Bad channels are not removed.

Also, we have tried to interpolate the figures to see the color connections in more resolutions. Figure 9 and 10 are the interpolated version of top figures.

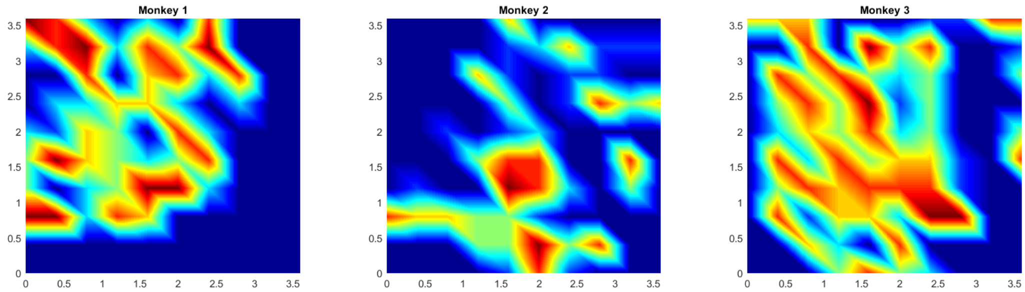

Figure 9: Area V1 orientation preference of monkey 1,2 and 3. Figure is interpolated. Dark blue areas are either bad channels which are removed, or NaN channels that were not included in the data from the begining.

Now we may see more similar patterns to the reference figure 6. But still we can not confidently say a pinwheel pattern is present.

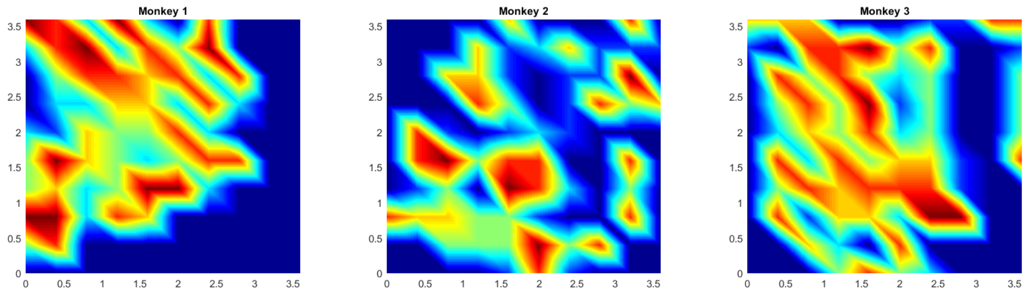

Figure 10: Area V1 orientation preference of monkey 1,2 and 3. Figure is interpolated. Dark blue areas are NaN channels that were not included in the data from the begining. Bad channels are not removed.

Part 3 - Dependence of R_{sc} on Distance for Similarly Oriented Neurons

Figures 11, 12 and 13 are reconstruction of figure 3A of paper. When we have a large tuning curve correlation (gray line) we have realitvely larger noise correlation and when distance increases the noise correlation also reduces. For smaller tuning curve correlations (red, blue and green lines), same thing happens but the noise correlations are significantly smaller.

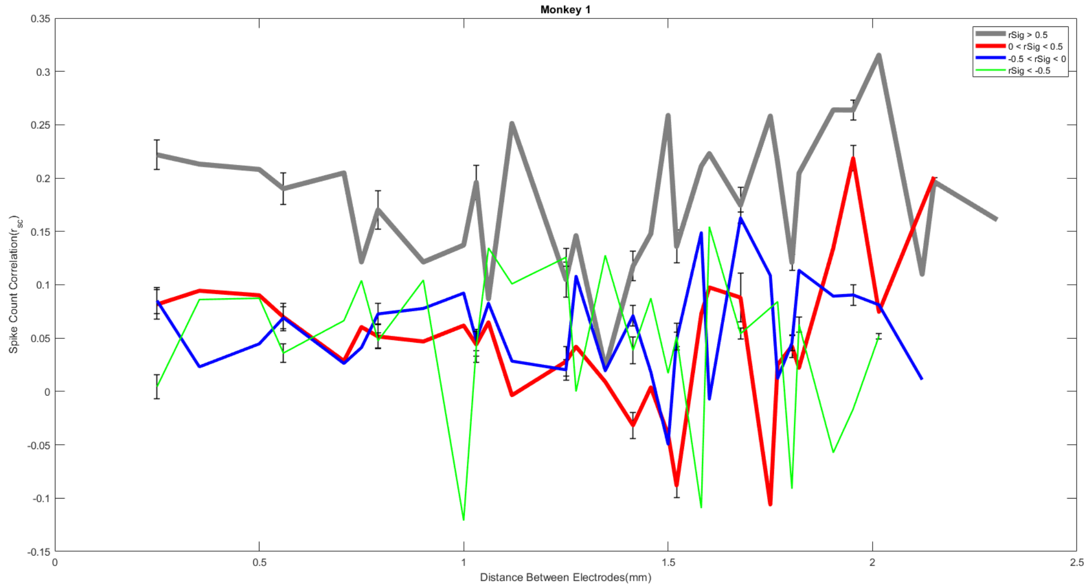

Figure 11: Monkey 1 - Noise correlation vs electrode distances for similar groups of neurons based on preferred stimuli.

Unlike the paper, here in figure 11 and 12 noise correlation slightly rises at the larger distances. But the average push of the curve is reducing.

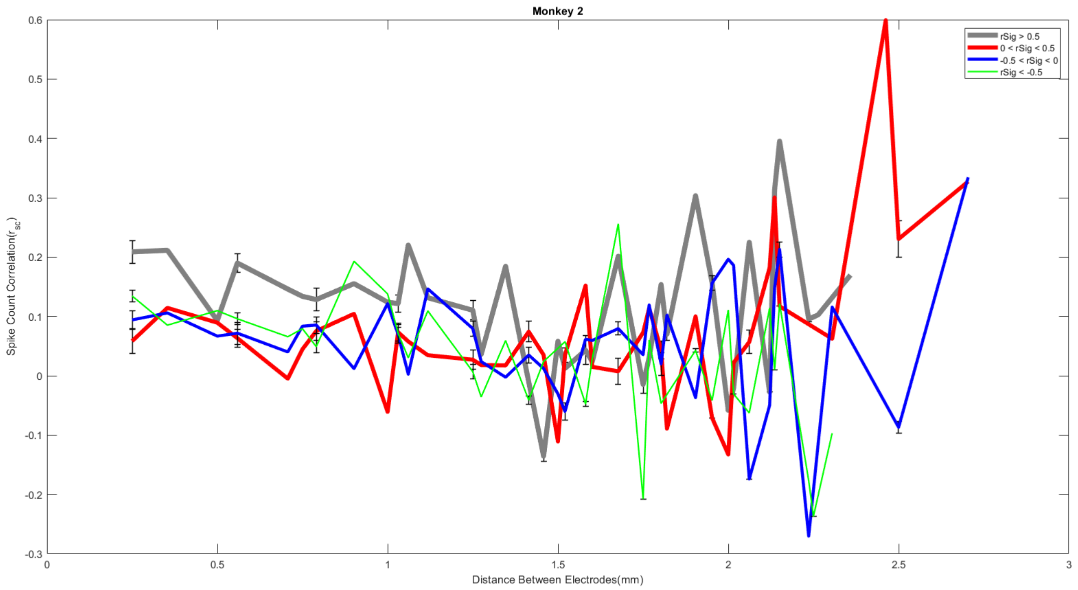

Figure 12: Monkey 2 - Noise correlation vs electrode distances for similar groups of neurons based on preferred stimuli.

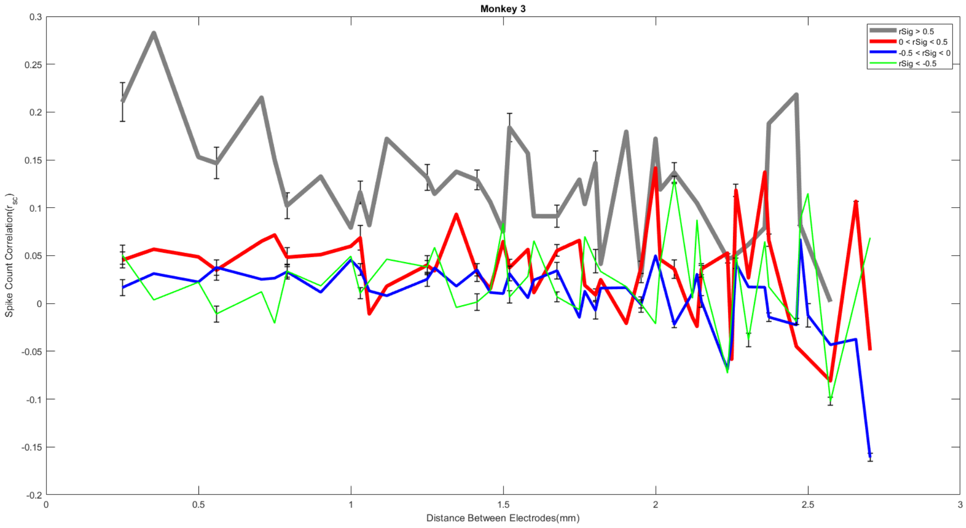

Figure 13: Monkey 3 - Noise correlation vs electrode distances for similar groups of neurons based on preferred stimuli.

Best figure to see the explained properties is the figure 13 which is for monkey 3. Figure 14 is brought here to show the reducing property of noise correlation more clearly.

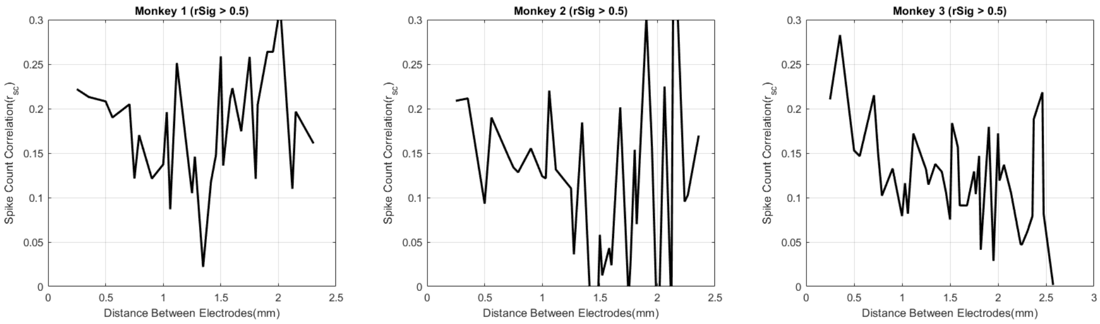

Figure 14: Noise correlation vs electrode distances for groups of neuron with a tuning curve correlation of more than 0.5.

Figure 15, 16 and 17 are the reconstruction of figure 3B of the paper.

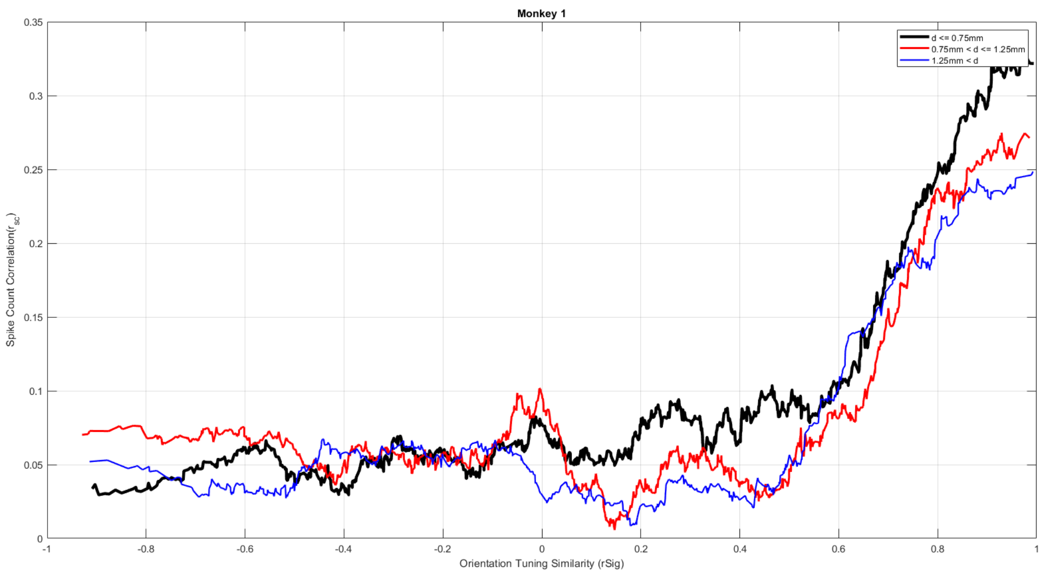

Figure 15: Monkey 1 - Noise correlation vs orientaion tuning similarity for different distances.

Notice that the distaces are different from the distances in paper because there was a lot of removed or NaN channels in the dataset. But the concept of the figures are the same. We can see that when rSig is small the noise correlation is small for all the distances. But as rSig becomes larger the noise correlation also rises in a manner that smaller distances have more correlations in the end.

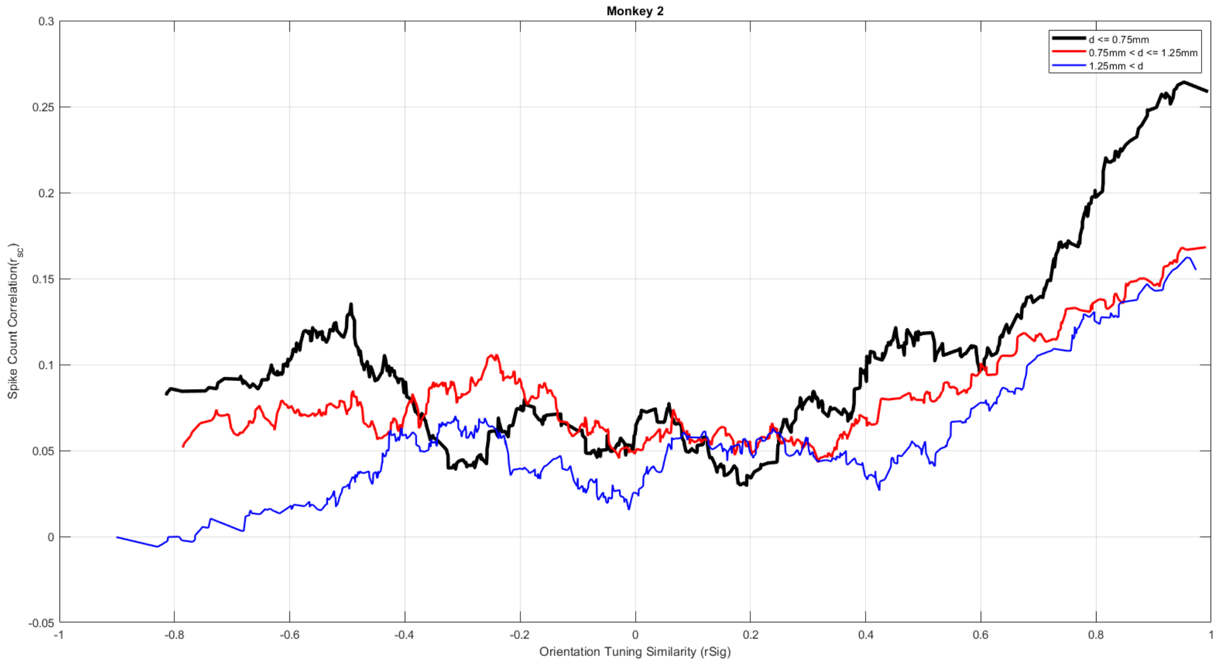

Figure 16: Monkey 2 - Noise correlation vs orientaion tuning similarity for different distances.

Same thing can be seem in figure 16 and 17. Specially the case that smaller distances have larger noise correlations.

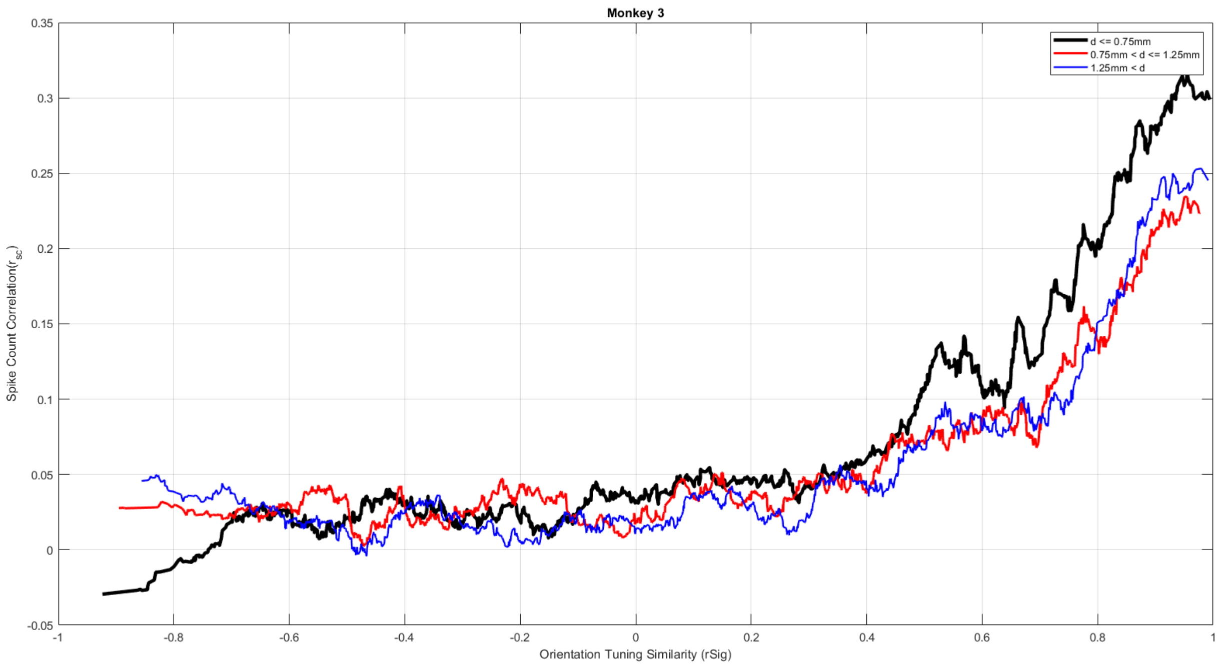

Figure 17: Monkey 3 - Noise correlation vs orientaion tuning similarity for different distances.

Figure 18 is the reconstruction of figure 3C of the paper. As was expected from the figure, it is also similar to the one in the paper. If we move from the top left of the plot to the other side of the diagonal, noise correlation decreaes. It means that as the distance rises and rSig becomes smaller, the noise correlation decreases.

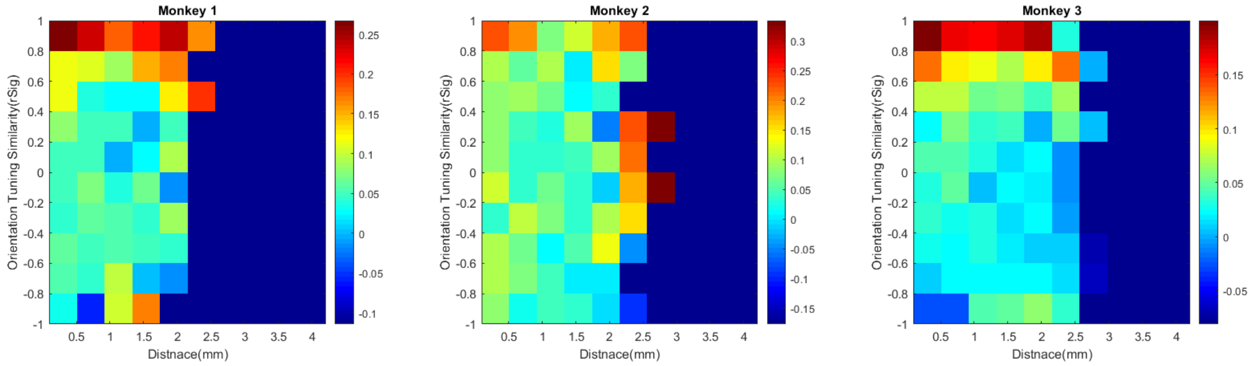

Figure 18: Noise correlation with respect to ditance between electrodes and orientation tuning.

Part 4 - Noise Correlation Reuction at Stimulus Onset

As explained in the discussion part of Kohn and Smith 2008, the correlation could be physiologically because of the feedback neurons in upper layer. This means that downstream neuron may have a role in the noise correlation. So one may suggest that when there is not a stimulus and a gray window is being shown to the monkey, the feedback signals to all the neurons could be more similar because the activity of the similar neurons is more similar. Furthermore, when a specific stimulus is being shown to the monkey, the feedback signals could be more different than before because now each neuron act differently from other neurons so the specific feedback could be different for each neuron.

Also as shown in Churchland Cunningham 2010, the variability of responses between trials of a neuron decreases significantly after the stimuli onset. So imagine before there is an stimulus, there is a noise correlation between trials of different neurons. In other words, neurons responses are variable in different trials of recording neural respones. After the stimuli onset the variability of responses on trials significantly reduces. If we imagine a phase-plane for these responses, the response of each neuron moves to one of the points of the phase-plane. And in different trials, the response fluctuates around the mentioned point. So a criteria could be that the noise between the trials of neuron will be reduced or in another word, it will change its behavior to some specific direction. As a conclusion, noise correlation between the trials of a neuron may now decrease significantly. Yet it will not become zero because there are still inputs like the feedback signals that come from other layers and they have correlations.