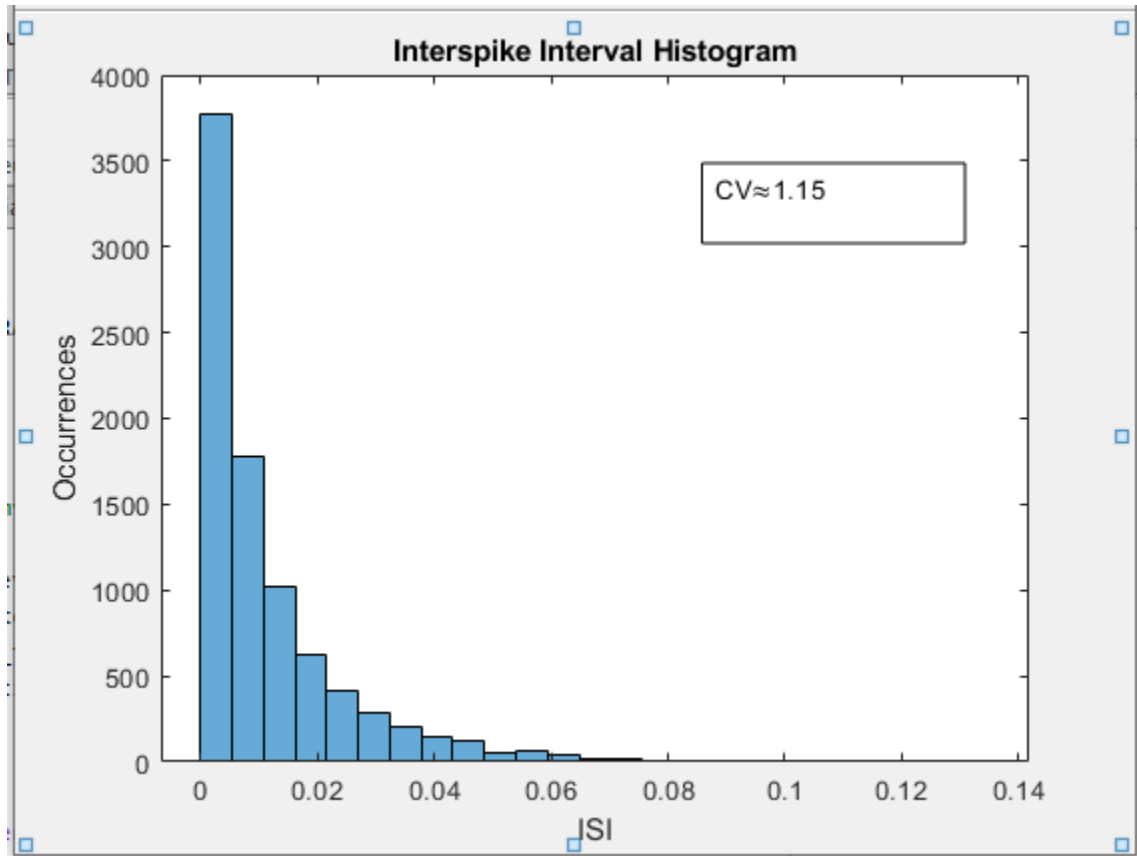Connor Zawacki

Tutorial 3.2

# 1a. (i-ii)



Histogram of interspike intervals reveals that most spikes occur within fairly small time frames of each other, and amount of spikes that occur farther apart from each other continue to decrease according to how far apart they are (exponential decay). This makes sense, as if spikes are happening quickly, it stands to reason that many more of them would occur in a short timeframe than later on, especially in the case where the adaption current isn't scaled following a spike. After running the model several times, the CV value seems to fluctuate from 1.13 to about 1.16, usually lying somewhere near 1.15, however. This would imply either a changing firing rate over time or an irregular spike train. Considering the randomness associated with the noise value, this makes sense.

# 1a. (iii-iv)
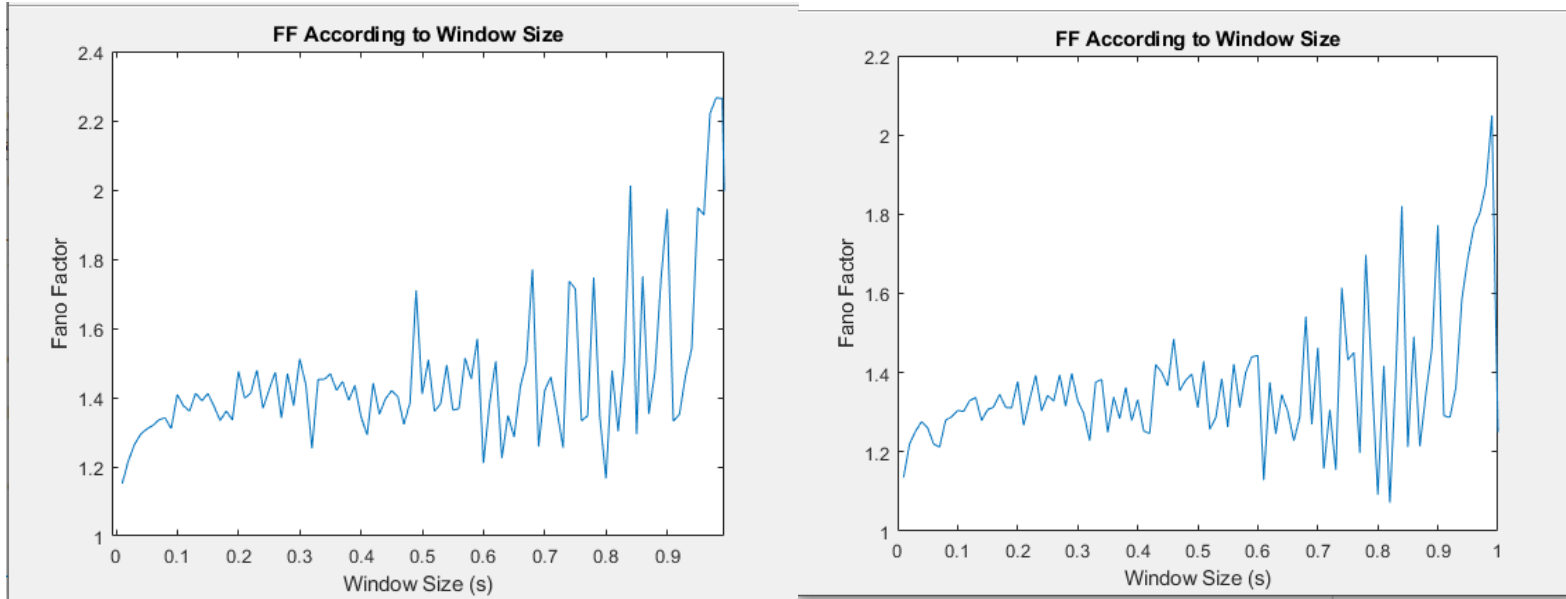


The same calculations/simulations were performed several times in order to analyze common trends seen above. All figures generated looked similar to the ones above. The random nature of spike generation in this particular model creates a significant noise and oscillation in the calculated Fano Factors. Moreover, the larger the window size of a trial, the fewer time bins. If there are fewer time bins, the impact of a randomly generated input current will be more and more apparent. This is because the variance among time bins is very likely (although in principle, not necessarily) to be higher if the time bins are both larger and fewer total.

# 1b. (i-ii)



**Interspike Interval Histogram**
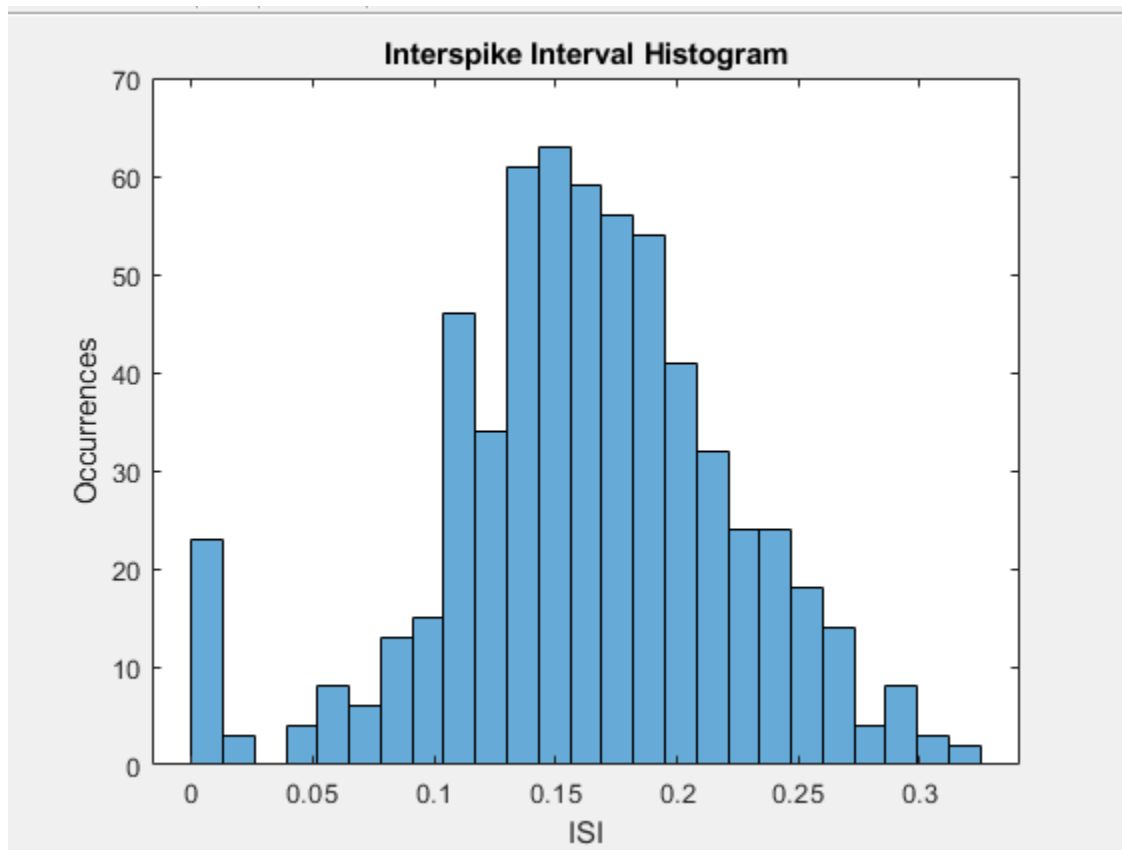
A couple of differences worth particular note here. The only difference between this simulation and the one prior (see 1a) is the change in parameter "b", which is the step used to scale the adaption current after a spike, from 0 to 1nA. Immediately noticeable is that the shape of the histogram is very different. While there is still a considerable number of occurrences of very small ISI values, the increase in adaption current shifted the majority of ISIs to around 0.15 seconds, and a gradual decline in occurrences for values getting increasingly larger or smaller. An additional important impact is that there are considerably less spikes in general. Notice in the last histogram "occurrences" were measured in hundreds to thousands, now they are measured in tens.

ALSO important to note: while not detailed on the graph above, there was a significant reduction in the CV value. CV value in this model lies around 0.38 most of the time, likely mostly due to a higher mean ISI value.

# 1b. (iii-iv)
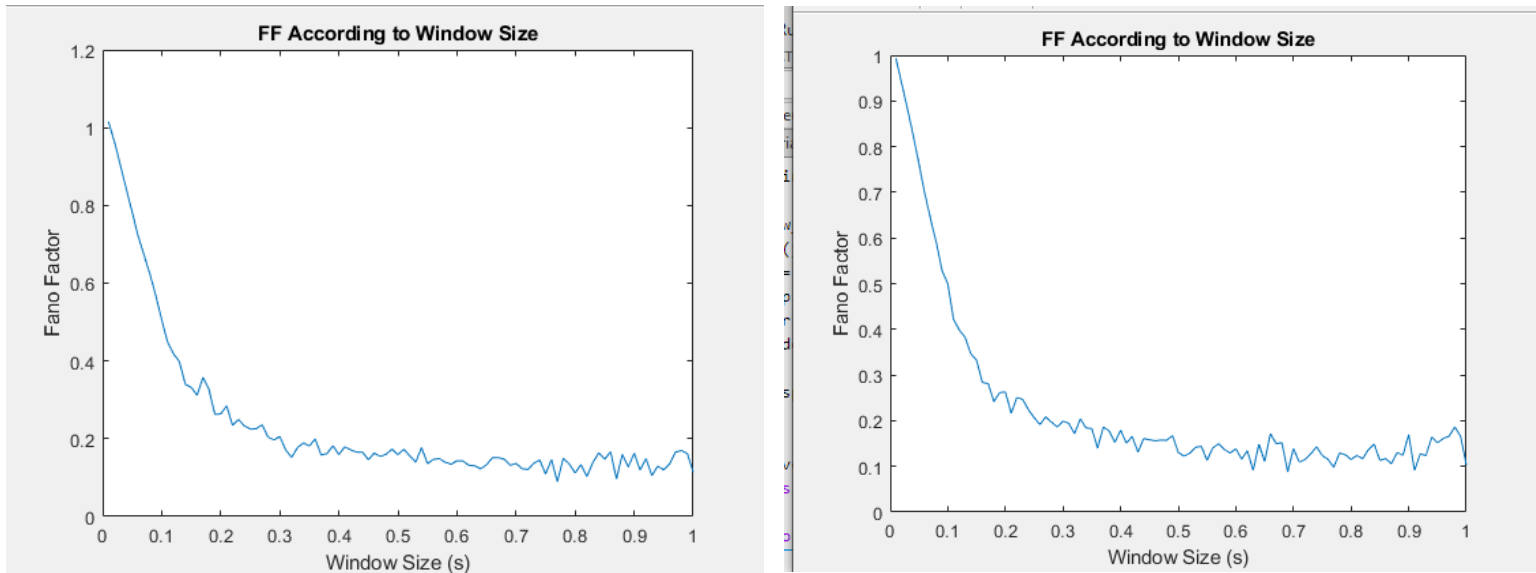


As before, both figures above were results of the same simulation. Fano Factor vs Window size looks very different with a b value of 1nA then it did without a step increase in the ISRA value (adaption current). To begin with, when window size is small, Fano Factor is always very close to 1. This implies that the variance of the number of spikes in each window is very close to the mean of the number of spikes in each window. This makes logical sense, as for very small time bins, the number of spikes in any bin is likely to be either 0 or 1, and the mean of a data set of 0s and 1s should be close to the variation of the same data set.

The big difference to notice however is that as opposed to increasing from a Fano Factor of 1, an increase in the size of the window actually decreases the Fano Factor, implying that the variance is growing slower than the mean. This is because now the spiking of the neuron is somewhat less random, or more accurately, it follows a rule where if it spiked recently, it is unlikely that it will spike again immediately due to the adaption current. This makes spikes more spread apart, and appear at more regular intervals, allowing the mean spikes per window to scale fairly quickly with window size, but variance to lag behind in comparison.
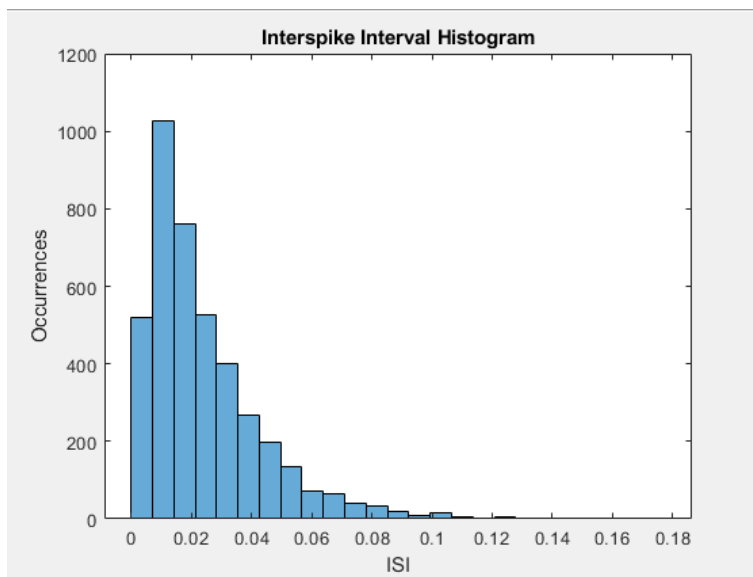
# 1c. (i-iii)
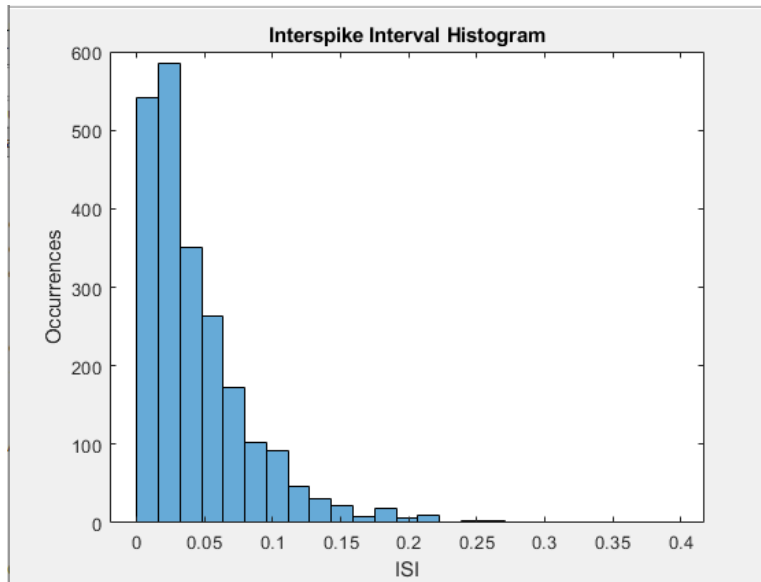


0 added charge

**CV**: usually ranges from 0.85 to 0.9

**Mean spikes in 100ms**: 2.2-2.3 ish

**Variance spikes in 100ms window**: 1.75-1.8 ish
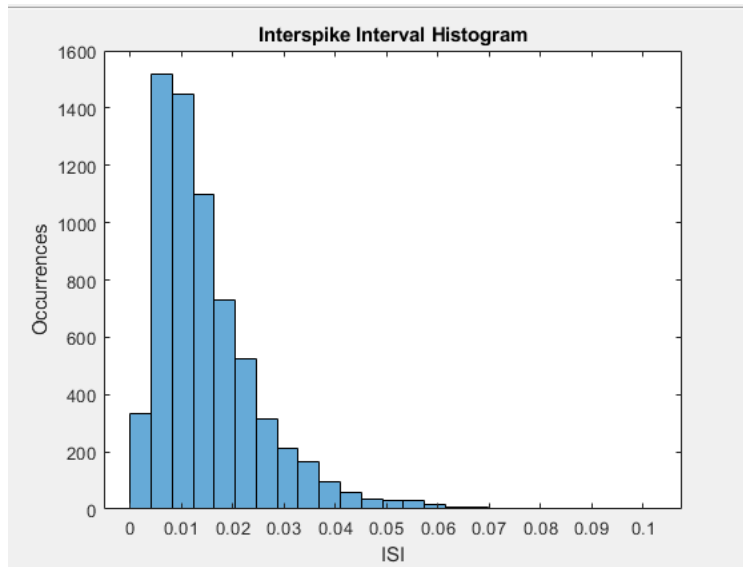
**Fano Factor for 100ms windows:**

usually about 0.8



0.1nA added charge

**CV**: usually ranges from 0.77 to 0.8

**Mean spikes in 100ms**: usually ranges from 4.15-4.22

**Variance spikes in 100ms window**: usually ranges from 2.5-2.8

**Fano Factor for 100ms windows:**

usually about 0.6

Interspike Interval Histogram

0.2nA added charge

**CV**: usually ranges from 0.69 to 0.71

**Mean spikes in 100ms**: usually ranges from 6.5-6.7

**Variance spikes in 100ms window**: usually ranges from 3-3.3

**Fano Factor for 100ms windows:**

usually about 0.47-0.5

As added charge increases, several things happen. Firstly and most obviously, there are just more spikes as the added charge increases. Along similar lines, the most common ISIs get shorter and shorter due to an increase in firing rate. CV (standard deviation / mean) of the ISIs gets progressively smaller as applied charge increases, implying that the standard deviation of the interspike intervals is shrinking faster than the mean. Note that these stats are different form the ones listed in 100ms windows.

The mean spikes in 100ms windows increases with charge, which is expected due to the increase in spikes/firing rate. Variance between several 100ms windows also increases, although less drastically. Fano Factor sees a significant decrease for each increase in charge because the aforementioned mean is growing considerably quicker than the variance, and the Fano Factor is defined as variance/mean of the data.