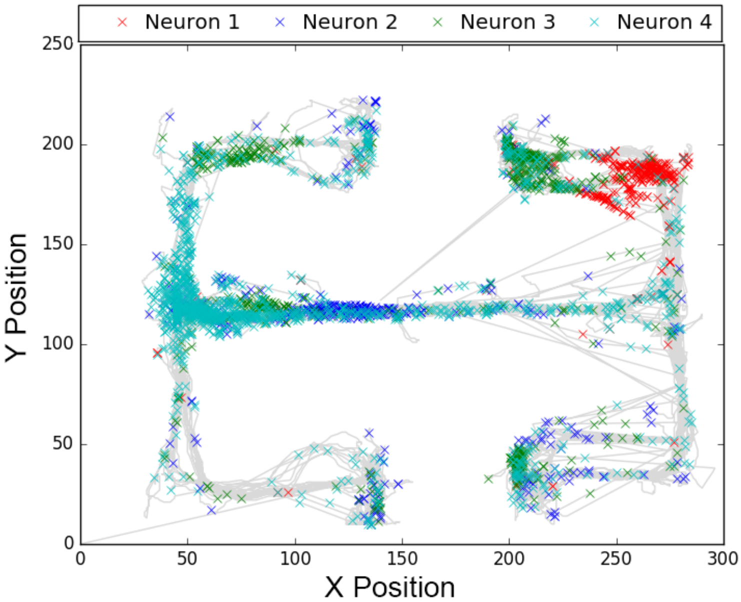
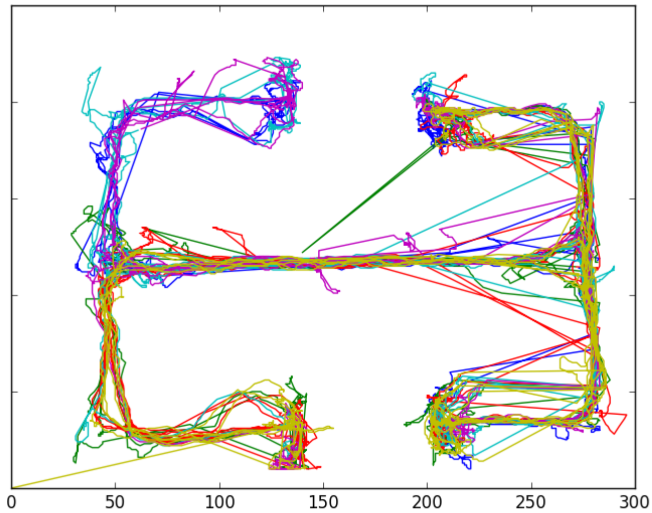
**Computational Neuroscience: Coursework 2**

**An analysis of** *Matthew W. Jones & Matthew A. Wilson (2005) Theta rhythms coordinate hippocampal-prefrontal interactions in a spatial memory task*

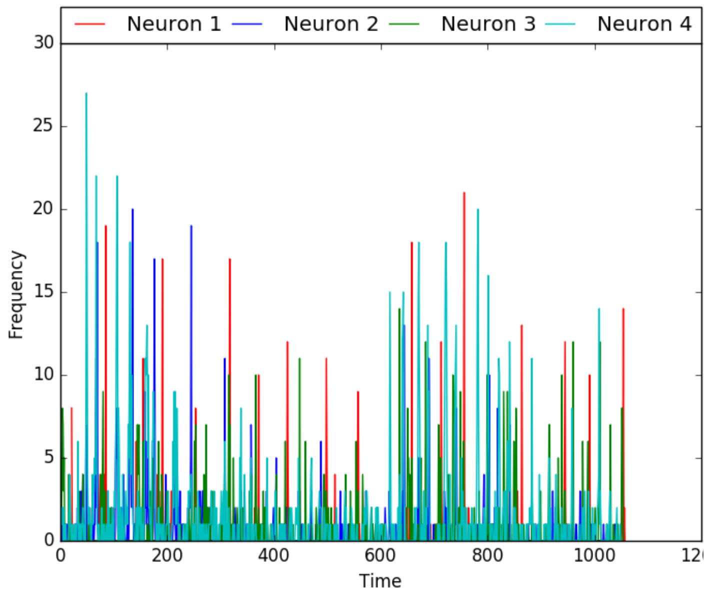
| Order | | |
|---|---|---|
| 1. Blue | 2. Green | 3. Red |
| 4. Cyan | 5. Magenta | 6. Yellow |

**Rat position + spikes.**

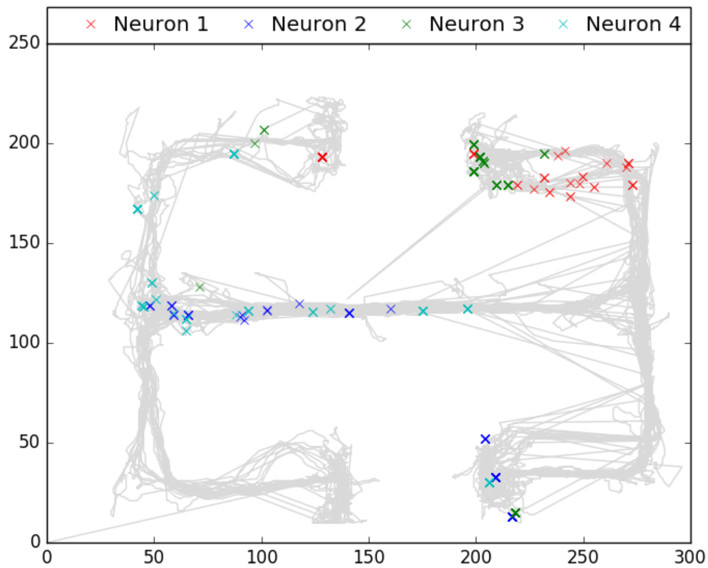


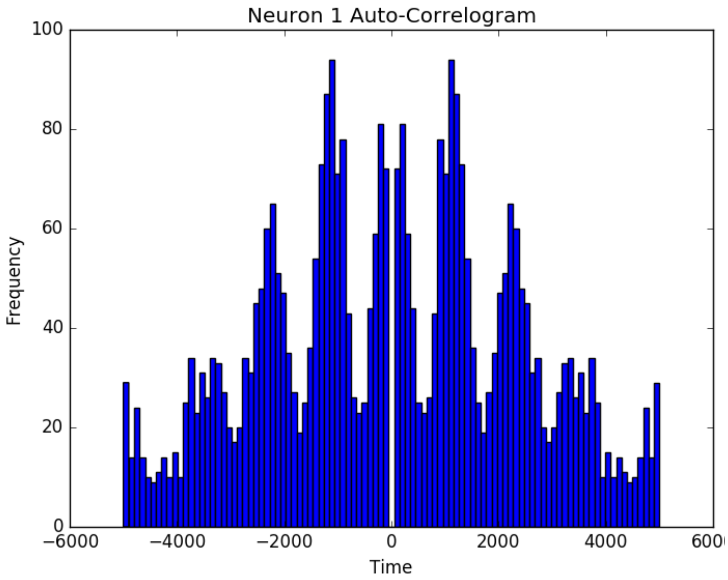
**Firing Rate over time in seconds**

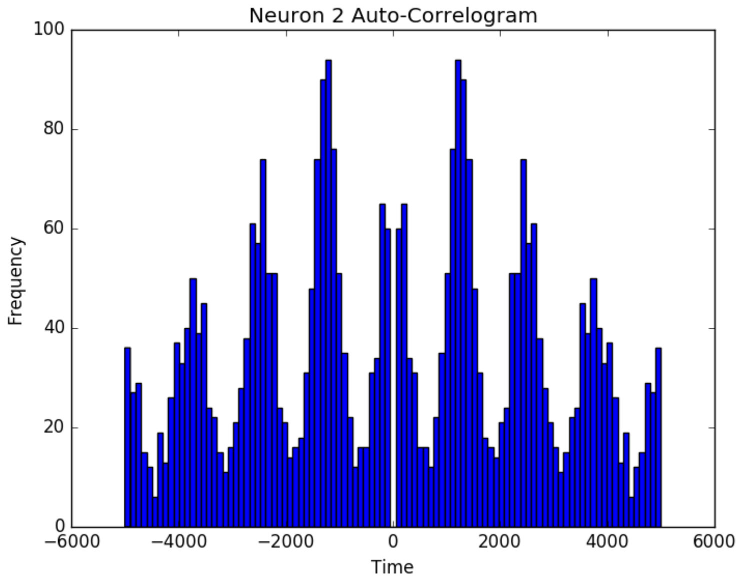


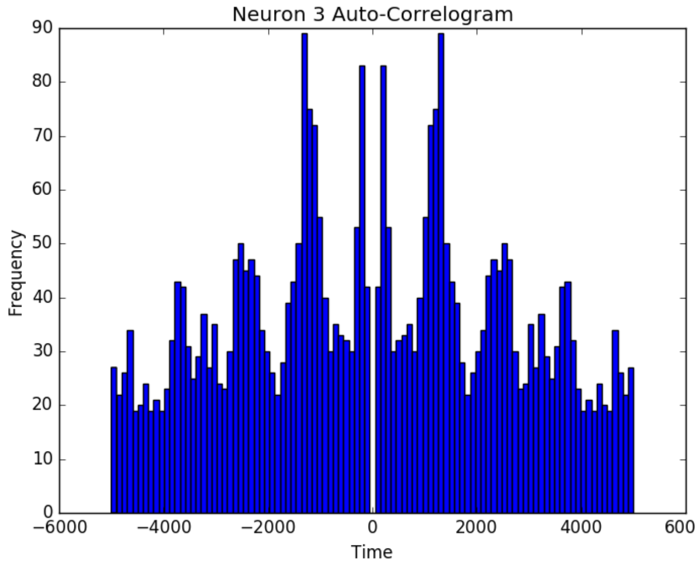

**Locations s.t. firing rates are larger than one standard deviation from mean.**

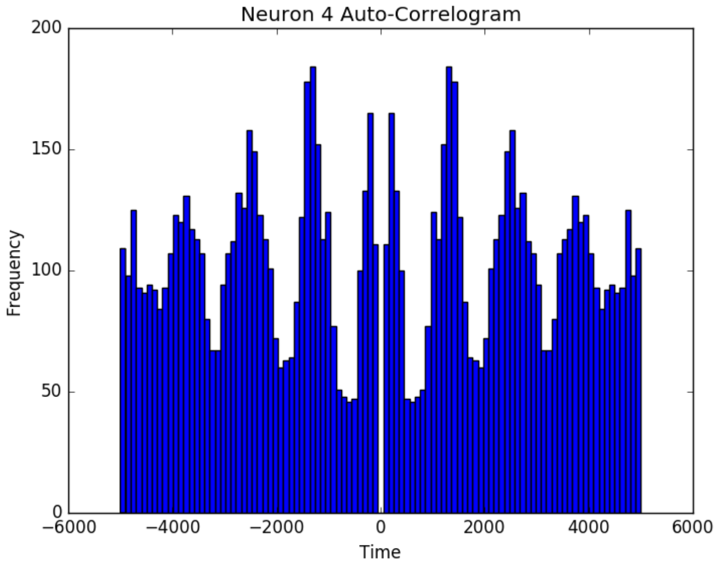


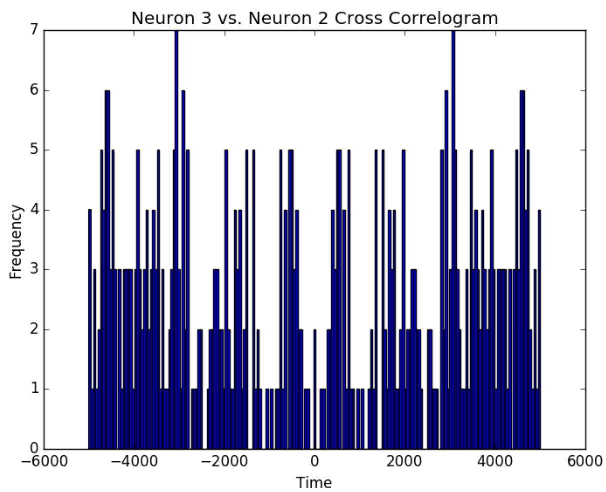

The locations where firing rates are over one standard deviation from the mean show more precisely which neurons are most active in particular areas.

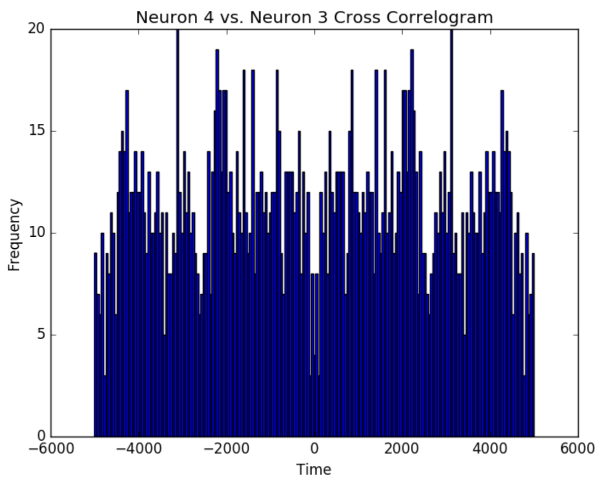

Neuron 1 Auto-Correlogram
Frequency
Time

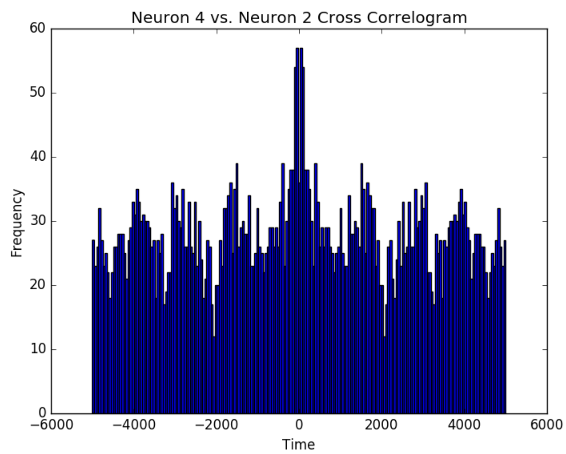

Neuron 2 Auto-Correlogram
Frequency
Time

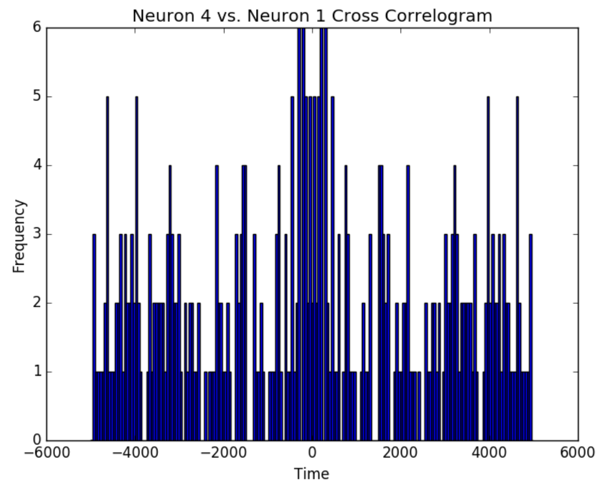

Neuron 3 Auto-Correlogram
Frequency
Time


Neuron 4 Auto-Correlogram
Frequency
Time


Neuron 3 vs. Neuron 2 Cross Correlogram
Frequency
Time


Neuron 4 vs. Neuron 3 Cross Correlogram
Frequency
Time


Neuron 4 vs. Neuron 2 Cross Correlogram
Frequency
Time


Neuron 4 vs. Neuron 1 Cross Correlogram
Frequency
Time

All times listed below have units s.t. 10,000 units is one second. The auto-correlograms distinctly show hippocampal theta waves from 6-10Hz, which infer active motor behaviour and exploratory sniffing.

Neuron 1: ~7 Hz
Neuron 2: ~7 Hz
Neuron 3: ~9 Hz
Neuron 4: ~7 Hz

The cross-correlogram for neuron 4 versus 2, show that immediately after either one neuron fires, the other one fires. This makes sense as they both fire at the central decision point, which indicates these may be involved with coordinating with working memory to remember which path to go down to achieve reward. There seems to be strong periodicity with these neurons which may show that they affect each other in a loop. Neuron one is clearly activated in the reward mechanism. Neuron 4 and 3 also seem to be heavily related.

Theta precession occurs when asymmetry between excitatory and inhibitory neurons causes a negative correlation of spike phase to animal position as the rat moves through the field i.e. the place cell firing rate is related by the distance from the animal to the landmark. As it approaches the place, the spiking of the place cell moves earlier in phase relative to background inhibitory theta oscillations in the hippocampus. This is mentioned by (Keefe & Recce) 1993, where the phase starts at one phase when entering the place field and systematically progresses forward, meaning the neuron is active for a larger fraction of the theta cycle yielding the firing rate as a function of position and phase (spatio temporal receptive field).

The following shows the phase against time for neuron 2 which is very localised, so I thought it would be an ideal neuron to choose. The start and end points correspond to entering and leaving the zone I designated.

There seems to be a decrease of phase when the rat leaves the zone highlighted in Fig B. I have highlighted the areas where the rat leaves the maze in the A with the red bars. With further analysis I would have constructed a heat map with the firing rate, but unfortunately I did not have time. The phase was not a weighted average, but in each 2 second interval, I took the phase of the wave with the highest magnitude above 3 (to avoid aperiodic trivial 0 phase waves). The weighted average yielded a flat line.

X = START POINT

Fig A.

X = END POINT

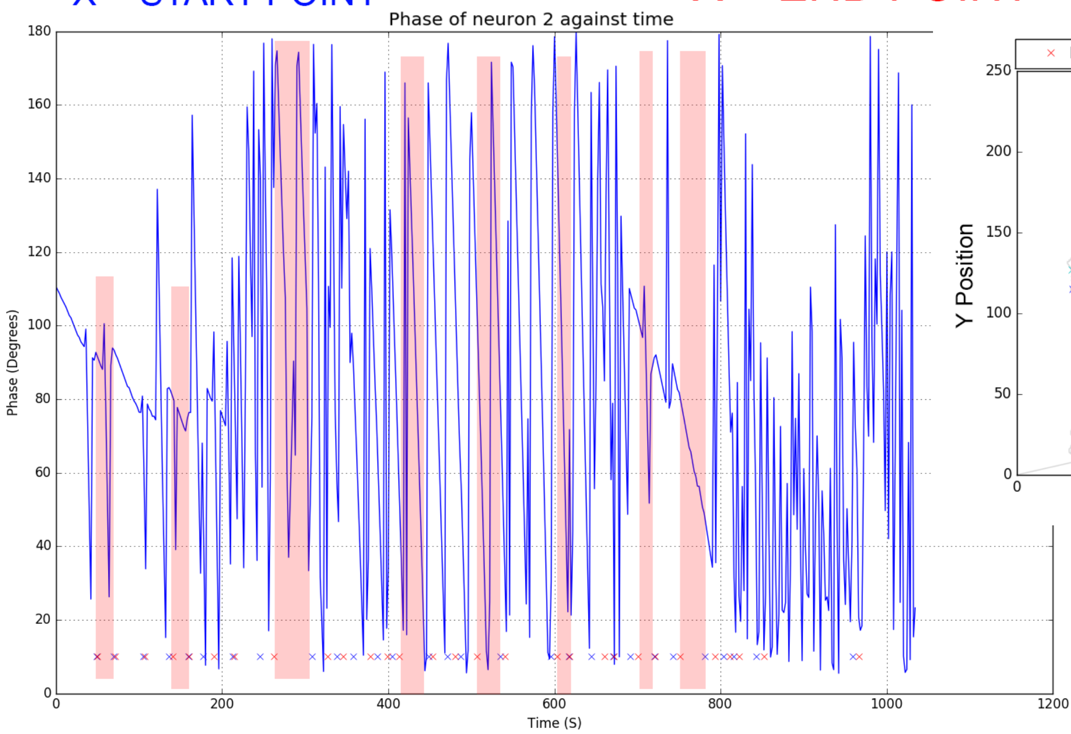



Fig B.