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NEUR 603 Assignment 9:
Cell Assemblies

Note: Running the included *cell_assemblies.m* file should reproduce all figures in this report.

1) The correlation matrix was computed during running, pre-sleep, and post sleep. The correlation values are distributed on the range [-1, 1] as expected, where a correlation of 1 indicates perfect positive correlation and a correlation of -1 indicates perfect negative correlation. Figure 1 shows the correlation matrices with the diagonal removed; the diagonal of the correlation matrix will only have values of 1 because each entry of the diagonal is the autocorrelation of a particular neuron (we expect that a neuron is perfectly correlated with itself and therefore will have an auto-correlation of 1).

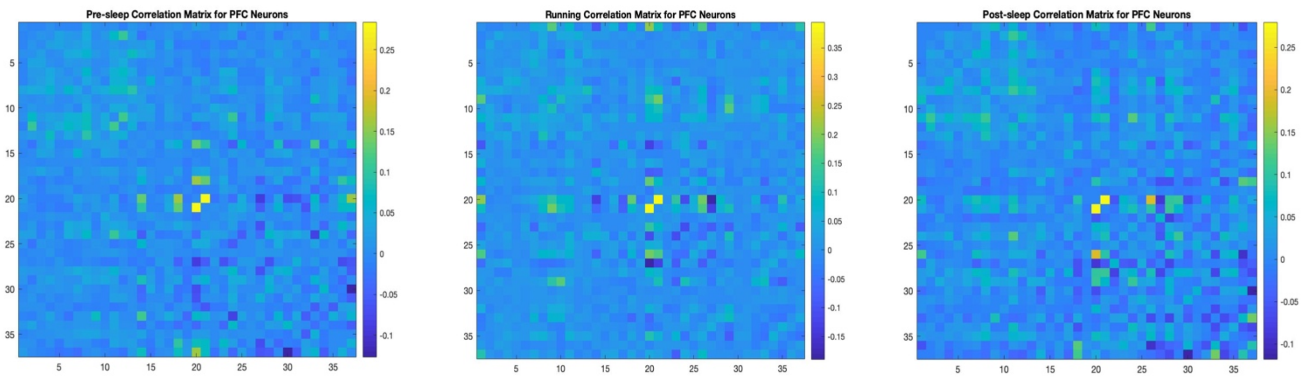

Figure 1 - Correlation matrix during (from left to right) pre-sleep, running, and post sleep. Note that the diagonal has been set to 0 here for visualization purposes.

2) From Figure 1 we can see that cells #20 and #26 change their correlation from being somewhat negatively correlated sleep-pre to being positively correlated sleep-post. Figure 2 illustrates the cross-correlations of these two neurons in the sleep-pre, sleep-post, and running states. We can observe that during sleep-pre, there is little correlation between the two neurons. During running, the two neurons show greater correlation; the neurons tend to be active together and for a long time (as illustrated by the peak width).

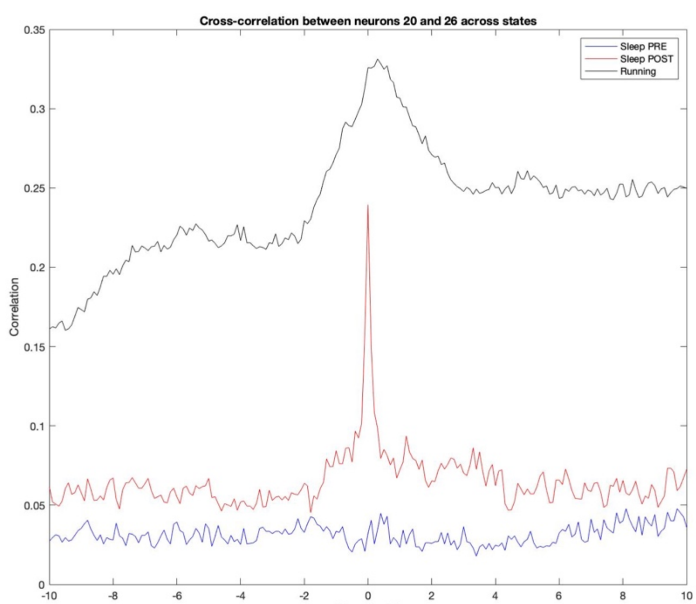

Figure 2 - Cross-correlation of neuron 20 and neuron 26 in three states (pre-sleep, post-sleep, and running)

Finally, during sleep-post, the two neurons are correlated, though they tend to be active together for shorter periods of time than during running. Note that the chance-level correlation is significantly higher during running; however, the neuron 20 - neuron 26 correlation is still higher than chance.

3) The weights and the score of the first principal component during running were computed; scores were computed by projecting whitened binned spike trains onto the first principle component.

4) The average firing rates of each neuron were plotted against the first principle component weights (Figure 3). From the figure, we can observe that there is not a strong relationship between firing rate and principle component weights, and so we might conclude that the neuron-neuron correlations here do not depend on their intrinsic excitability.

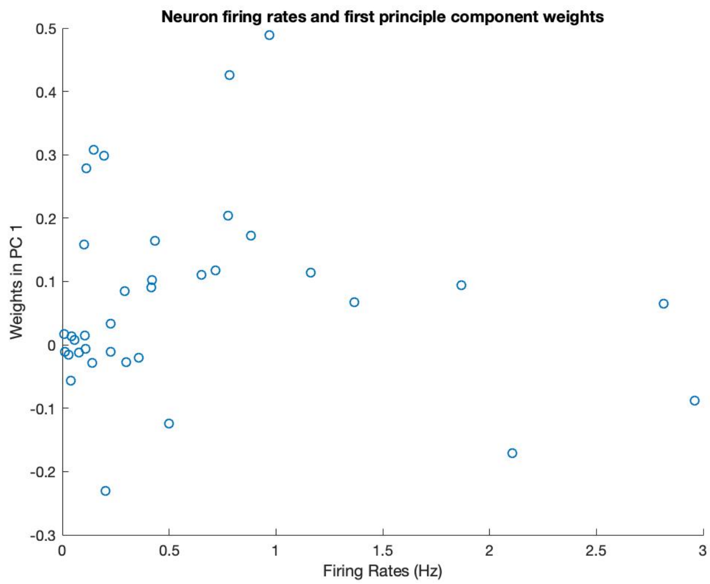

Figure 3 - Neuron firing rates plotted against the weights in the first principle component

5) The score of the first principle component during sleep was computed based on the PC weights of running.

6) Now, we compute the reactivation strength (the squared value of sleep-pre or sleep-post, minus the contribution of individual neurons). This should illustrate relationships between the neuron assembly during sleep pre-running, running, and sleep post-running. Figure 4 shows the reactivation strength as a function of time during sleep-pre and sleep-post. Similar to Figure 2a in Peyrache et al. (Nature Neuroscience, 2009), the reactivation strength is higher during sleep-post running, suggesting that patterns of activity seen during running are re-activated during sleep post-running (i.e. replay). Figure 2a in Peyrache et al. further suggests that this increase in reactivation strength is mostly seen during slow wave (non-REM) sleep, suggesting that it is during these periods of non-REM sleep post-running that we see activity in neuronal assemblies similar to the activity seem during running. Both sleep-pre and sleep-post epochs show a similar lack of replay activity during non-slow wave sleep.

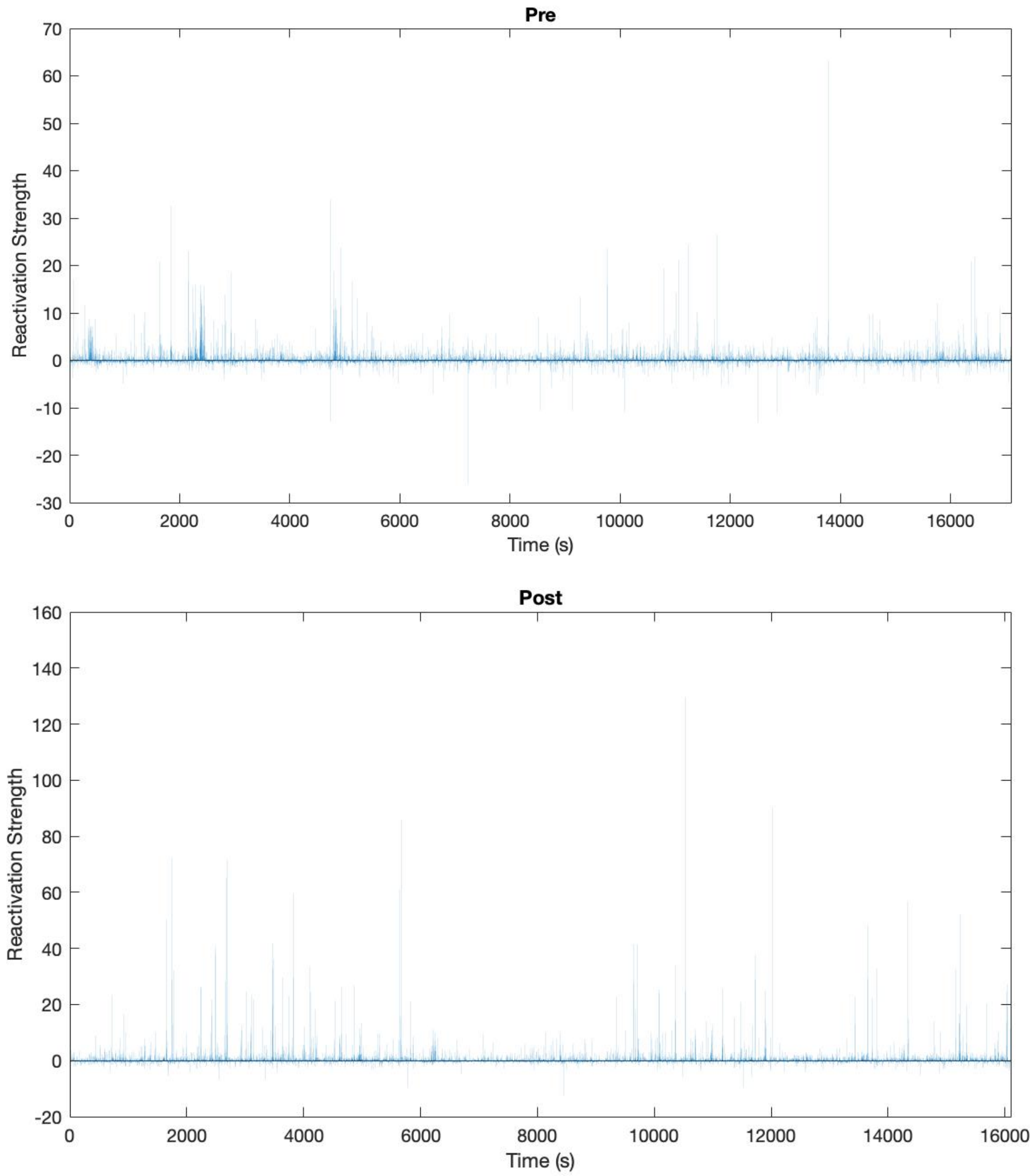

Figure 4 - Reactivation strength calculated from the score of the first principle component during sleep pre- (top) and post- (bottom) running. Note the different scales of reactivation strength seen during sleep-pre and sleep-post.