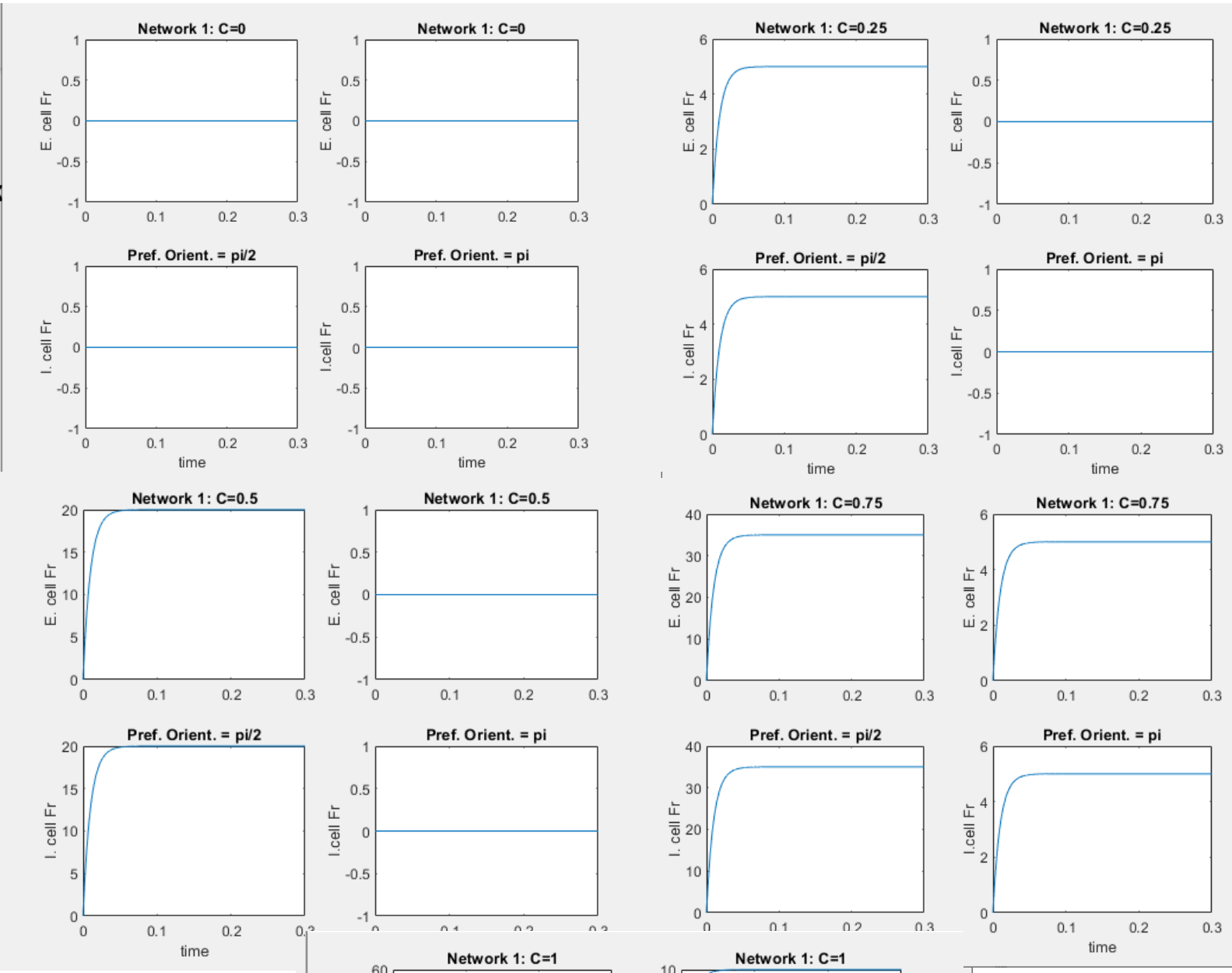
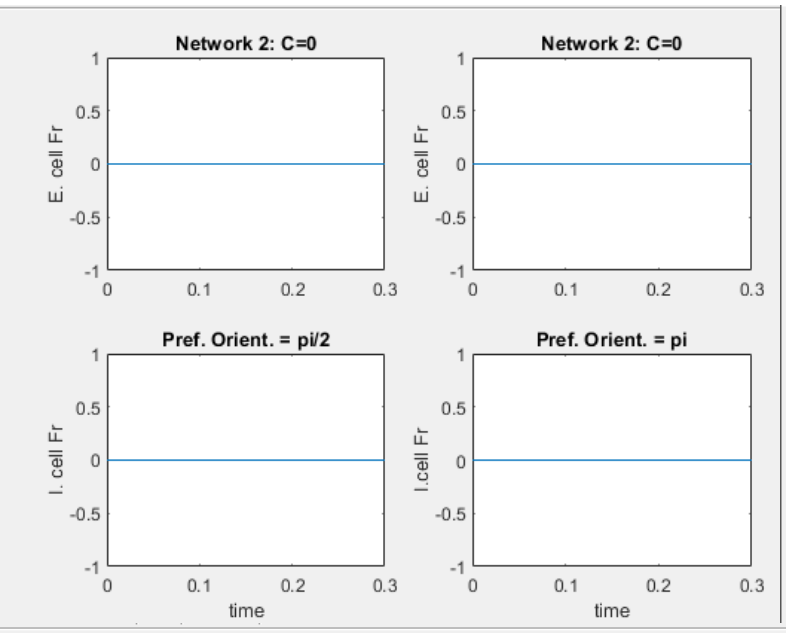
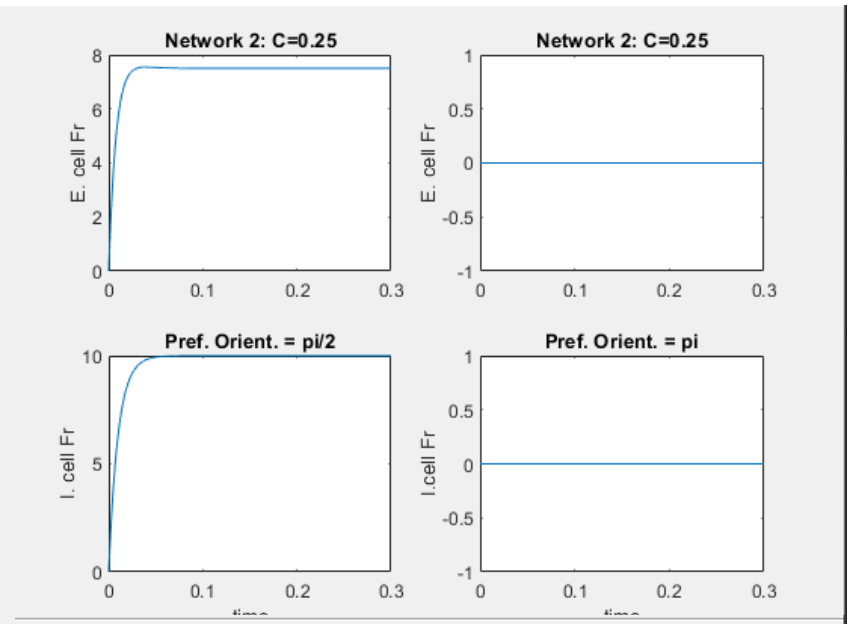
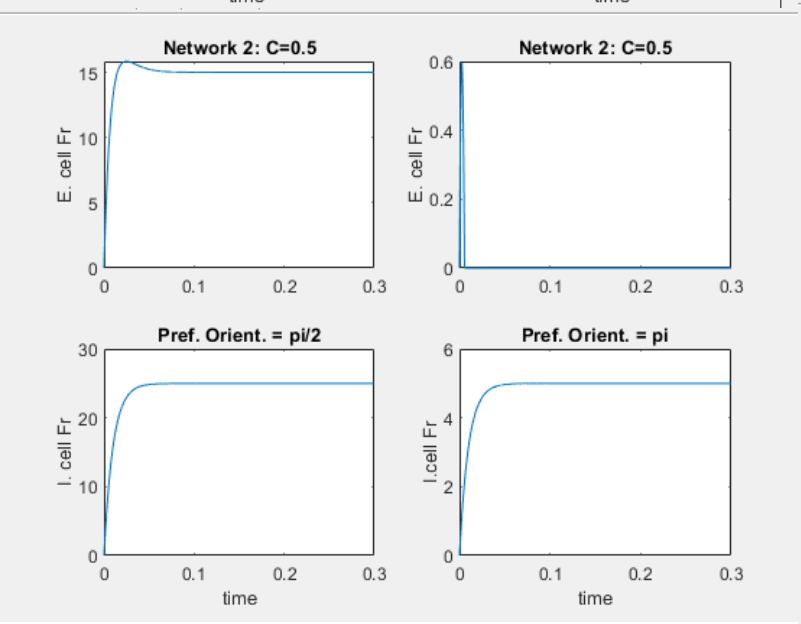
Connor Zawacki

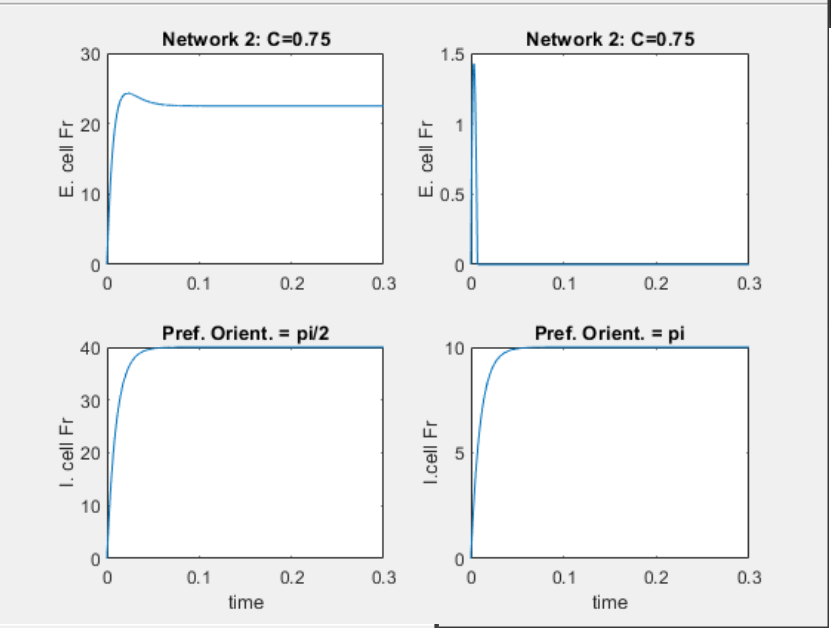
Tutorial 6.42.) NOTE: network 1 = network A, 2=B, 3=C

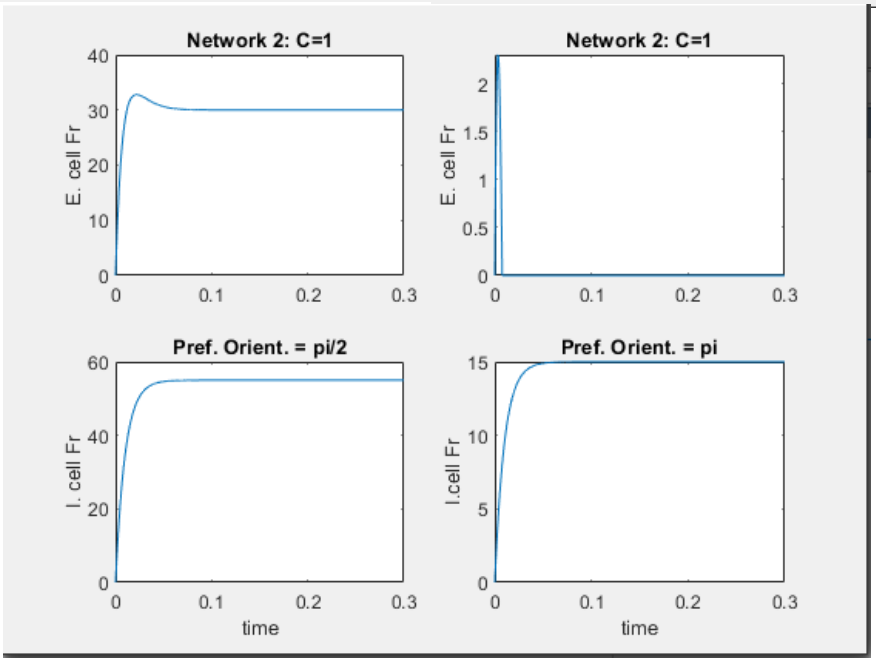


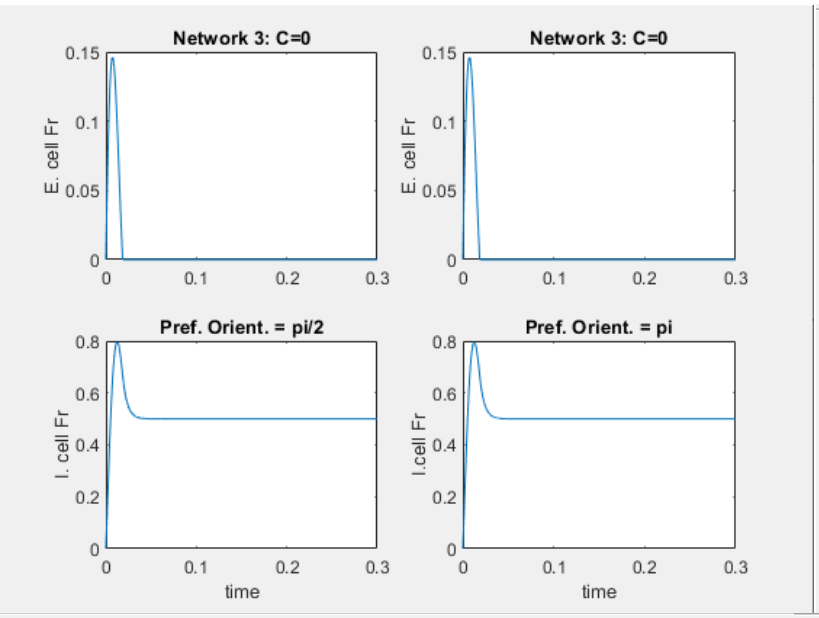

Network 2: C=0
E. cell Fr
Network 2: C=0
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time

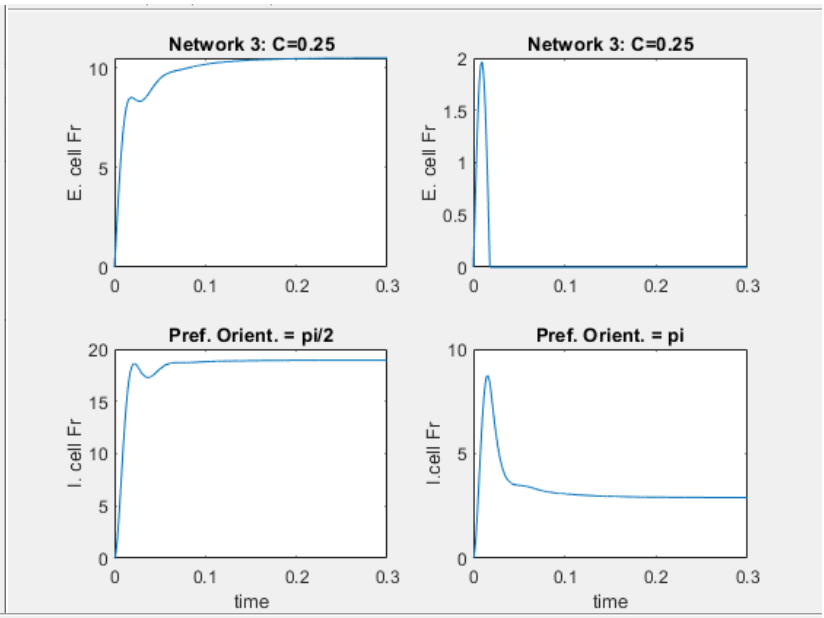

Network 2: C=0.25
E. cell Fr
Network 2: C=0.25
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
Pref. Orient. = pi
I.cell Fr

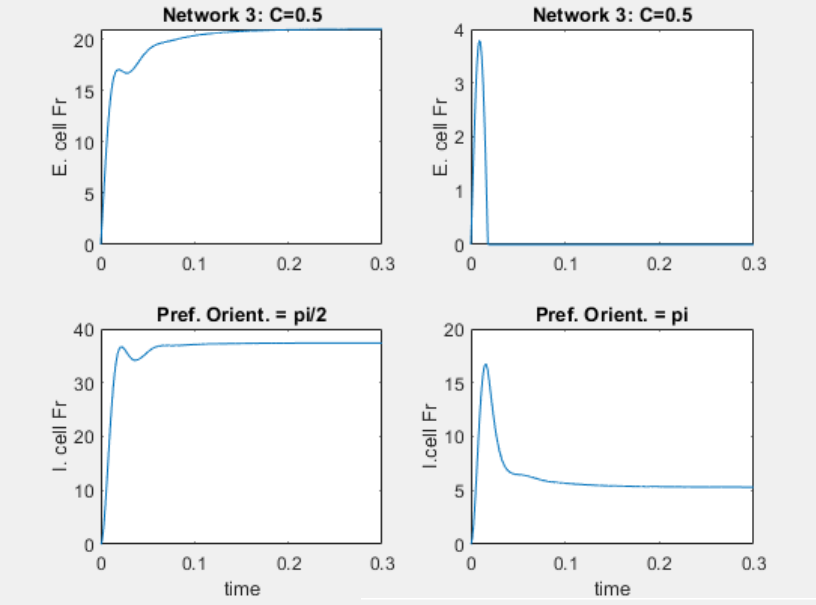

Network 2: C=0.5
E. cell Fr
Network 2: C=0.5
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time

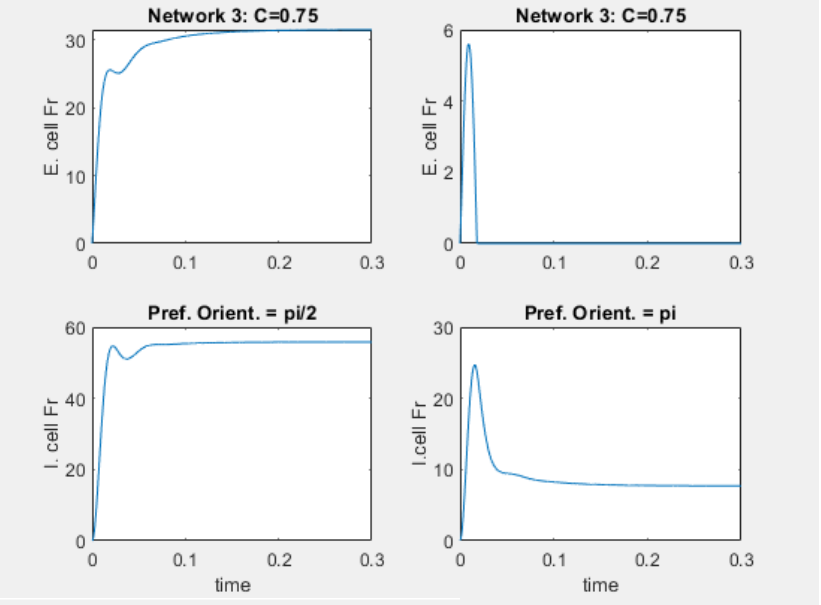

Network 2: C=0.75
E. cell Fr
Network 2: C=0.75
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time

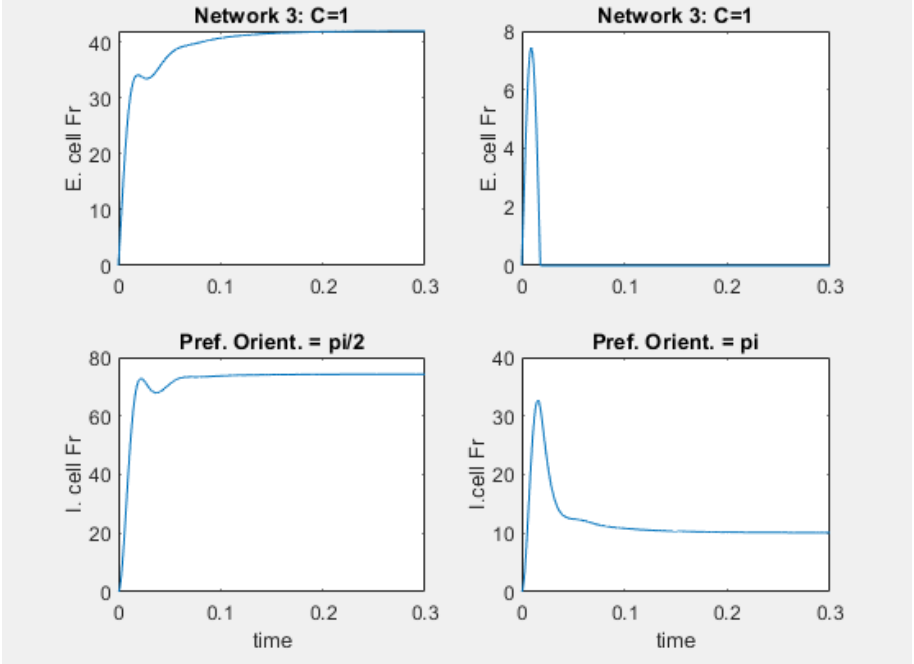

Network 2: C=1
E. cell Fr
Network 2: C=1
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time


Network 3: C=0
E. cell Fr
Network 3: C=0
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time


Network 3: C=0.25
E. cell Fr
Network 3: C=0.25
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time


Network 3: C=0.5
E. cell Fr
Network 3: C=0.5
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time


Network 3: C=0.75
E. cell Fr
Network 3: C=0.75
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time

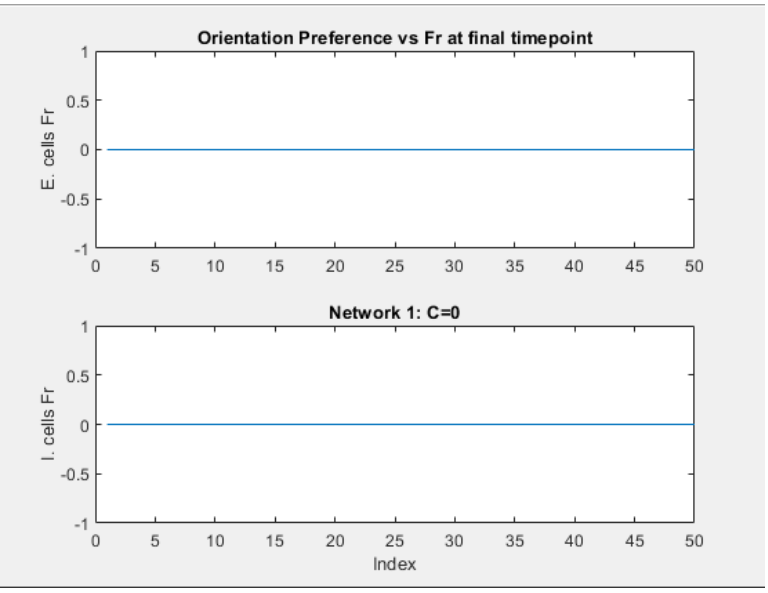

Network 3: C=1
E. cell Fr
Network 3: C=1
E. cell Fr
Pref. Orient. = pi/2
I. cell Fr
time
Pref. Orient. = pi
I.cell Fr
time

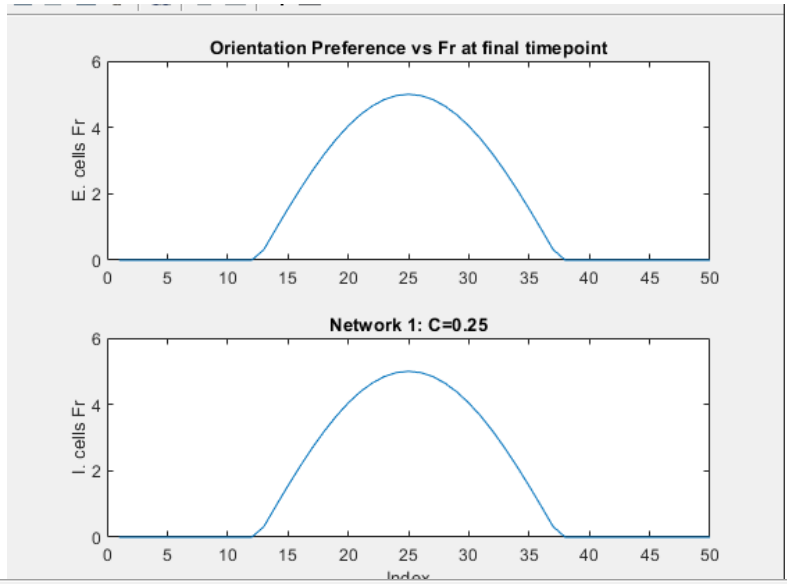
The above are the firing rate curves for cells with preferred stimulus orientation of pi/2 and pi, both excitatory and inhibitory, for different network models and different contrast values. In all of the above figures, in each block of 4 (a single trial), the figures on the left have a preferred orientation of pi/2, the ones on the right have a preferred orientation of pi. Immediately noticeable are those curves which are flat throughout the simulation. These appear in the networks where one or more of the connection strengths between units is set to 0. The figures on the first page for example follow a model with no connection between units, making rate of firing rate change only depend on baseline current and stimulus dependent inputs (as well as the firing rate). In a simulation with no contrast between visual stimuli, this will create a static "curve" representing no firing whatsoever. Even with no interunit connections however, we see that increasing contrast is responsible for an increase in firing rate for specifically the pi/2 oriented cells. In each case, inhibitory and excitatory cells saturate at similar values, notably higher than that of the pi oriented cell.

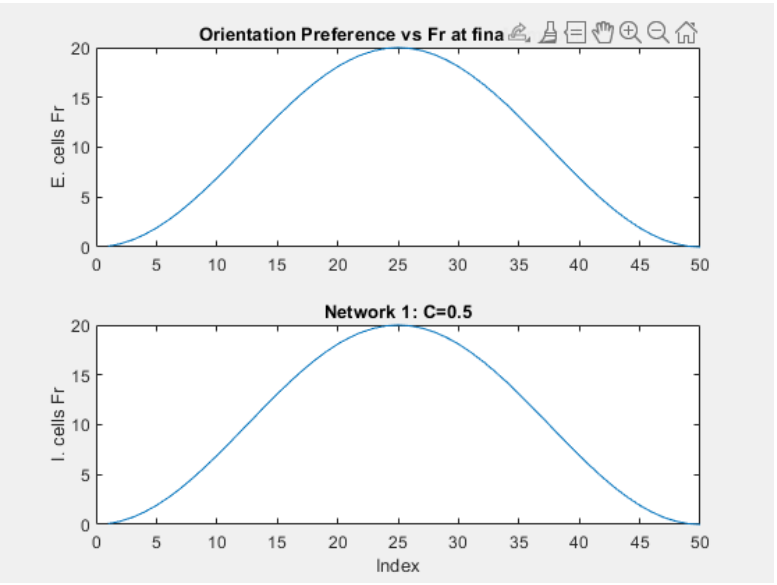
In network 2, inhibitory units have an impact on excitatory units, but all other connection strengths are set to 0. We see a similar trend to network 1 when 0 or close to 0 contrast leads to a lack of pi orientation preferred cell activity. Starting at about contrast of 0.5 however, there are notable differences from network 1. The pi/2 oriented inhibitory units begin to have a firing rate higher than their network 1 counterparts, likely due to a less inhibitory baseline current as a part of the model. Along similar lines, this increase in inhibitory firing (and presence of inhibitory to excitatory connection) causes a slight decrease in excitatory unit firing. Largest differences can be seen for the high contrast trial however. The excitatory unit spikes significantly less than the inhibitory unit, although their curves follow similar shape. Excitatory units whose preferred orientation are opposite the stimulus are completely inactive for high levels of contrast, due to low level of stimulus dependent input and the presence of inhibition from the associated unit.

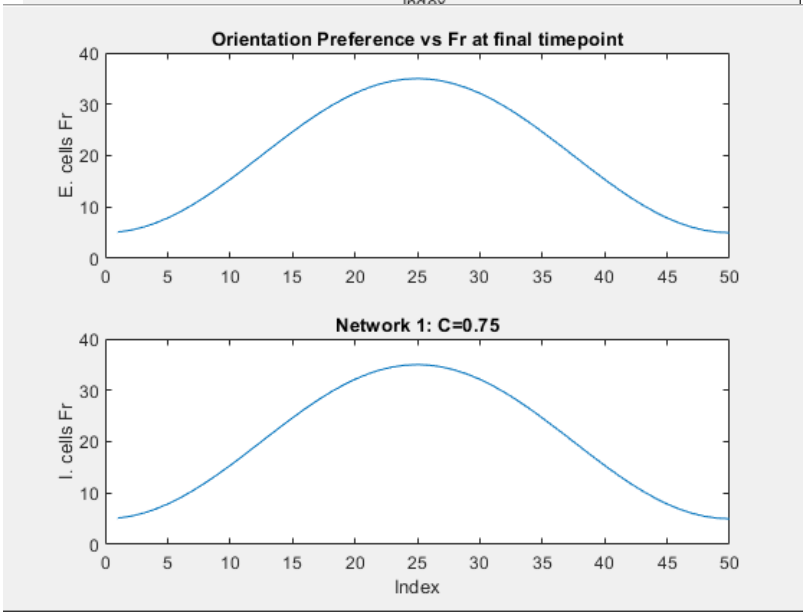
In network 3, all connections are given a strength, inhibitory cells are denied a stimulus dependent input, and the time constant for change in the inhibitory unit is an order of magnitude faster than the excitatory. This network gives rise to several changes when compared to the last pair. Firstly, low levels of baseline input destabilize the firing rate of 0 in inhibitory units even with no contrast, this in turn applies a small level of inhibition to the excitatory units, making all excitatory units at 0 contrast have a firing rate of 0. Worth noting in this network is that pi oriented excitatory cells (opposite orientation to stimulus) never actually fire after inhibitory cells are given time to impact the system. This lack of excitatory spiking makes the inhibitory cells therefore settle at a lower firing rate, but still enough to prevent activity. The network in general continues to follow the trend of an increase in contrast provides an increase in firing rate, but now in a more consistent way, each figure having roughly the same shape as the previous set of figures (with the exception of 0 contrast).

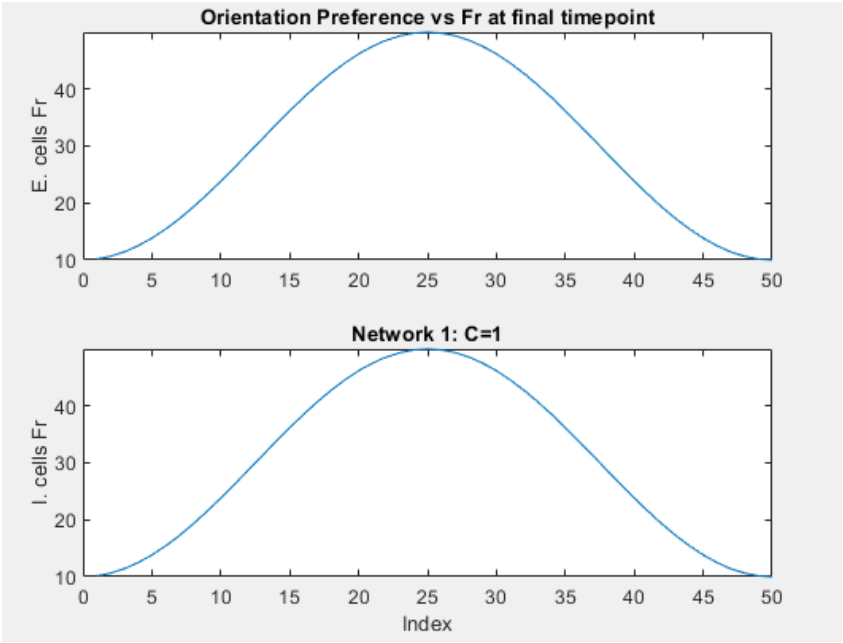
3.)

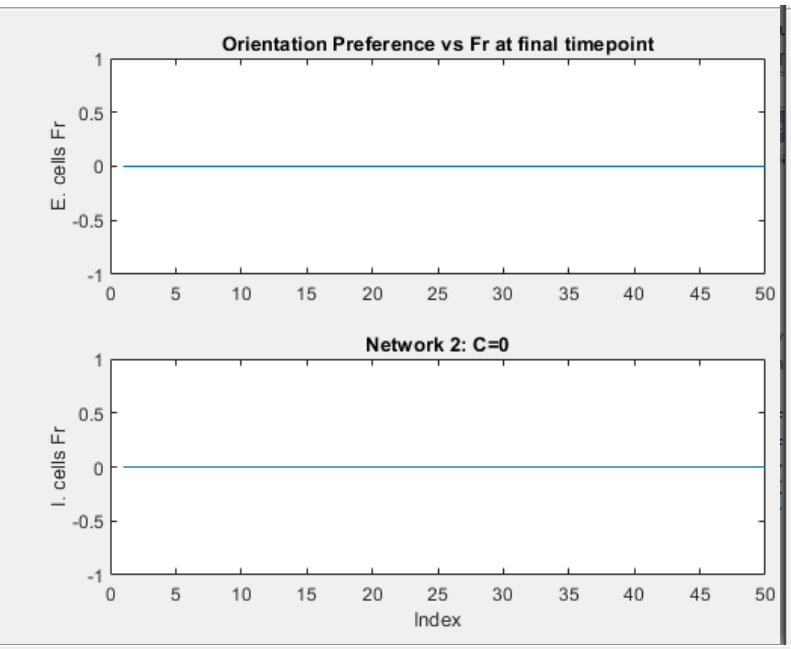

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 1: C=0
I. cells Fr
Index

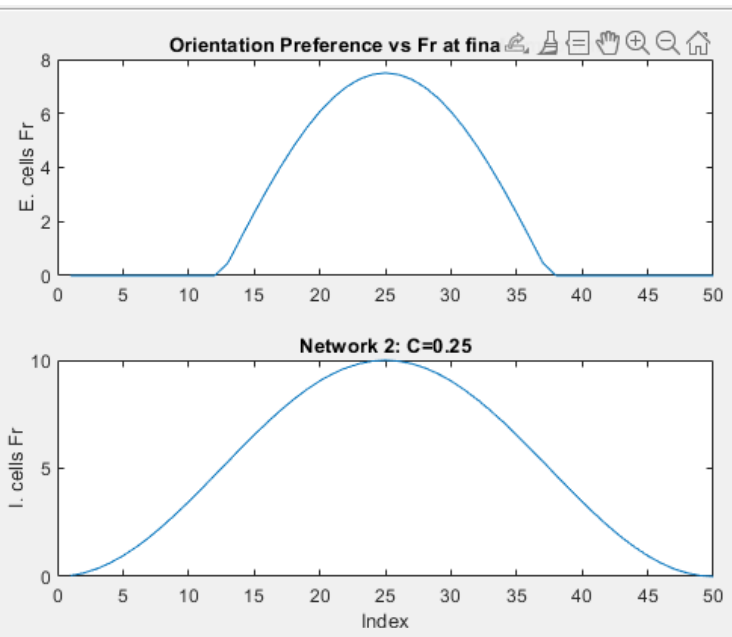

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 1: C=0.25
I. cells Fr

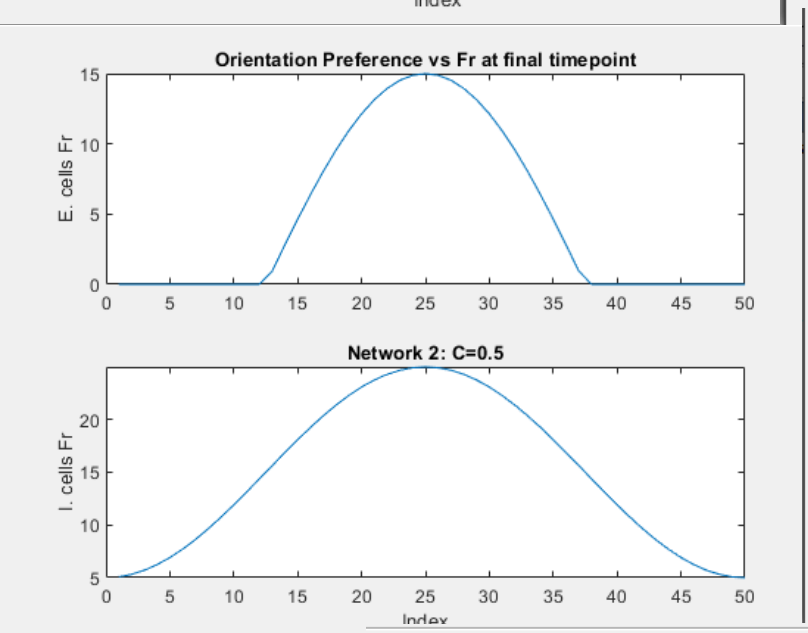

Orientation Preference vs Fr at fina
E. cells Fr
Network 1: C=0.5
I. cells Fr
Index

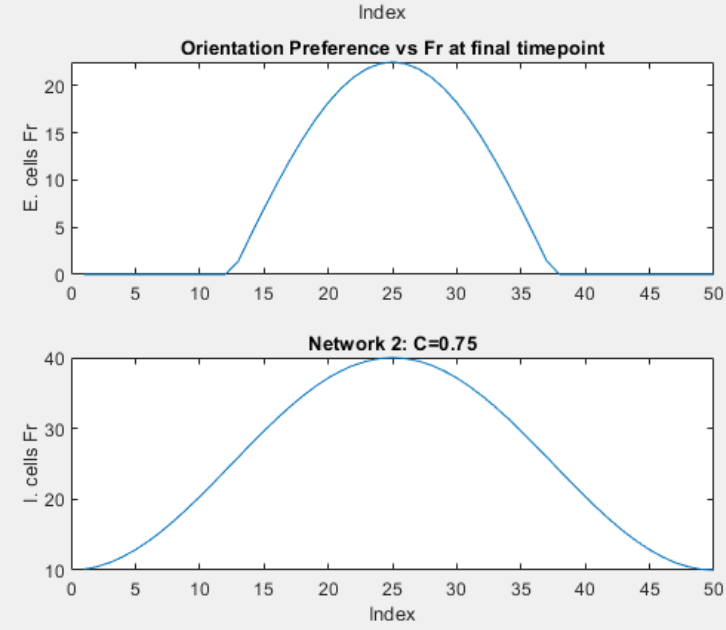

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 1: C=0.75
I. cells Fr
Index

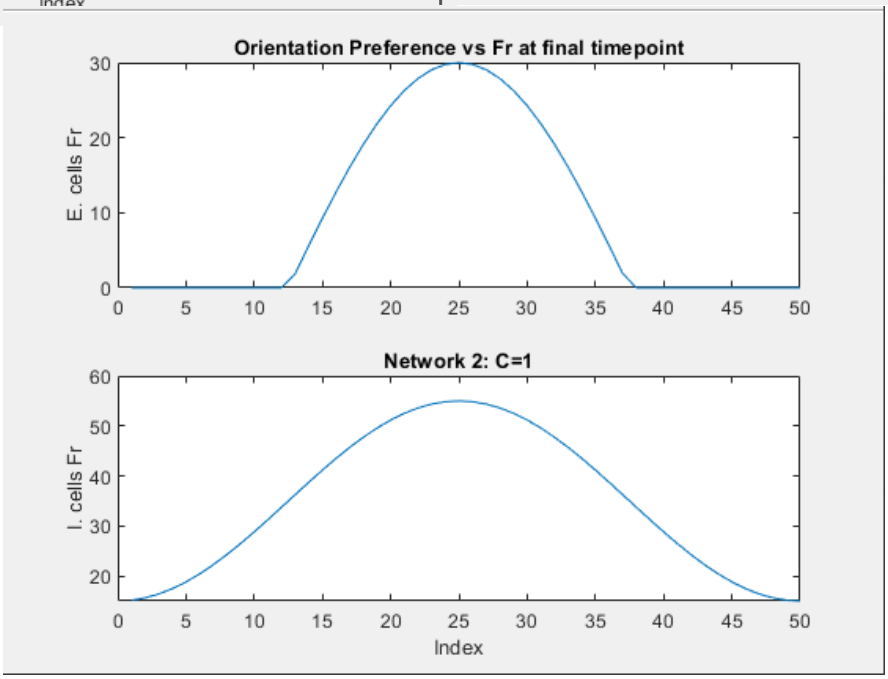

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 1: C=1
I. cells Fr
Index

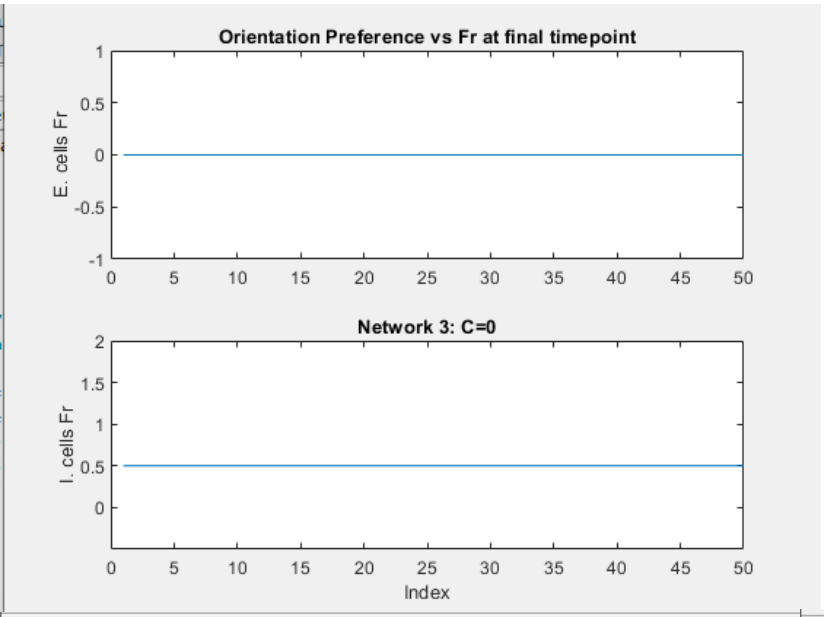

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 2: C=0
I. cells Fr
Index

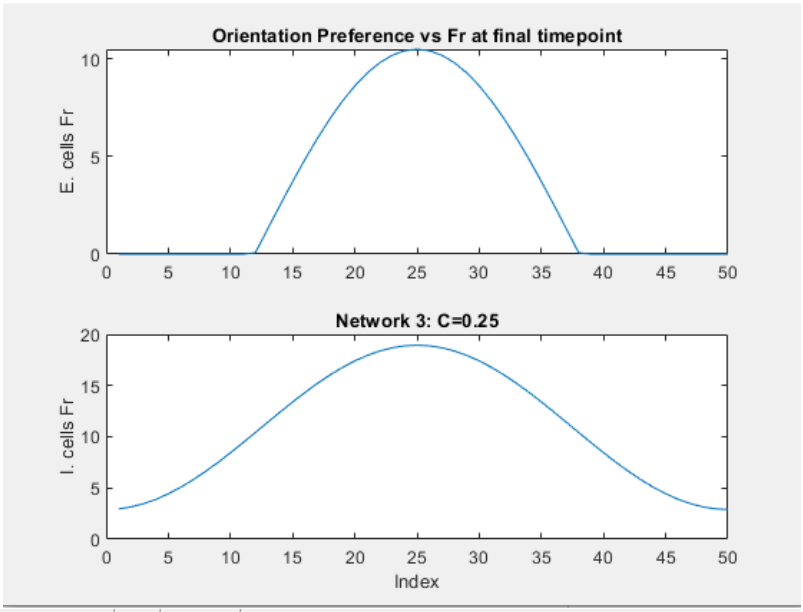

Orientation Preference vs Fr at fina
E. cells Fr
Network 2: C=0.25
I. cells Fr
Index

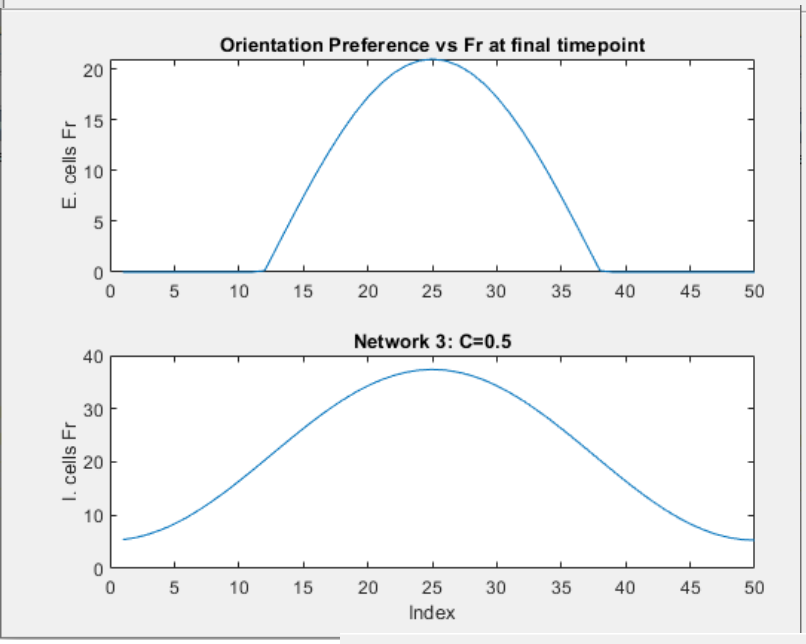

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 2: C=0.5
I. cells Fr
Index

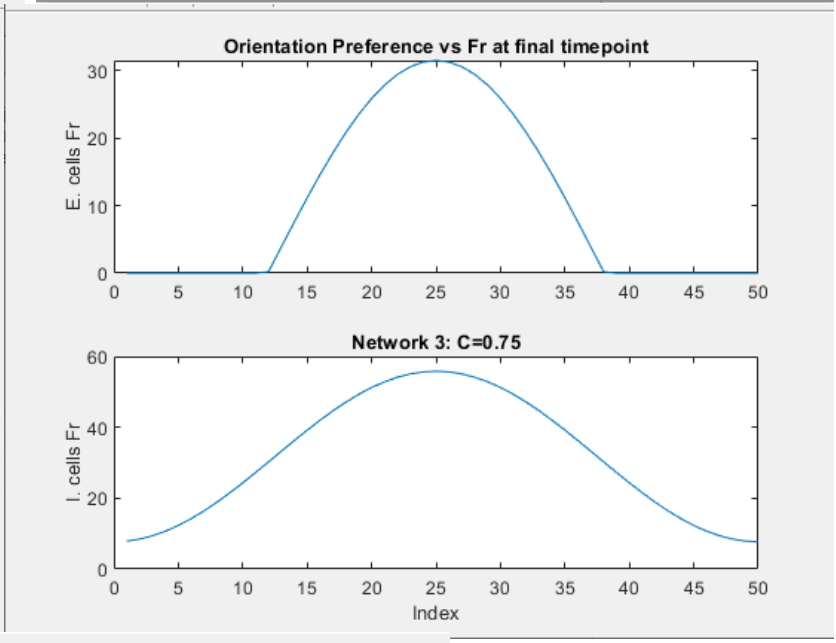

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 2: C=0.75
I. cells Fr
Index

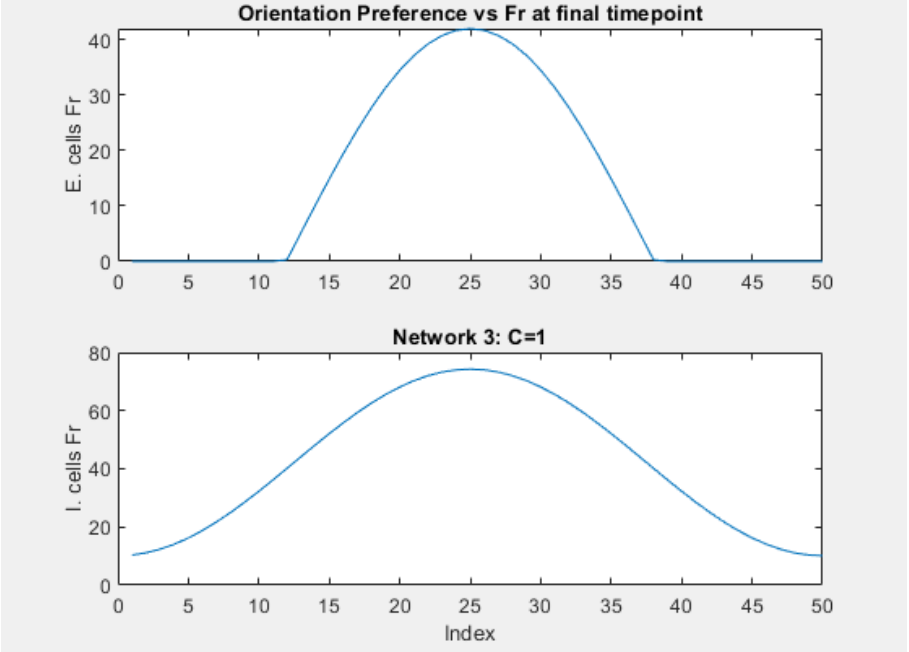

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 2: C=1
I. cells Fr
Index


Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 3: C=0
I. cells Fr
Index


Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 3: C=0.25
I. cells Fr
Index

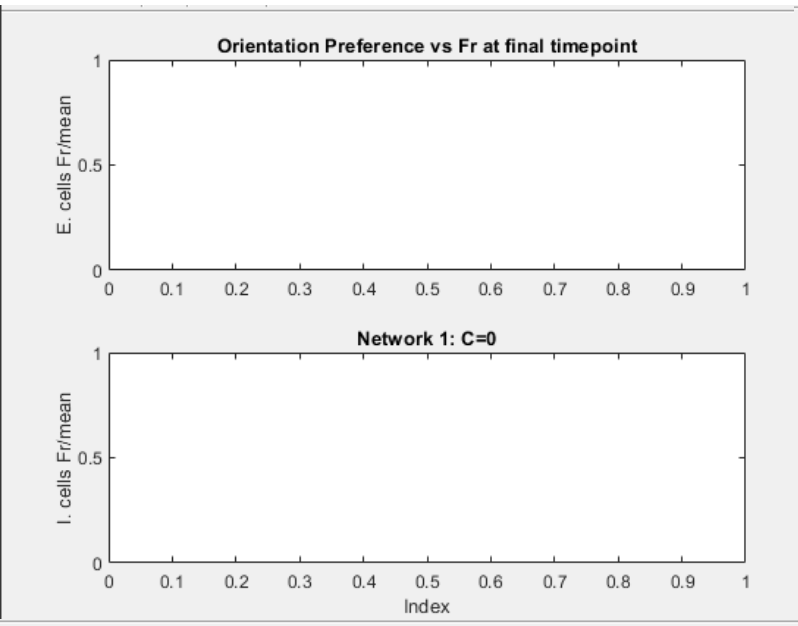

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 3: C=0.5
I. cells Fr
Index

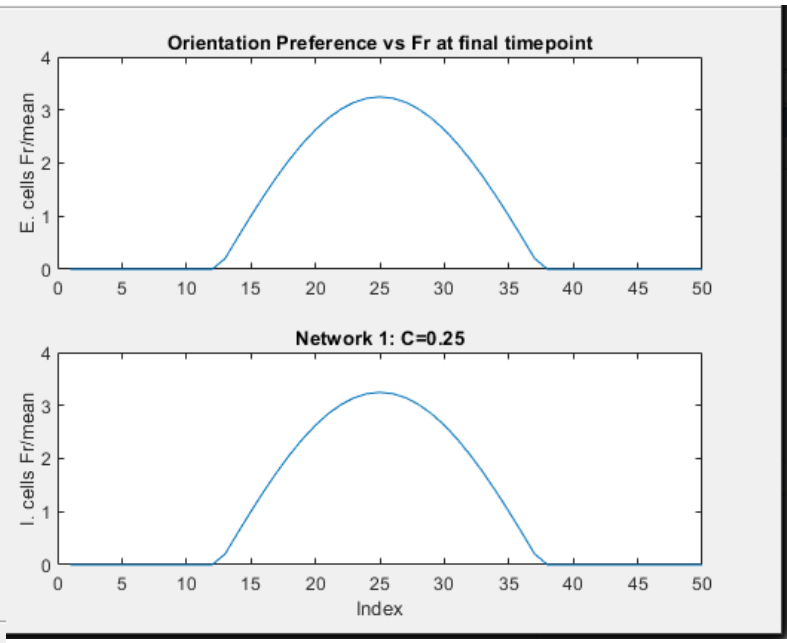

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 3: C=0.75
I. cells Fr
Index

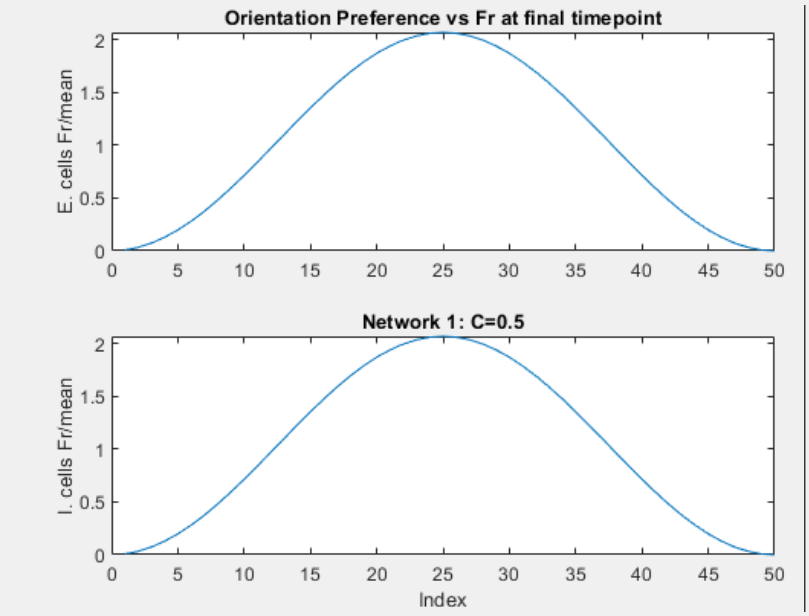

Orientation Preference vs Fr at final timepoint
E. cells Fr
Network 3: C=1
I. cells Fr
Index

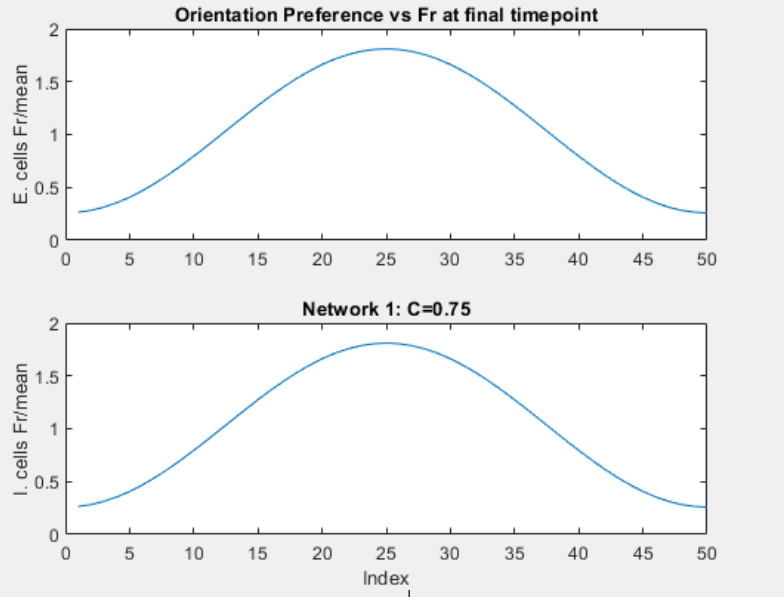
(discussion after question 4 figures)

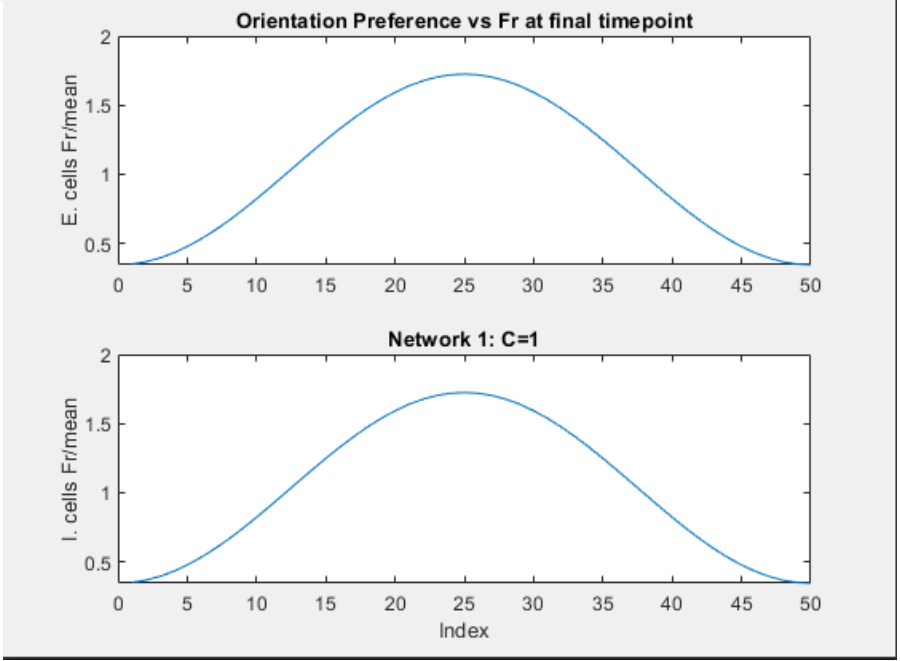
4.)

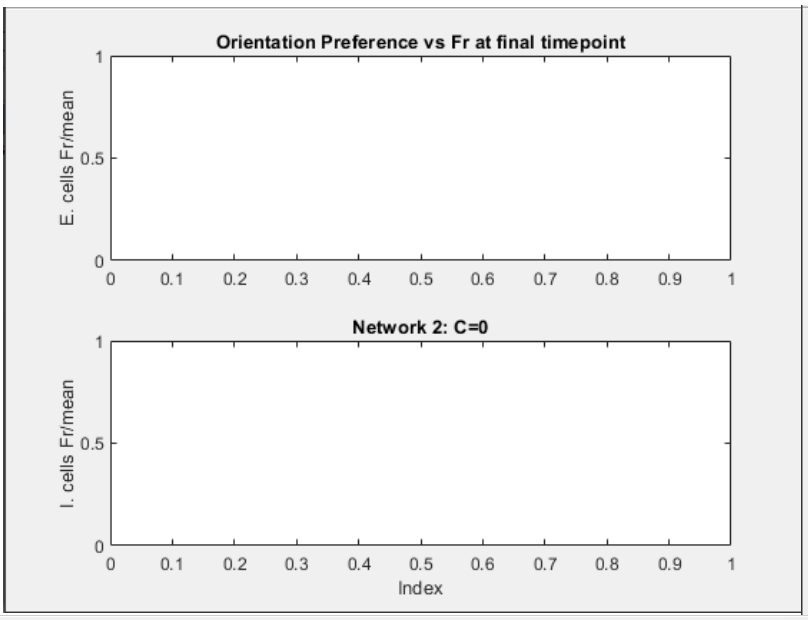

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 1: C=0
I. cells Fr/mean
Index

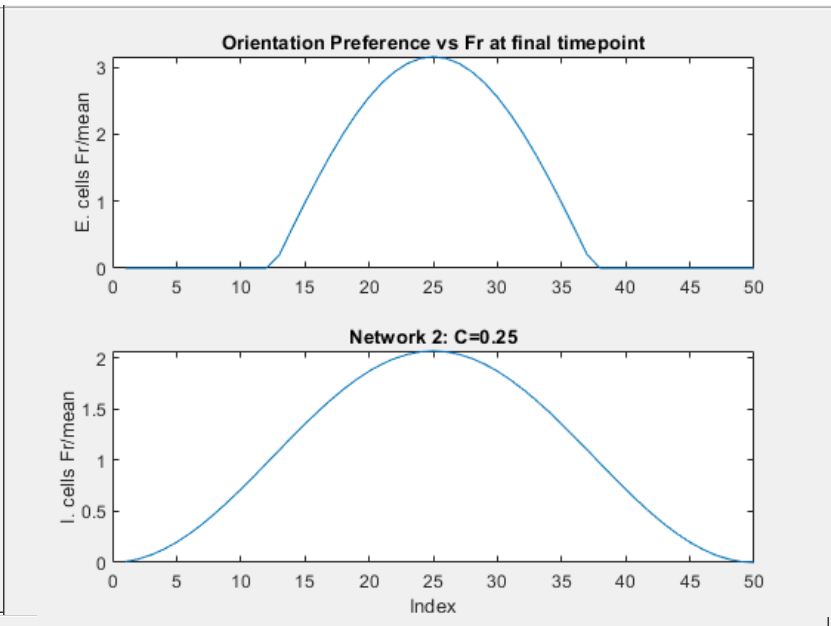

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 1: C=0.25
I. cells Fr/mean
Index

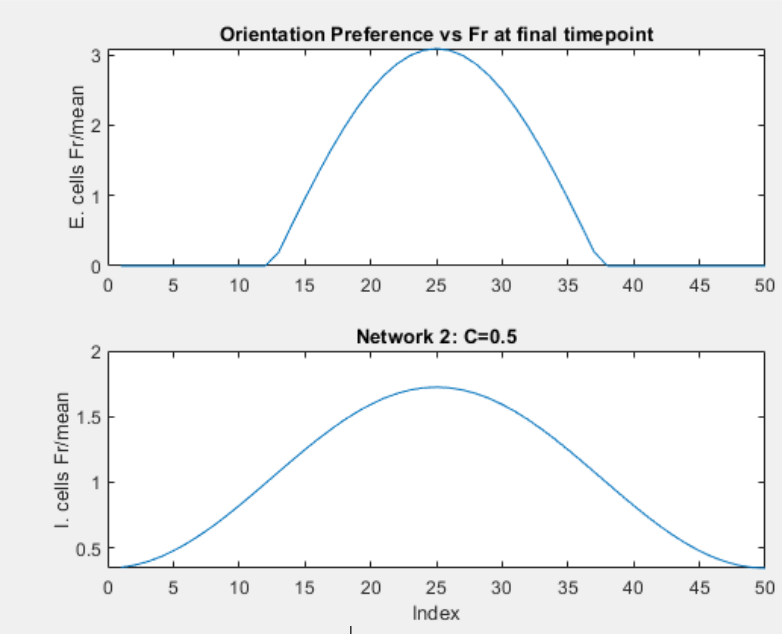

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 1: C=0.5
I. cells Fr/mean
Index

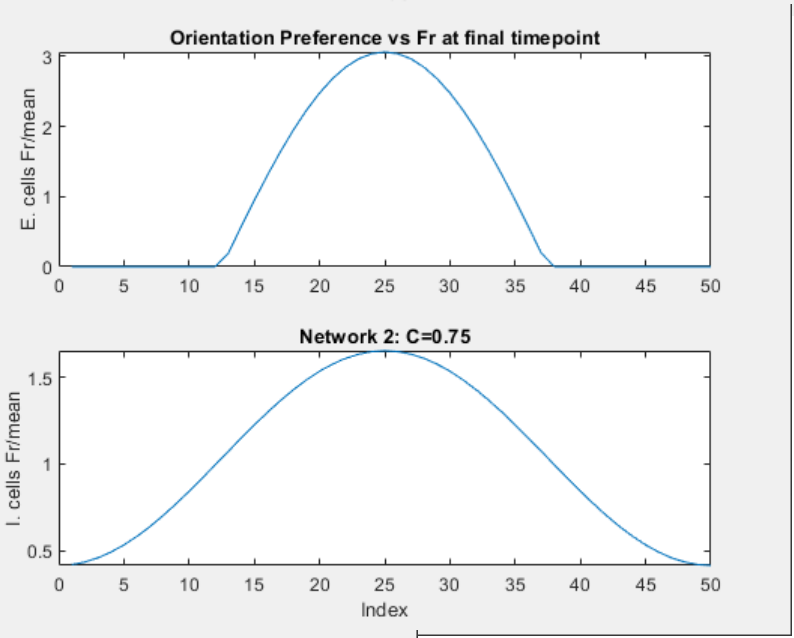

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 1: C=0.75
I. cells Fr/mean
Index

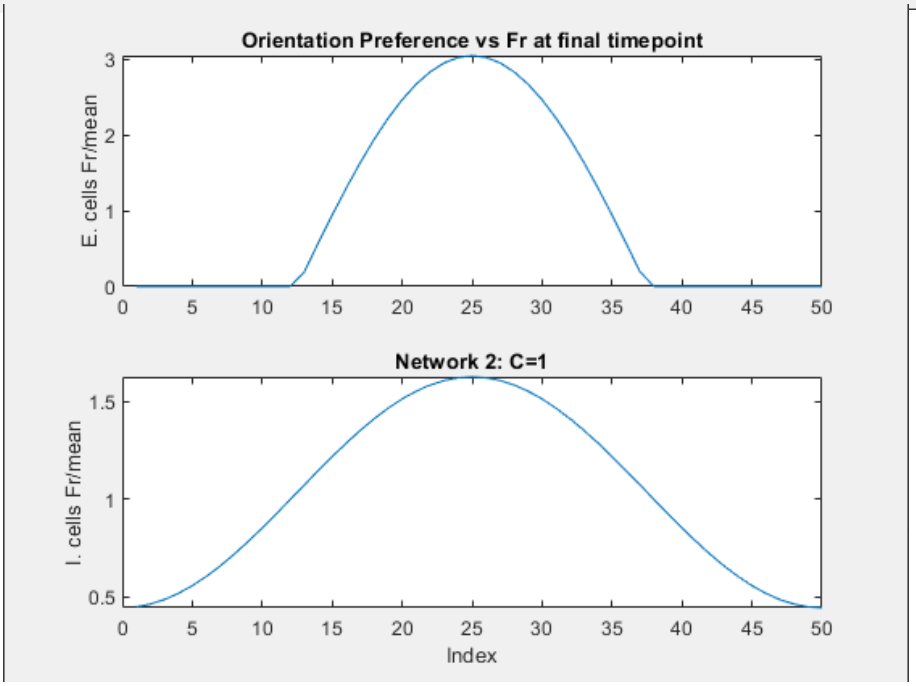

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 1: C=1
I. cells Fr/mean
Index

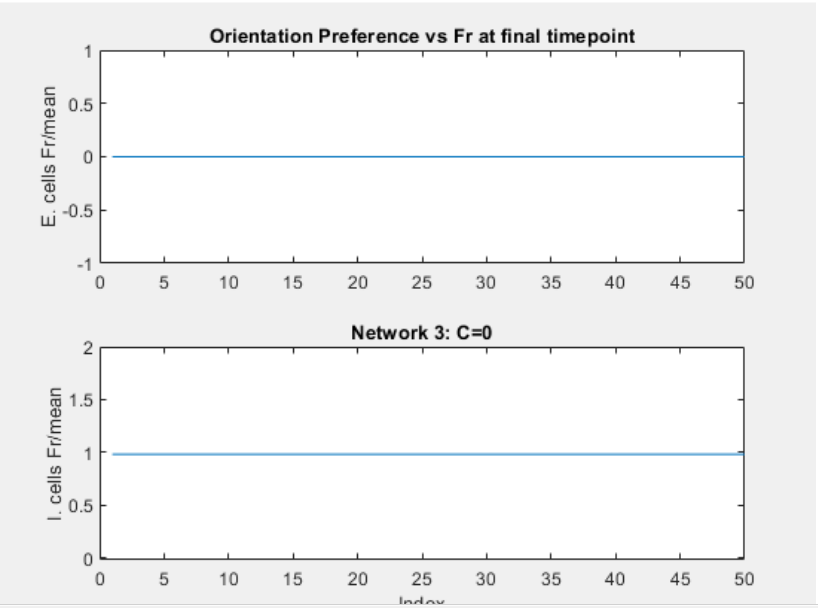

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 2: C=0
I. cells Fr/mean
Index

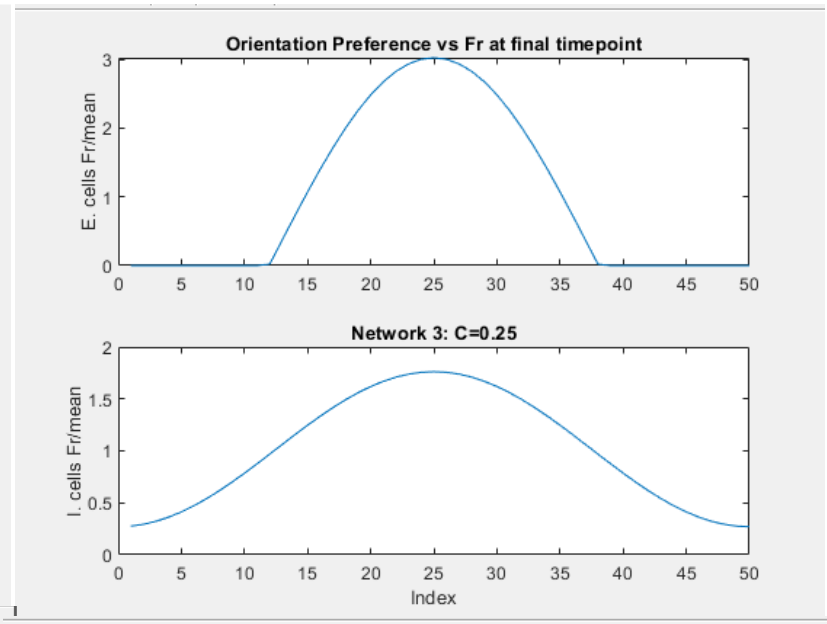

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 2: C=0.25
I. cells Fr/mean
Index

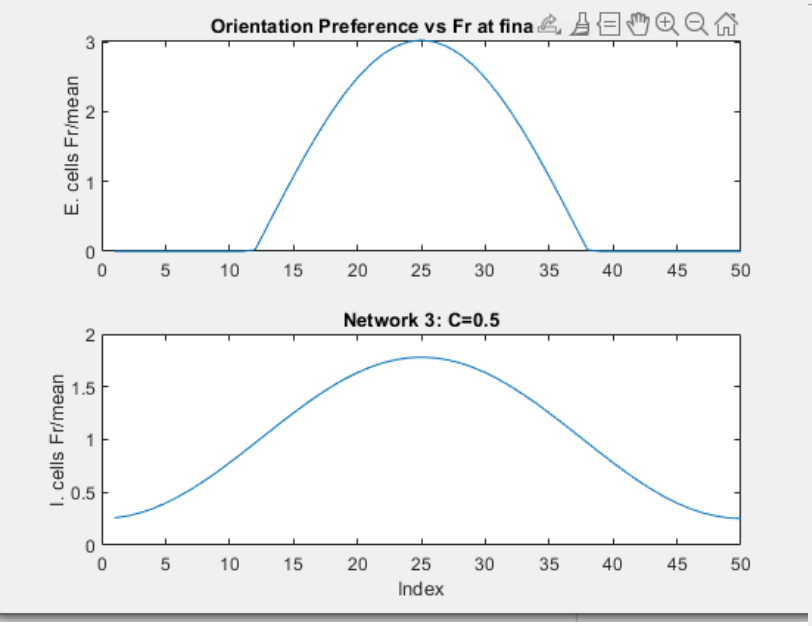

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 2: C=0.5
I. cells Fr/mean
Index

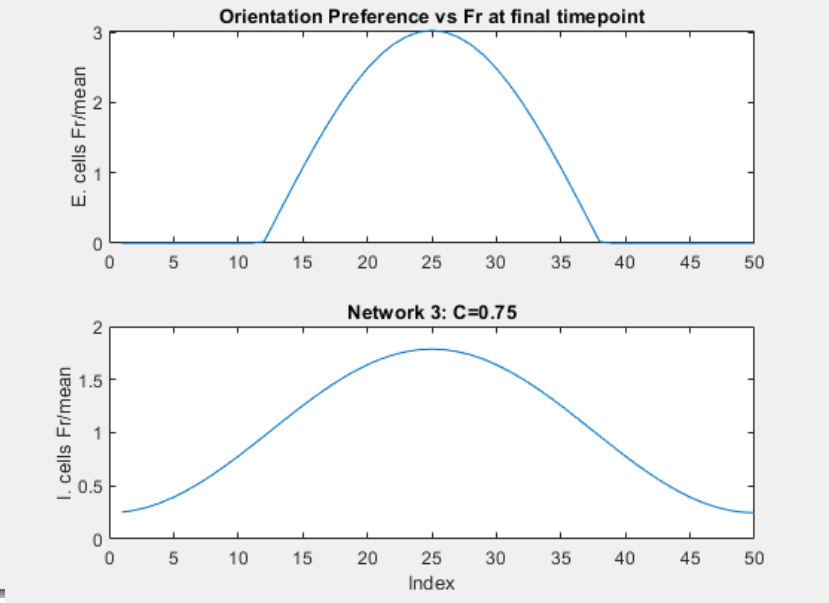

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 2: C=0.75
I. cells Fr/mean
Index

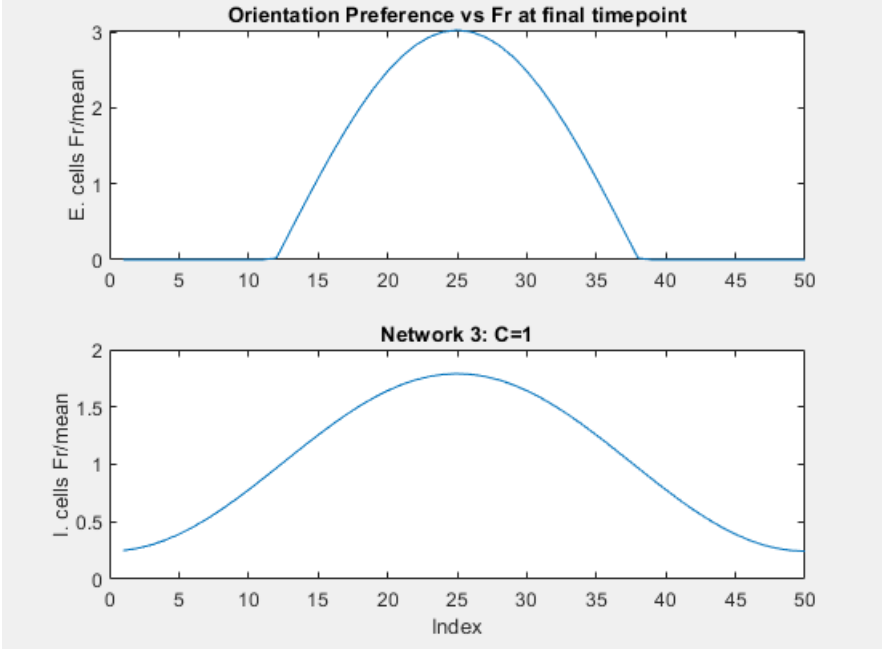

Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 2: C=1
I. cells Fr/mean
Index


Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 3: C=0
I. cells Fr/mean


Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 3: C=0.25
I. cells Fr/mean
Index


Orientation Preference vs Fr at fina
E. cells Fr/mean
Network 3: C=0.5
I. cells Fr/mean
Index


Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 3: C=0.75
I. cells Fr/mean
Index


Orientation Preference vs Fr at final timepoint
E. cells Fr/mean
Network 3: C=1
I. cells Fr/mean
Index

In question 3, plots were produced as firing rate vs cell index, where cell index represented the cell's orientation preference (preference = i*pi/50). In question 4, the same plots were produced, except on the y axis where previously firing rate was plotted, now firing rate /avg firing rate for that cell type in that trial was plotted (that may not have been totally clear in the above figures, so I figured I should include it here).

Plots that produce horizontal lines in questions 3 and 4 represent a level of activity independent of cell orientation preference. In most cases this is because of a lack of activity, resulting in a horizontal line at 0. In the case of the plots with no line whatsoever in question 4, this is a result of dividing by a mean firing rate of 0, which would of course fail to provide meaningful resutls. In the case of the horizontal line at 1 (network 3 C = 0), each cell had identical low levels of activity that prevented the excitatory cells from firing.

In network 1, we fail to see contrast invariance. For low levels of contrast, (0.25) there is a clearly, different shape firing rate activity "tuning" curve than for higher levels of contrast, and the output of each unit can not be multiplicitively scaled. This lack of contrast invariance is highlighted when in the figures for question 4, plots appear different from one another depending on their levels of contrast. If I had to guess, this lack of contrast invarience likely stems from the fact that all units were independent from one another, so their firing rate changed dependant on only their own, making a change in contrast have a large impact rate of firing rate change.

In network 2, we see some small levels of contrast invarience between trials, but not perfect. Discounting the trial where 0 contrast was present, in question 3 we see plots that have the same shape (or at least very similar) for the most part regardless of contrast, the main diffference being the increased scaling of firing rate as contrast increases (as to be expected). When analyzing the plots in question 4, plots where c=1 and where c = 0.75 appear identical, implying at the very least contrast invariance amoung specifically high levels of contrast. Upon further inspection, the inhibitory plot where c=0.5 is incredibly close to (but not actually equal to) the two plots with higher contrast. However, the c=025 plot does reveal significant differences when compared to the rest in terms of relative inhibitory cell activity, implying that the model is not truly 100% contrast invarient. Some of this difference is likely similar to how it occurred in network 1, seeing as how excitatory cells never provide inhibitory cells with any sort of feedback in this particular method, inhibitory cells are greatly impacted by only their own firing rate, scaled by contrast, therefore impacting the system as a whole unequally.

In netowork 3, we see contrast invarianve in the excitatory cells, as all response curves in question 3 share the exact same shape, and are only multiplicatively scaled with the contrast. Indeed, when each excitatory figure is rescaled with average firing rates in mind, they all appear to be identical (with the exception of contrast = 0, a straight line because in in a trial where c = 0, both kinds of units maintain a steady firing rate representative of an absence in stimulus).

5.)

In order to determine models are compatable with the result that a neuron recieves its highest excitatory and inhibitory input when the stimulus is at their preferred oreintation, we must consider each network's connectivity matricies. For a model agree with this observation, its excitatory (sum of WEE*rates of excitatory cells) and its inhibitory (WIE*rates of inhibitory cells) inputs should be highest when the stimulus is at the preferred oreintation (in this case when index=25). Seeing as how all connection strengths are 0 in network 1, excitatory cells do not recive inhibitory input, making network 1 not compatible. Network 2 has no excitatory connections to the excitatory unit, making its only excitatory input the stimulus dependent input. It is unclear if the question is whether or not the excitatory input would be greatest independent of stimulus dependent input, but I will assume that it is, as the observation that each cell responds most to a stimulus that is its preferred stimulus is not exactly profound. Seeing as how the excitatory input to excitatory cells in network 2 is only stimulus dependent, I will therefore say it does not strictly adhere to the results described. Network 3 on the other hand comforms perfectly, as WIE and WEE are at their greatest connection strengths when the preferred stimulus is presented, providing both the hgihest level of excitatory, and inhibitory input in this scenario.

6.)

While it is true that in our findings we only ever simulated input with a single orientation, we still received data from all cells with all preferred orientation. Given that the stimulus/detection is circularly symmetrical, we should now be able to accurately predict the activity of the ring model given any stimulus orientation. Such a shift in stimulus orientation would produce activity/figures identical to the ones above, save for a "shift" left or right depending on the difference from pi/2. For example, if the stimulus had orientation of pi, the 50^{th} unit would have the same level of activity that the 25^{th} unit does above, and the 25^{th} unit would have the same activity as the 50^{th} above. Because the system is symmetrical, any portion of the above curves that would be cut off could simply be wrapped around (ie for stimulus orientation of pi, the unit "1" would have the same activity as the unit "26" above, and so on). In this way, our single simulation with a single input gave us all the information we would need to discuss how a single cell would respond to a variety of inputs.