**Exercise: Using spike-triggered averaging to characterize neural receptive fields**

In this exercise you will learn a simple but important technique to determine to which stimulus a given neuron fires spikes preferentially. The technique is called *Spike-triggered averaging (STA)* and is one of the simplest ways to characterize the receptive field of a neuron.

The idea behind STA is straightforward from a conceptual point of view. Basically we will construct a time-varying stimulus, typically random samples from white noise. The objective here is that a sufficiently long trace of white noise captures all possible stimuli. Then, we will present this stimulus to a neuron and record concurrently the time at which spikes occur.

In Figure 1 we illustrate how the STA is computed. In essence, for each spike we look at the stimulus that preceded it over a fixed time-window (shown as a pink box for each spike event). Next we add up these stimulus snippets and divide by the total number of spikes, to get an estimate of the average stimulus that most likely makes the neuron fire. This final result is the STA, which is shown at the bottom of Figure 1 as a red trace.

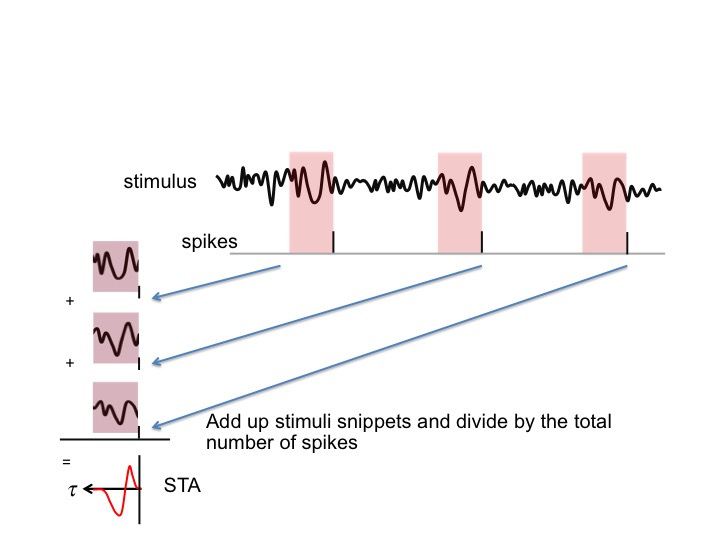


Figure 1: Schematic diagram of how to compute the STA

This calculation has a set of implicit assumptions about the neuron and how it responds to stimuli. We leave as an open mental exercise for you to pinpoint what these assumptions are, and more importantly, to identify the potential limitations and shortcomings of this method.

**Part 1: Calculating the STA for the H1 motion-sensitive neuron**

The data set given to you is in the MATLAB file named c1p8.mat. This file comprises a stimulus vector (named stim) and a binary spike train vector (named rho), both sampled at 500 Hz. These two vectors are the same length because they represent measurements of two different quantities over the same time period. The binary spike train vector has a 1 if a spike occurred in the time bin corresponding to that index and a 0 otherwise.

The spikes were recorded from the famous H1 motion-sensitive neuron of the fly *Calliphora vicina*[[1]](#footnote-1). This neuron responds to motion: your job is to determine how exactly it processes a motion stimulus. The stim vector contains the velocity of a pattern of vertical bars experienced by the fly during the recording of those spikes.

Your task is to write some MATLAB code to read the data and compute the spike-triggered average to recover the temporal receptive field of this neuron.

1. Load the data file c1p8.mat into MATLAB
2. How many milliseconds are there between adjacent samples (what is the sampling period)?
3. For how many hours was the activity of the neuron recorded? Round your answer to the closest integer.

We wish to compute the spike-triggered average for this neuron over a window of width 300 msec. Suppose we do not care about the value that is exactly 300 msec before the spike.

1. How many elements (time steps) will be in the resulting spike-triggered average vector?

In order to calculate the average, it is necessary for us to know how many time windows (stimulus vectors) we are averaging over. This is equal to the number of observed spikes that occurred after 300 msec into the recording.

1. How many spikes were observed in this recording? You should not count any spikes that occurred before 300 ms from the beginning of the recording. Why is this necessary?

With all this information we are now ready to write MATLAB code to compute the spike-triggered average. Remember that the spike-triggered average is the element-wise mean of the time windows starting 300 msec before (exclusive) and ending 0 msec before a spike (i.e. at the bin where the spike occurred). This calculation is easy to implement with a for-loop iterating over the number of spikes that occurred after 300 msec into the recording. Once you finish the computations, plot the STA. It should look like this:



Note that we have set as time zero, the instant where the spike occurs, and all other times are negative, as they happen before the spike.

1. Look at the STA and think about what is the stimulus preference of this neuron. Additionally think about what mathematical operation of the stimulus it implements.

1. Courtesy of the lab of Dr. Robert de Ruyter van Steveninck. Data obtained from: <http://www.gatsby.ucl.ac.uk/~dayan/book/exercises/c1/data/c1p8.mat> [↑](#footnote-ref-1)