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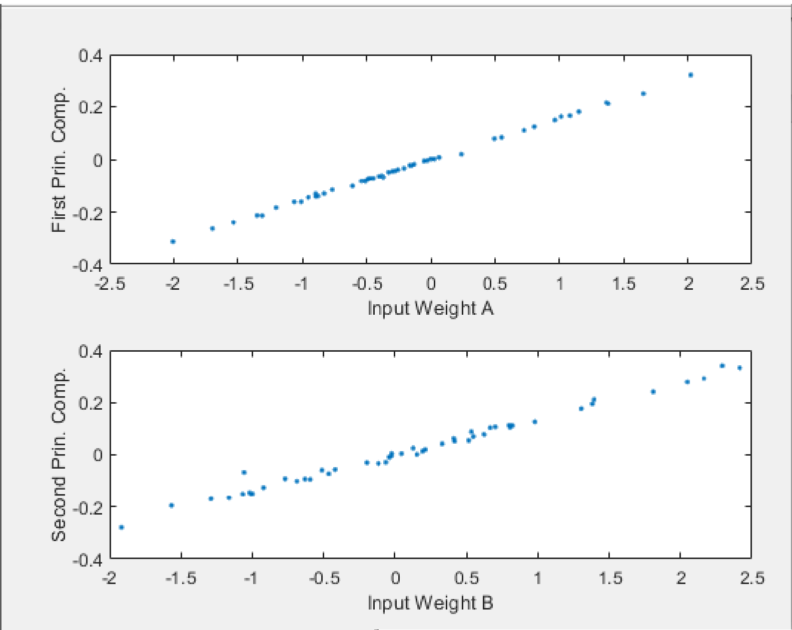
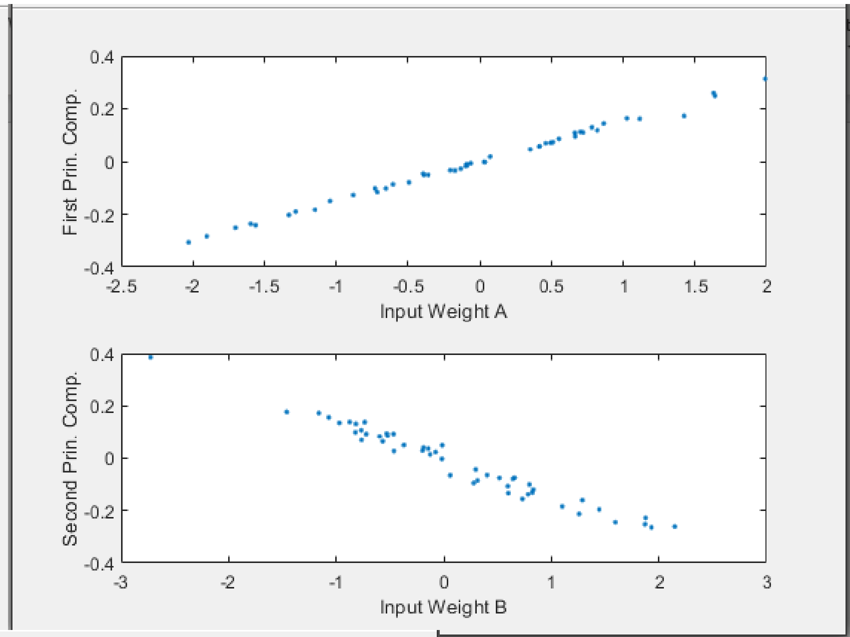
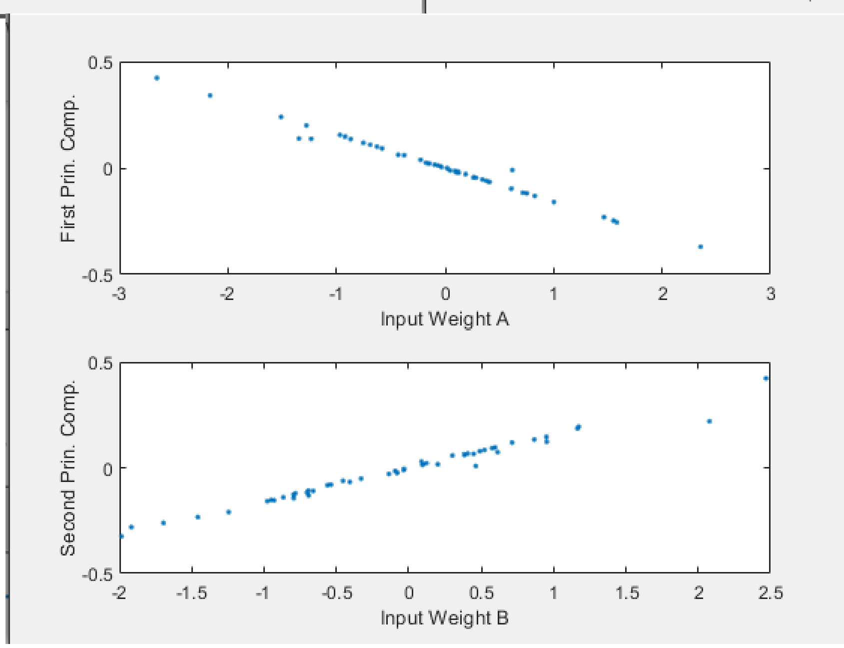
Tutorial 9.1

d.)

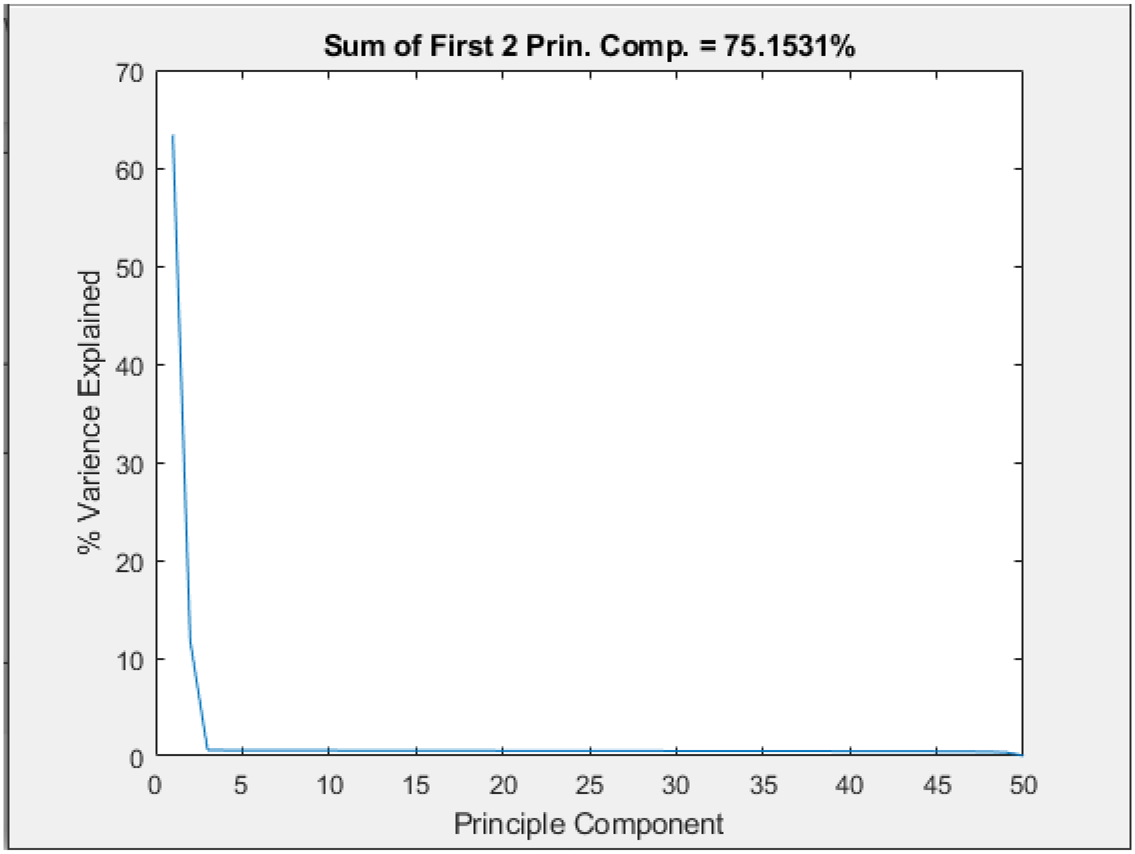






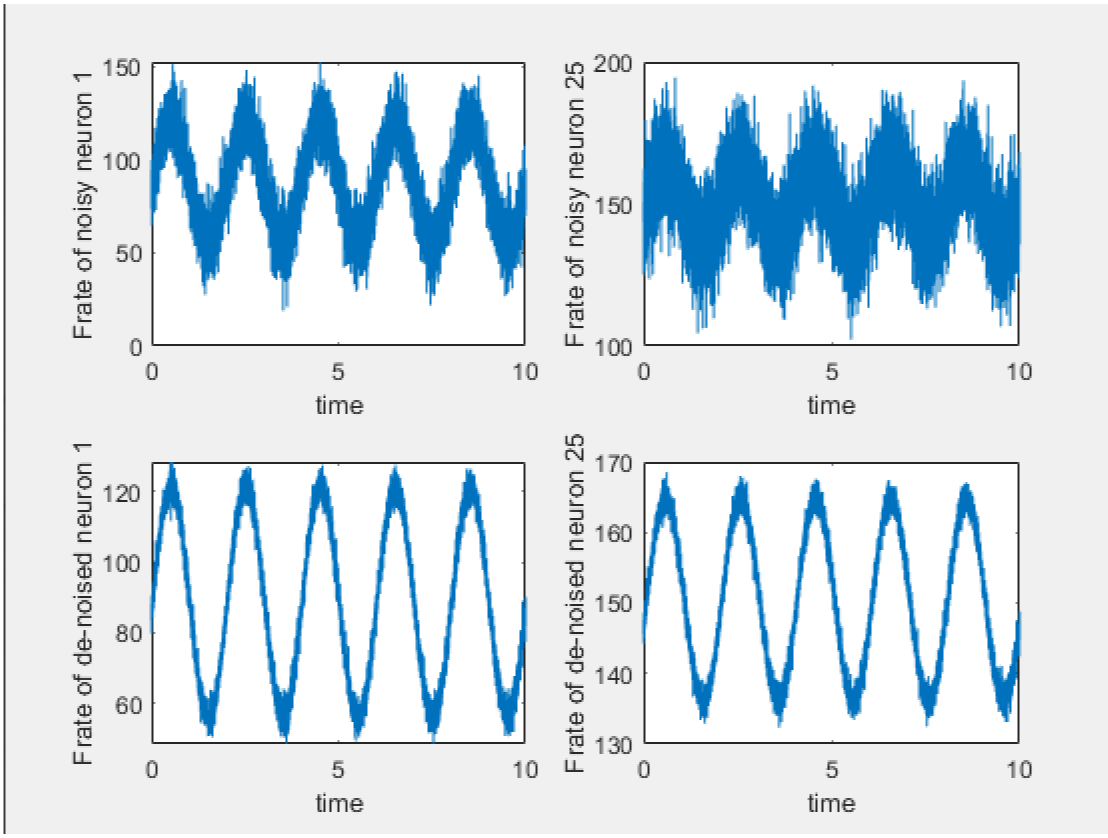
Above are 3 separate results from the same simulation/code, showing the contribution of each neuron to the first principal component according to the input weight A, and the contribution of each neuron to the second principal component according to input weight B. The sign of the slope is irrelevant (as implied by the differing slopes in the three figures), rather the important information lies in the steepness(absolute value) and existence of the slope.

e.)



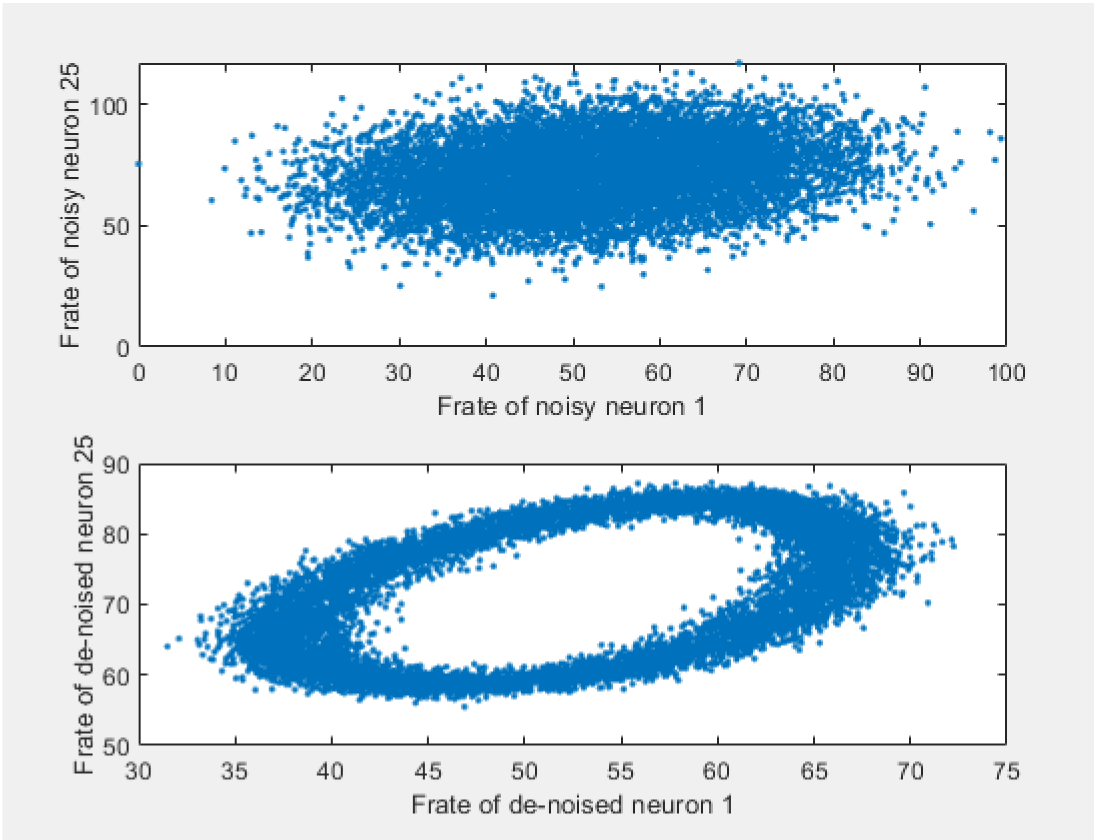
The first principal component explains the vast majority of variance in the system. The second principal component is responsible for considerably less variance, but still significantly more than the rest of the 50 components as part of the system. Because of the random component to the simulation, the sum of the variance explained by the first 2 principal components varies between runs, but is usually very close to 75% and is always considerably above half of the variance. This implies that the data can be simplified to 2 dimensions without sacrificing too too much information.

g.)



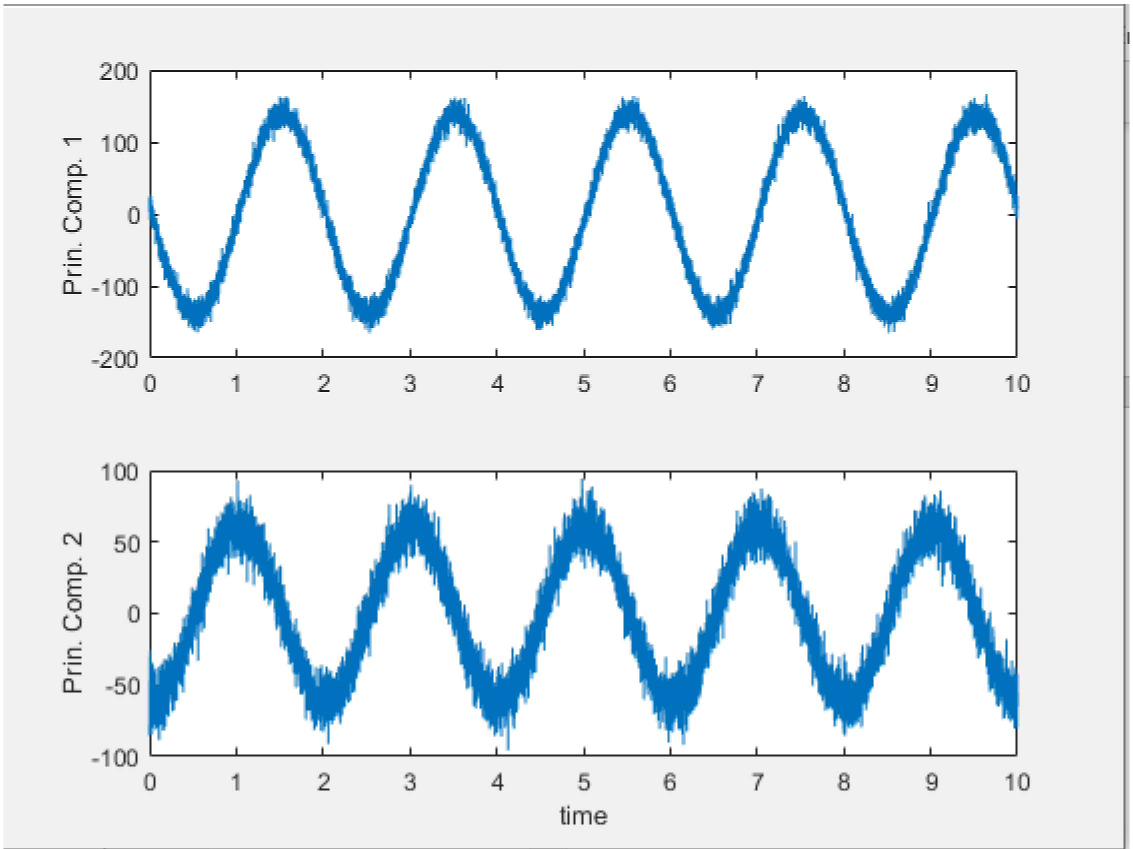
Denoised data (firing rates recreated by projecting each neurons firing rate onto the first two principal components) heavily resembles original data in the simulation. Neurons indexed 1 and 25 were selected, but the dynamic where denoised figures heavily resemble their original counterparts is consistent with all 50 neurons tested. The high level of similarity between the figures implies that the first 2 principal components are in fact sufficient to describe activity, at least on the order of phenomenality. Firing rates follow oscillations because of the time dependent oscillating inputs.

h.)



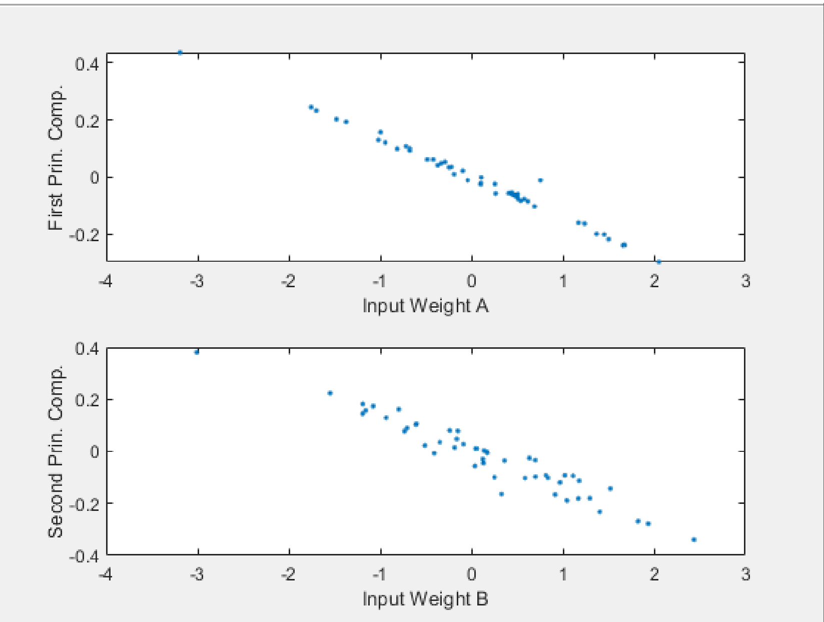
In the original data, there does not seem to be any sort of relationship between the firing rate of the two neurons analyzed, which is to be expected given that they do not rely or depend on one another. In the case where all but the first 2 principal components are omitted however, a very clear pattern emerges. This is likely because of the regularly fluctuating inputs that are given to each of the cells given by sin and cos functions are time dependent, not cell dependent, meaning both cells analyzed are being given 2 oscillating inputs heavily impacting their firing rate, the impact being dramatized in the lower of the two images above.

i.)

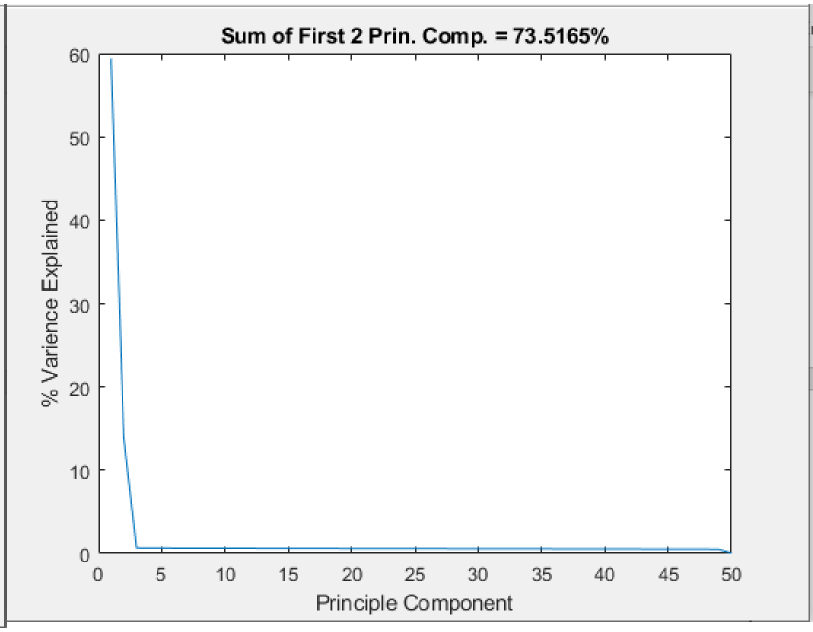


Principle component 1 and 2 bear heavy resemblance to the time dependent oscillating inputs we defined to be given to each cell (sin and cos functions respectively). Given that IA had twice the amplitude as IB, it makes sense that it had a larger impact on each cell and would therefore be the first principal component. It also makes intuitive sense that the first principal component be more streamlined so to speak with time, given that its impact is heavier and therefore relationship more concrete with firing rate.

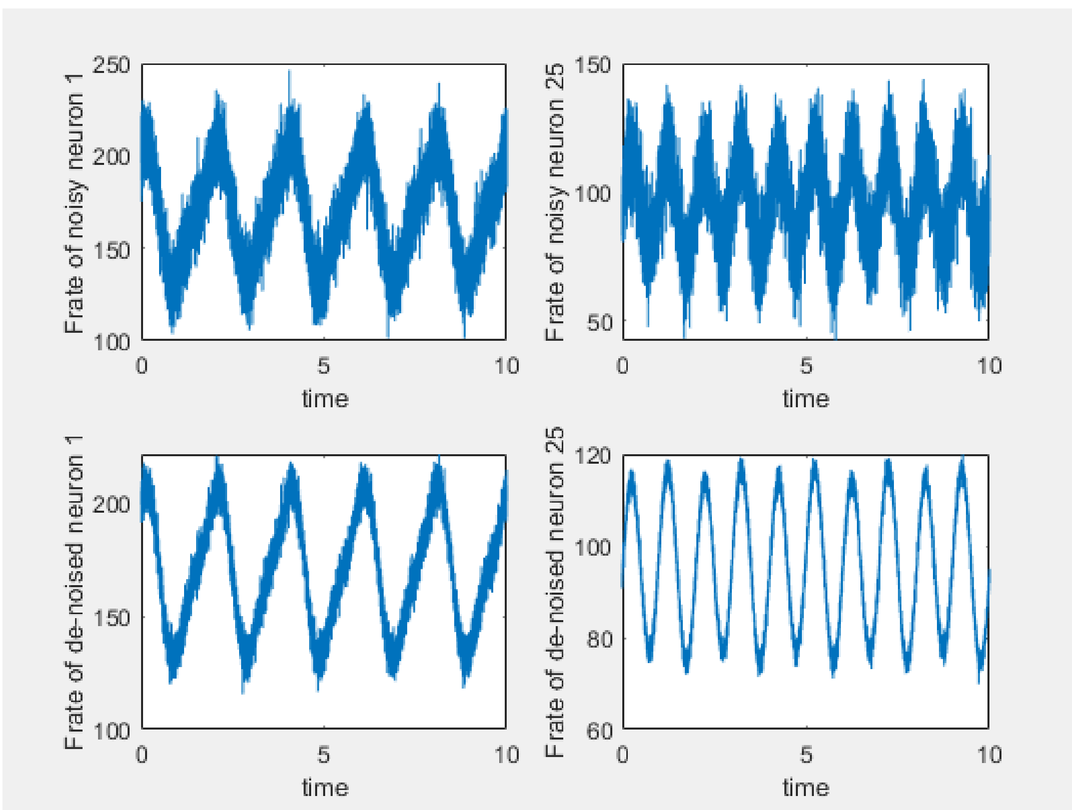
2.)



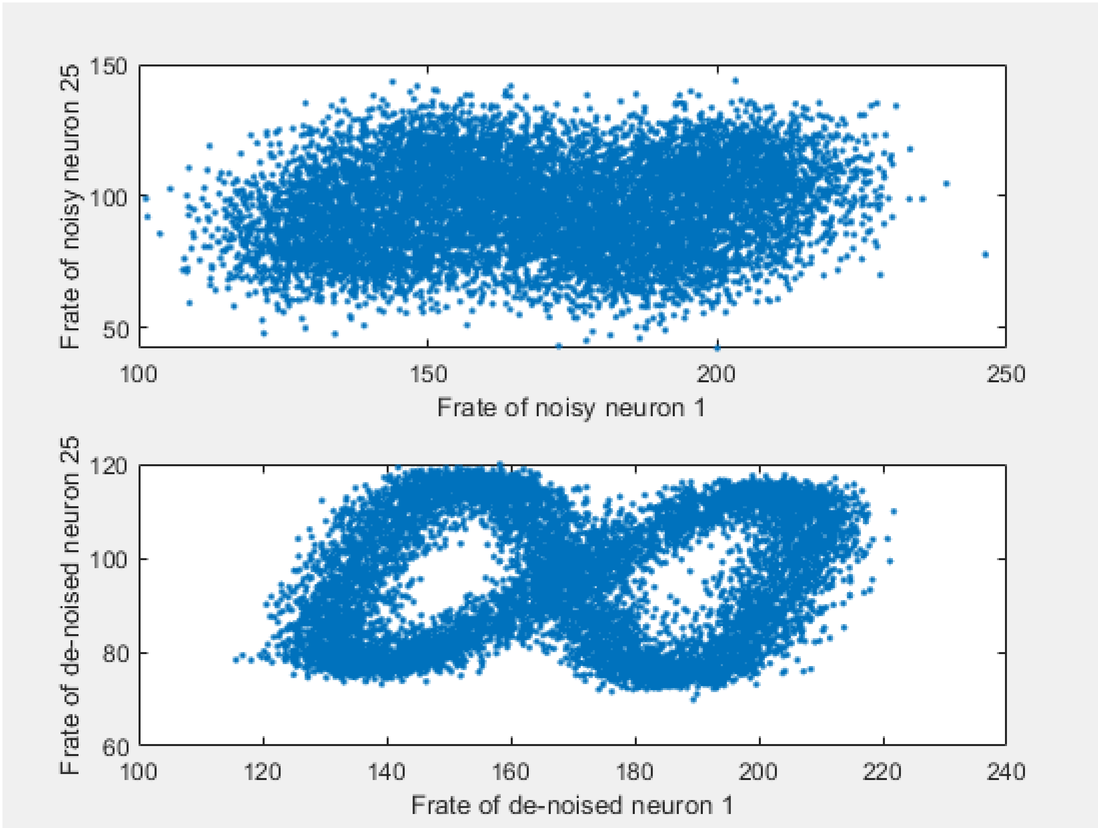
First Prin. Comp.
Input Weight A
Second Prin. Comp.
Input Weight B

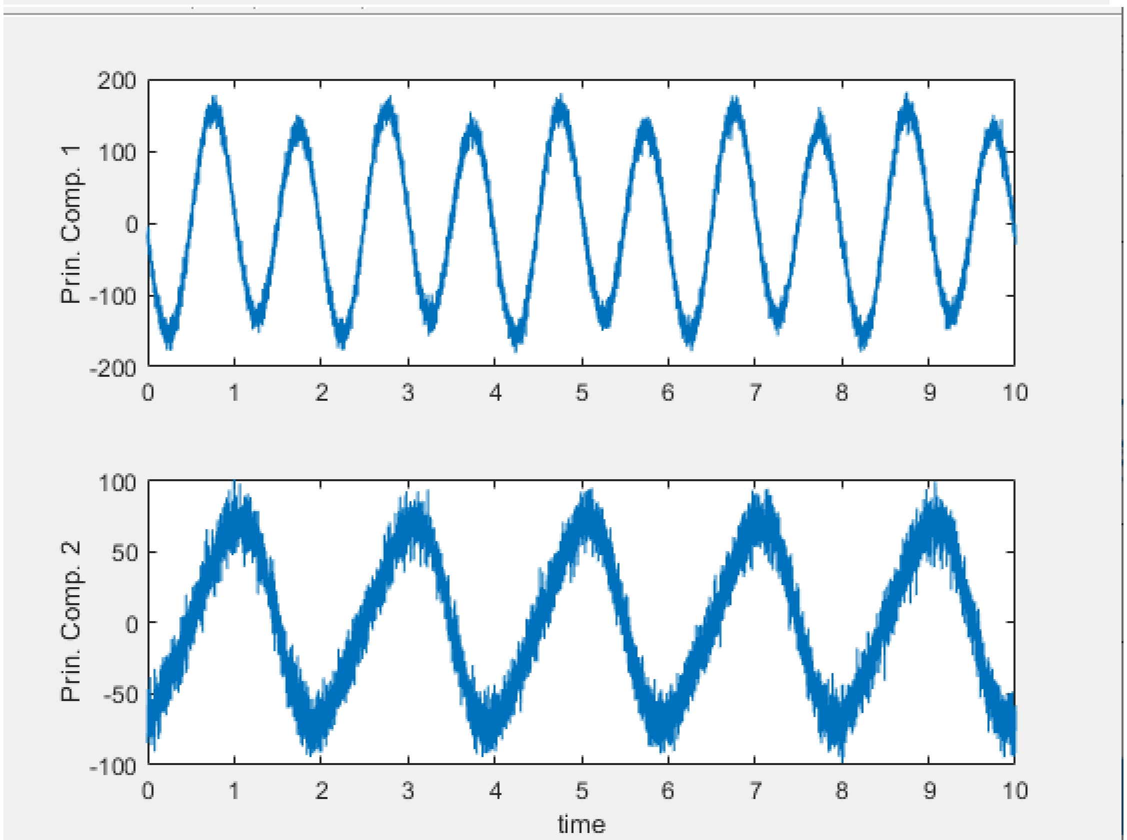


Sum of First 2 Prin. Comp. = 73.5165%
% Varience Explained
Principle Component



Frate of noisy neuron 1
Frate of noisy neuron 25
Frate of de-noised neuron 1
Frate of de-noised neuron 25
time


Frate of noisy neuron 25
150
100
50
100
150
200
250
Frate of noisy neuron 1
Frate of de-noised neuron 25
120
100
80
60
100
120
140
160
180
200
220
240
Frate of de-noised neuron 1


Prin. Comp. 1
200
100
0
-100
-200
0
1
2
3
4
5
6
7
8
9
10
Prin. Comp. 2
100
50
0
-50
-100
0
1
2
3
4
5
6
7
8
9
10
time

2d.) sign of the slopes still doesn't matter, and trends are still easily observable

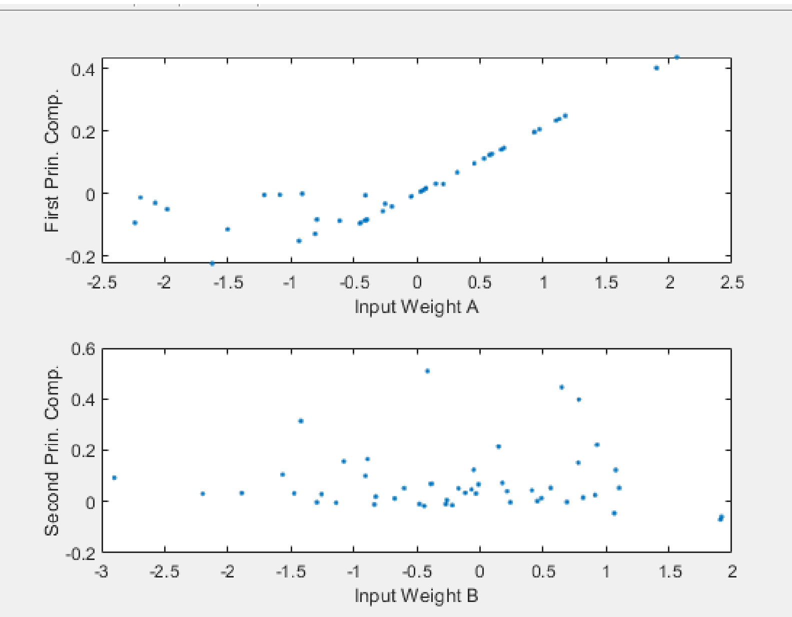
2e.) Results are very comparable to part 1, nearly identical percent range of sum of first 2 components.

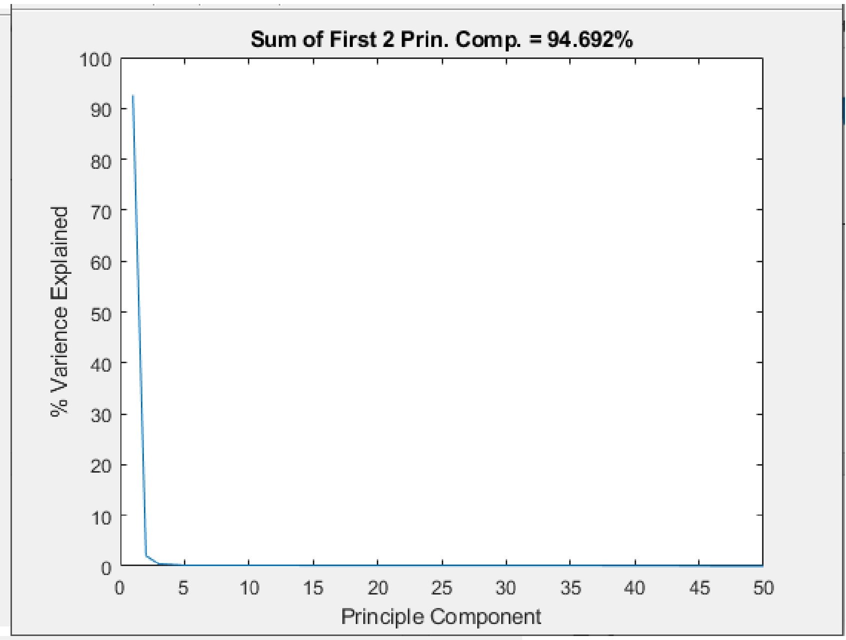
2g.) Frequency of oscilation in firing rates has increased when compared to question 1 (as to be expected given that the only real difference in parameters is the IA's sin function has a greater frequency). In each case denoised activity still heavily mimics the original counterpart, providing further evidence that 2 dimensions is sufficient to describe the activity observed.

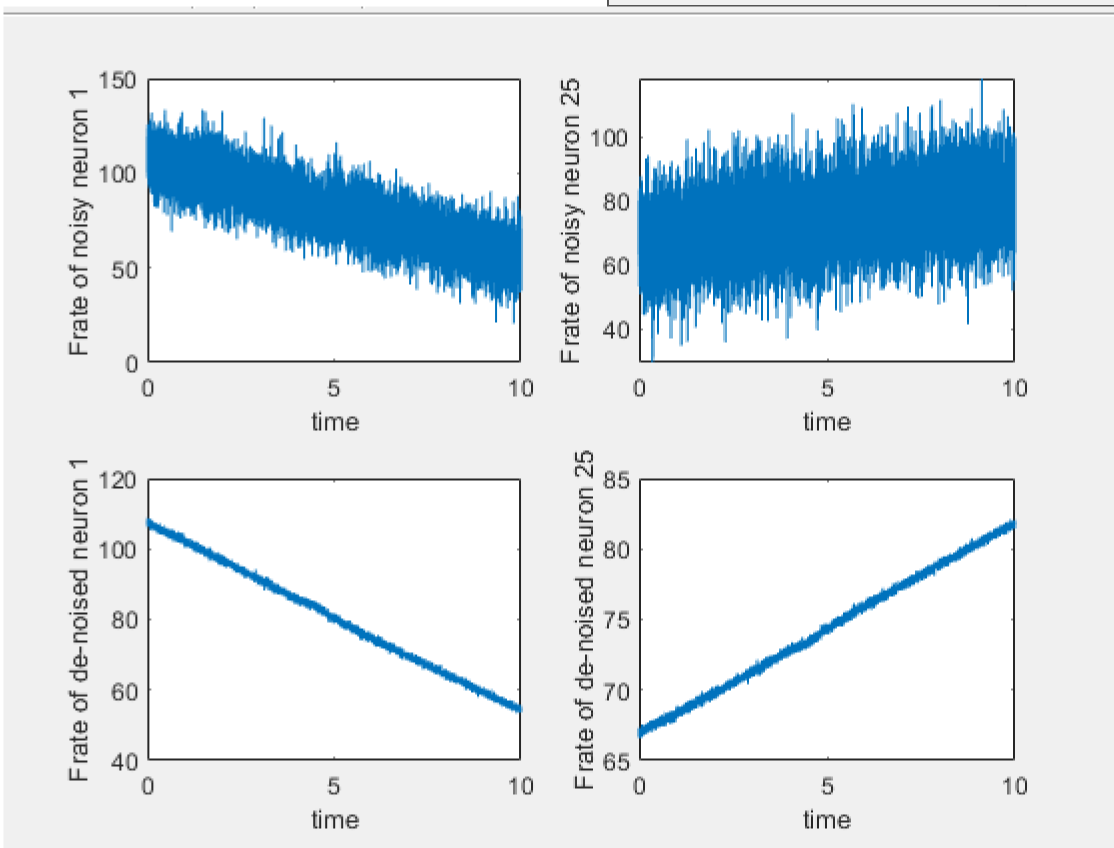
2h.) In question 1 we saw a single "loop" in the denoised data signifying the fact that any given firing rate was being caused primarily by the combination of 2 oscillating inputs, and because they were oscillating at the same frequency, their combined input also oscillated regularly. However, in the case where one of the inputs (and therefore the principal component associated with it) oscillates at double the frequency of the other, there are in fact 2 possible combinations of combined output for any 1 value of the slower oscillating input, save for a section of overlap.

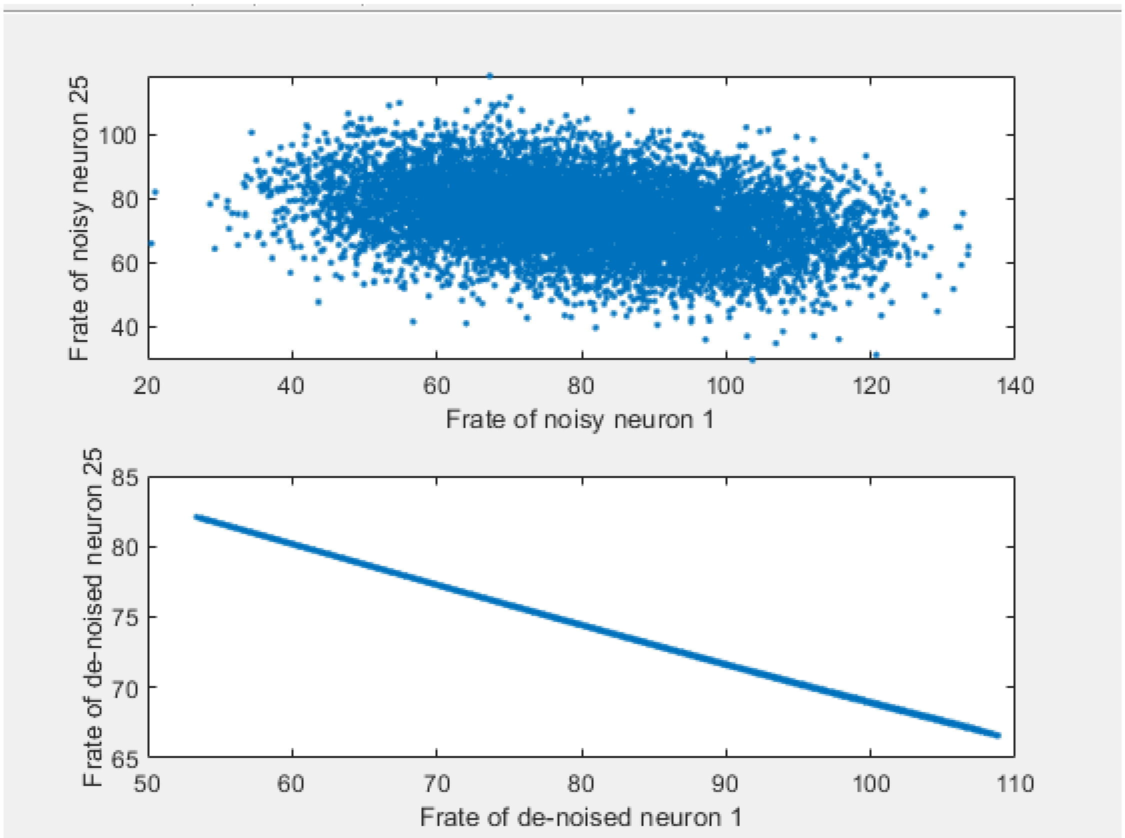
2i.) As elluded to in the prior answer, prin comp. 1 still is associated with the input function IA and prin comp 2 is still associated with IB, as evidenced by the fact that both still oscilate as a sin or cos function does, and principal component 1 is oscilating at roughly twice the frequency.

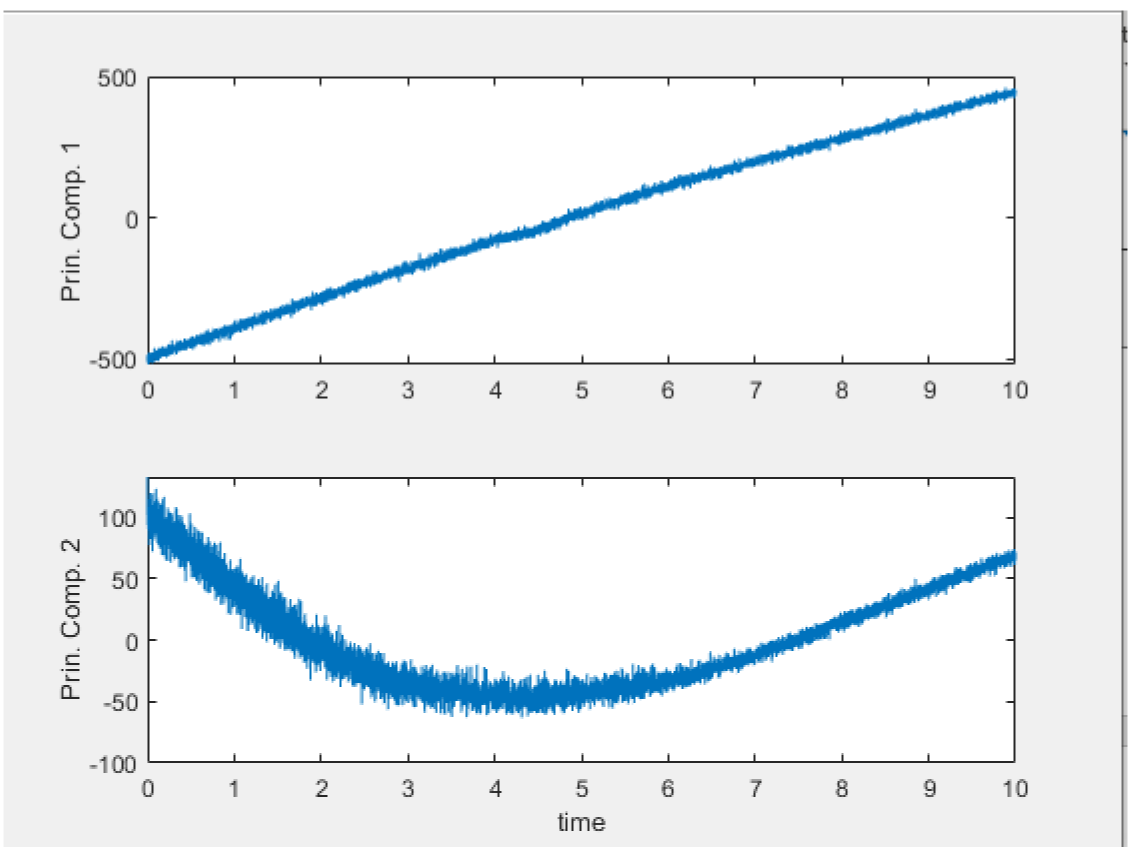
3.)


First Prin. Comp.
Input Weight A
Second Prin. Comp.
Input Weight B


Sum of First 2 Prin. Comp. = 94.692%
% Varience Explained
Principle Component


Frate of noisy neuron 1
time
Frate of noisy neuron 25
time
Frate of de-noised neuron 1
time
Frate of de-noised neuron 25
time


Frate of noisy neuron 25
Frate of noisy neuron 1
Frate of de-noised neuron 25
Frate of de-noised neuron 1


Prin. Comp. 1
Prin. Comp. 2
time

3d.) sign of the slopes still doesn't matter, but the "trend" in the second principal component has all but disappeared, implying that the first principal component is responsible for the vast majority of the data.

3e.) The sum of variance explained by the first two principal compoents is significantly larger than previously, (mid 90s % usually) but this is almost ALL due to the first principal component, which makes sense seeing how IB is likely correlated with the second principal compoenent, and has a value of 0 for the most part save for a spike upward between 4 and 5s that resembles the upward portion of a sinwave.

3g.) Oscillating pattern has disappeared, favoring instead a more "linear" relationship. This makes intuitive sense, because if firing rates are nearly entirely dependent on IA (as many of the figures indicate) and IA is a linear time dependent function, then firing rates will naturally folow a static linear pattern

3h.) Whereas before we saw different "loop" like relationships when plotting our denoised neurons against one another, here we see a straight line, signifying that our summed inputs/principal components are in fact not oscillating but are instead moving consistently in one direction. Given that the first principal compoenent is responsible for graeter than 90% of the explained variance, we can all but ignore the "pulse" of input provided from IB.

3i.) As elluded to in the prior answer, prin comp. 1 still is associated with the input function IA, which explains its gradual linear incline with time, as that is precisely what the input is doing. Principal compoennt 2 though is somewhat less clear, and given that there seems to be no purterbation in most figures that I produce between 4 and 5s, I am inclined to believe that it is either associted with another term in the firing rate equation, or its impacts are generally insiginicant enough to produce a proper figure when visualized graphically (more likely the former or I am missing something).