BMES 477/710: Neural Signals

Lab 4 PSTH

In this lab you are required to write MATLAB functions to generate peristimulus time histograms (PSTHs). You will find a respective dataset on Bb Learn. A description of the dataset organization is provided.

Answer all questions and provide all figures in one document. Please also separately attach your MATLAB code when you upload the homework on Bb Learn. **The code must be commented**.

Introduction: PSTH and neurophysiological parameters.

Dataset organization: The file PSTH.mat is a cell array whose first two elements contain numerical arrays representing the time each spike occurs (in seconds) for two neurons in the rat barrel cortex (somatosensory representation of the whisker system). Once you load this dataset in MATLAB you should be able to access all the spike times of neuron one or two with the command 'PSTHdata{1}' or 'PSTHdata{2}' respectively. The remaining 2 columns (PSTHdata{3,4}) contain numerical arrays representing the stimulation times (in **seconds**) of two different whiskers (locations L1 and L2).

PSTH Algorithm: In general, the peristimulus time histogram (PSTH) shows the conditional probability of a spike in the spike train at time t on the condition that there is a reference stimulus at time zero. The time axis is divided into bins of size Δt. The first bin is [XMin, XMin+Δt). The second bin is [XMin+Δt, Xmin+Δt *2), etc. The left end is included in each bin, the right end is excluded from the bin. Let ref[k] be the array of reference events (stimulation times) for one whisker and ts[i] be the array of spike times for one neuron.

If you are familiar with counting how many times something occurs and putting it in bins, you may realize this is essentially the creation of a histogram. You can write your own histogram function to collect spikes in bins (see **A** below) or you can use MATLAB functions like "histcounts" to do this for you.

A. If you are writing your own function, for each timestamp ref[k]:

1) calculate the distances from this stimulus to all the spikes in the spike train: d[i] = ts[i] - ref[k]

2) for each i:

if d[i] is inside the first bin, increment the bin counter for the first bin:
if d[i] >= XMin and d[i] < XMin + Δt

then bincount[1] = bincount[1] +1

if d[i] is inside the second bin, increment the bin counter for the second bin:
if d[i] >= XMin+Δt and d[i] < XMin + Δt *2

then bincount[2] = bincount[2] +1

and so on... .

If the desired unit of measure is Counts/Δt, no further calculations are performed. If the desired unit of measure is Probability, bin counts are divided by the number reference events (remember, this does not apply if Δt is too large). If the desired unit of measure is Spikes/Sec, bin counts are divided by NumRefEvents*Δt, where NumRefEvents is the number of reference events.

B. If you instead decide to use a function like *histcounts* to place spikes in bins, you still need to shift the spikes with respect to each stimulus time before collecting the spikes around that stimulus time. We will walk through this in class, but please contact Dr. von Reyn if you still have questions.

Part 1. Generation of the PSTH for location L1 and L2

a. Use your dataset to generate the peristimulus time histogram (PSTH) of the 2 neurons ('PSTHdata{1}' and 'PSTHdata{2}') for stimulus location L1 and L2 ('PSTHdata{3}' and 'PSTHdata{4}'). Use a binsize (Δt) of 1ms (**0.001 seconds**) and let Xmin = -100 ms and Xmax = 100 ms (**-0.1 seconds and 0.1 seconds**). Generate a graph for each neuron for each stimulated location. Make sure you put the unit of measures on each axis (x is time, y is the probability a spike occurs in that bin).
b. Describe qualitatively if the neurons are responding to the stimulus.

Part 2. Extraction of neurophysiological measures from the PSTH

The PSTH can be used to extract quantitative measures that characterize the response of the neurons to the stimulus. In order to identify significant responses in the PSTHs: a threshold is set as the average background activity (BA) of the neuron (evaluated from 100 to 5 ms before the stimulus) plus 3 standard deviations (SD) of the BA, the first and the last significant bin (1ms binsize) must exceed the threshold in a window between 5 and 90 ms after the stimuli are identified and the first significant bin must be followed by at least two additional consecutive bins over the threshold. For every significant response, four parameters are extracted from the PSTH: (i) the response magnitude (**RM**), defined as the sum of the PSTH between the first and the last significant bin (**FSB** and **LSB**); (ii) the peak response (**PR**), defined as the maximum probability of a spike occurring in a bin; (iii) the first significant bin latency (**FBL**); (iv) the last significant bin latency (**LBL**) and (v) the peak latency (**PL**), defined as the time intervals between the stimulus onset and the first significant bin or the peak, respectively

a. Generate a table for both neurons for both stimulated locations containing each of the five parameters (**RM**, **PR, FBL**, **LBL**, and **PL**) given above. Make sure the starting PSTHs are generated using the probability unit of measure.
b. How do these measures relate to the qualitative observations for part 1.b?
c. Which of these parameters would you use to decide if the neuron responded or not to a stimulus location and why?
d. The threshold is calculated as the BA + K*SD(BA), where we set K=3 to obtain the measures calculate in (2.a). What do you think it will happen, if you vary the value of K, to the measures of the table obtained in (2.a)?
e. Given your observation in point (2.d), what is the advantage of having K different than zero?