Notes to answers NC Assignment 1

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Question 1 Examine how 1) the background stimulus strength, and 2) the standard deviation of the noise influence the response of the population to the stimulus. Explain the findings. (No fully extensive parameter sweeps needed).

In the case of no noise and no background stimulus, all neurons will have a potential very close to the resting potential when the stimulus arrives at 200ms. As a result, the neurons will hit the threshold and fire roughly at the same time, i.e. the response is highly synchronous.

The background stimulus and the (independent) noise will cause the neurons to have a broad distribution of potentials roughly between resting and threshold potential. Therefore they will fire at different latencies when the stimulus arrives (and on average earlier than without the background). The synchrony will be much reduced.

Common noise will not destroy the synchrony.

Question 2 What would happen if multiple populations from the previous question were chained in succession in the low noise regime?

First, there is a gain between the layers that, dependent on its value, responses in subsequent layers become stronger or weaker. Second, synchronization becomes stronger and stronger with each layer, leading to a so-called synfire chain. (see lecture notes for a figure, effective gain was set to one there by numerical means).

Next, replace the background and stimulus current with synaptic input currents driven by a Poisson process. The synaptic events have a decay time constant of 5ms.

Question 3 State how you implemented the Poisson input. How can you get the high and low noise regimes from Question 1?

Synaptic input can be modelled as in two steps:

```
isyn += isyn0/tausyn*(rand(1,ncells)<dt*inrate);
```

Here every so often, the synaptic currents get a kick. The Poisson process is simply a binary number (changes for multiple spikes per bin, $\propto (dt.inrate)^2$, should be very small). It is also possible to drawn the intervals from an exponential distribution, but this is trickier when the rate varies. Note, as a minor thing, we scaled the amplitude of the current with tausyn so that the charge transferred per event ($Q = \int I(t)dt$) is independent of it.

Second,

```
isyn *= (1-dt/tausyn);
```

In all cases exponentially decay the current with a time-constant tausyn.

If we just vary the input rate, we will vary both the mean and noise of the synaptic current. To keep the mean the same we should scale isyn0 with the rate. So that high rates will lead to many small events,