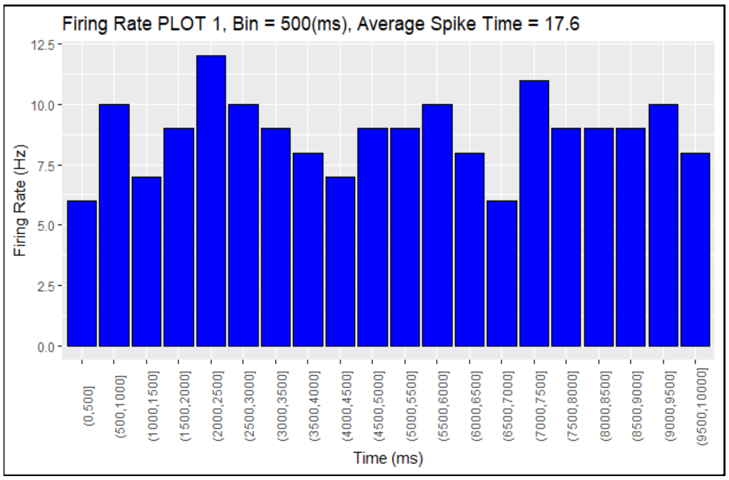
FACT SHEET

FIRING RATE

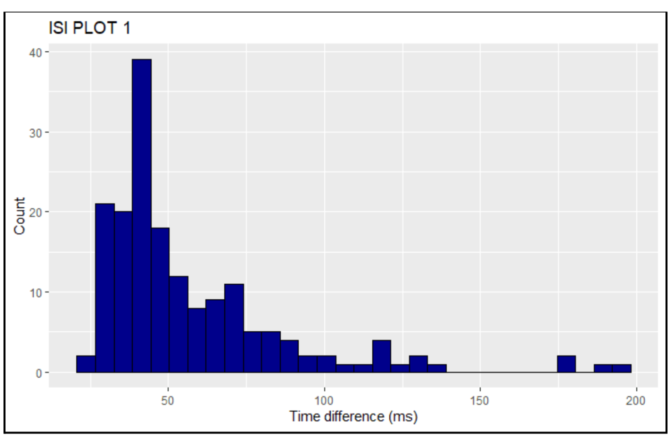
Average firing rate can be calculated using the equation below. R is average firing rate, n is the number of spikes, and t is the time interval in seconds. This outputs the frequency of spikes in the units hertz (Hz).

$$\boxed{r = \frac{n}{t}}$$



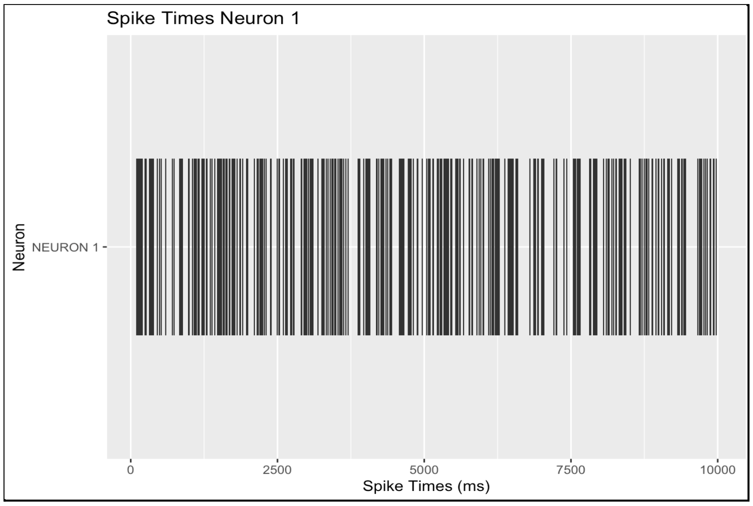
Firing rate plot 1 shows the firing rate in Hz over 10 seconds. There are 20 bins each one of which is 500ms as demonstrated. Each bin holds the spike times that occurred during that specific 500ms timespan to show a trend of how a neuron outputs spikes over 10 seconds. Calculating the average spike per second shows that there are roughly 17.6 spikes per second. While this graph is useful to easily interpret the amount of spikes that happen every 500ms, it’s not nearly the best to view time difference gaps as there are most definitely some gaps in between spikes that aren’t at all present. One way to see these gaps is to decrease the bin size aka the ms per bin. This would allow for the time between spikes to be present, though that isn’t what this graph is meant for. It’s intended to see the trend of firing rate throughout the entire trial. A trend which can also go into further detail if bin sizes were smaller.

INTERSPIKE INTERVAL (ISI)



ISI plot 1 is based on the same data as Firing Rate 1. This ISI plot is designed to show time differences in ms throughout the entirety of the data. To further explain it explains the length of time from one spike to another and gathers count of how often similar time differences occurred. In this case it seems each bin is roughly 10ms. Spikes within 10ms of a difference are grouped together into bins to show trends in time differences between spikes. This Specific ISI plot shows that a time difference of 40ms is clearly the most common. It appears slightly under 40 times throughout a 10 second time frame with second place being 20ms time difference but only appearing half as many times as a 40ms time difference. Throughout the plot it's also easy to identify that longer time differences are unpreferred due to the graph being skewed to the right. In the dataset table, it's easy to see over this 10 second period of time as time moves on and the time difference grows.

SPIKE TIMES



The spike train plot in the figure above shows the spike times of neuron 1 across 10,000 ms. For this graph, we can see that there is a high average firing rate because of the high density of the spikes. We can also see that there are fairly inconsistent interspike intervals because of the larger gaps in the spikes. Spike time plots like the one shown above are useful for showing general trends in the neurons data, such as the level and consistency of firing rate and interspike intervals. However, it is very difficult to extract specific information from this graph without binning the spikes or splitting up the data in a useful way. So, typically in representing neural data, the ISI or firing rate graphs are more useful for specific information.

PROBABILITY OF FIRING

A **Poisson Point** process is a random process that generates a sequence of events in which each event is independent. By computing the probability of n independent spikes occurring in a specific time interval (Δt) out of k total spikes, we get the Poisson probability density function (pdf) of spike counts. We can also compute the Poisson distribution for interspike intervals (ISI) of neurons by using the probability that a neuron did not spike in a specific time interval and differentiating it to get the pdf of ISI. Note that r is firing rate and must be kept constant. It is also important to note that although there is a high probability for short intervals in the ISI distribution, it is not possible to have super short intervals in neurons due to refractory periods.

Poisson of Spike Counts

$$\boxed{p(n \text{ spikes in } \Delta t) = \frac{(r\Delta t)^n}{n!} e^{-r\Delta t}}$$

Poisson of ISI

$$\boxed{\mathrm{pdf}(\tau) = re^{-r\tau}}$$

These equations compute the normal variability of spike counts and ISI's for neurons, and using these normal distributions, see if a specific neuron is more or less variable than the "normal". To compute the variability of spike counts we use the **Fano Factor (FF)** and to compute the variability of ISI we use the **Coefficient of Variation (CV)**. Conveniently, for a Posson process the **FF** and **CV** are both 1 which means if FF or CV < 1, it is more regular than Poisson, and if FF or CV > 1, it is more regular than Poisson. If the FF is more regular than Poisson, this means that it has low variance in firing rates and they are more constant through the whole recording (and vice versa). If the CV is more regular than Poisson, this means it has low variance in the interspike intervals and they are more consonant through the whole recording (and vice versa).

FANO FACTOR:

$$\boxed{FF = \frac{\sigma_n^2}{\mu_n}}$$

COEFFICIENT OF VARIATION:

$$\boxed{CV = \frac{\sigma_\tau}{\mu_\tau}}$$