Study of the variability of the response of AUDITORY NEURONS

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The auditory neurons produce action potentials (spikes) in response to sound stimulus. This spikes depends both on the stimulus and on the previous history of the neuron. When we use the same stimulus, there are some variability about the time where the spikes are produced. This can be seen in the Post Stimulus-Time Histogram (PSTH) as peaks. We can then get the mean-time value and the standard-time deviation (jitter) at whick the spikes are produced. Besides, different stimuli can elicit different number of spikes asociated to that stimulus(burst).

In this work we develop an algorithm to detect peaks in the PSTH. Then, we can get automatically the values of the mean-time value and the standard- time deviation ot those peaks. This is an alternative way of obtained the jitter to the calculation on a moving time window. Besides, we classified the response of the neuron attending the number of spikes being elicited (multiplicity). Then, we get the Stimulus Time Average (STA) for both the case where the response are not classified and the case where they are. This show a decrease in the error of the estimate for the second case. We get the correlations betwen the classified responses and show that there is no correlation betwen responses with different

EXPERIMENTS

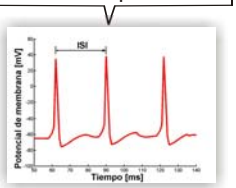
All the experiments were performed at Theoretical Biology Intitut of the Humboldt University.

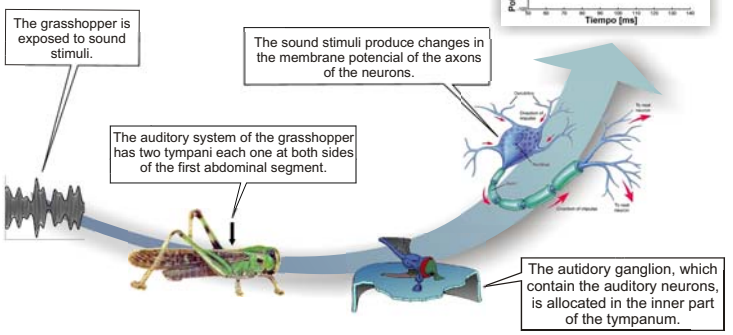
Measurement groups available:

1) 75 neurons, each one exposed to 2 stimuli with different deviation and/or cutoff frequency.
2) 106 neurons, each one exposed to 3 stimuli with different cutoff frequency.

Both groups: 1 measurement of 10s long and 100 to 500 measurements of 1s long .

The aim of the experiments is to measure this chain of action potencial (spikes train) after the stimulus was presented.

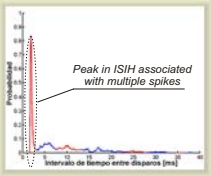




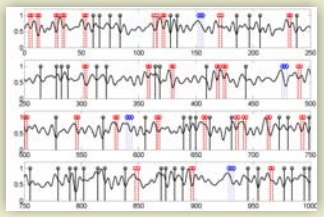
RESULTS

SPIKE CLASSIFICATION

We have seen that the presence of multiple spikes are associated to the presence of a sharp peak at the begining of the Interspike Interval Histogram (ISIH) as is showed in the figure at the left.



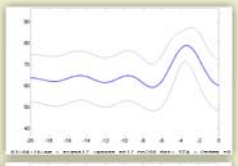
We found this sharp peak at the begining of the Interspike Interval Histogram and classified the spikes taking account of this peak as the long of the refractory period. The figure at the right shows the classification maden.



Simple spikes — Double spikes — Triple spikes

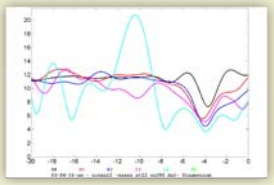
COMPARISON OF STIMULUS TIME AVERAGES OF DIFFERENTS MULTIPLICITIES

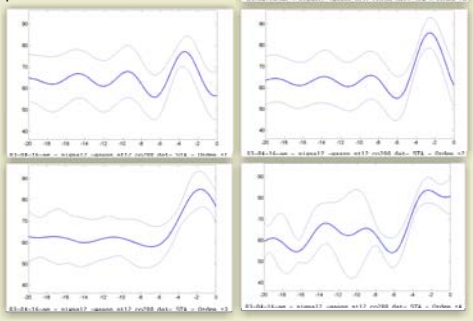
We calculate the Stimulus Time Average in the case of spikes without classified them (index 0) showed at the top right figure and in the case of spikes classified were we calculate a different Stimulus Time Average for each multiplicity (index 1..N) showd in the figures at the bottom right.



We saw that different multiplicity has different stimulus that elicit it. We can see that the difference is about the amplitude and the temporal wide of the fluctiation of the stimulus before it elicit a spike.

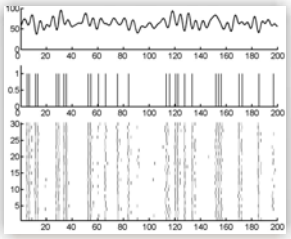
The uncertainty of the Stimulus Time Average is less in the case of considering classified spikes. This is showed in the figure at the bottom.





DATA ANALYSIS

GRAPHIC REPRESENTATION OF THE MEASUREMENTS



The figure at the top shows the amplitude of the envelope wave of the stimulus (dB) as a function of the time.

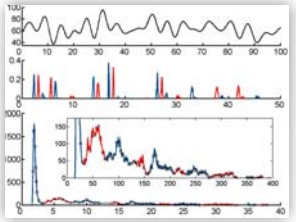
The figure at the middle shows the times where the neuron fired because of the stimulus showed above.

The figure at the bottom shows the times where the neuron fired after the stimulus was presented several sussesive times. We can see the variability in both the time where the neuron fired and the number of spikes fired by the neuron.

We can matematically write the measurements as *Spikes Trains* where the t_i^j are the times where the neuron fired: $\rho^j\left(t,\{t_i^j\}\right)=\sum_i \delta\left(t-t_i^j\right)$

From this we can build the *Post Stimulus Time Histogram (PSTH)* by abbing all the spikes trains measured as a response to the same stimulus: $PSTH(t)=\sum_j \rho^j\left(t,\{t_i^j\}\right)$

and the *Interspike Interval Histogram (ISIH)* : $ISIH(\tau)=\sum_j\sum_i \delta\left(t_{i+1}^j-t_i^j-\tau\right)$



The figure at the middle shows the *Post Stimulus Time Histogram (PSTH)* obteined from the measurements of the responses of the neuron to the stimulus showed above. The figure at the bottom shows the *Interspikes Interval Histogram (ISIH)*, where the picture at the top right shows the flat zone in a higher scale.

We applied the *peaks detection algorithm* to both the PSTH and the ISIH. The peaks found are shown in differents color for the sake of clarity.

PEAKS DETECTION ALGORITHM

We associate to *Post Stimulus Time Histogram (PSTH)* and to the *Interspikes Inteval Histogram (ISIH)* with relatives frequencies and estimate the fisrt moment (mean p) and second moment (standard deviation σ) for the *generating probability distributions (see **Samengo, Inés**)*.

Every peak is characterized by among a maximum **M** and two minima $\mathbf{m}_1$ y $\mathbf{m}_2$ at both sides of the maximum ($\mathbf{t}^m{}_1<\mathbf{t}^M<\mathbf{t}^m{}_2$). They must verified that :

- $p(\mathbf{t}^m{}_1)+\sigma(\mathbf{t}^m{}_1)<p(\mathbf{t}^M)-\sigma(\mathbf{t}^M)$
- $P(\mathbf{t}^m{}_2)+\sigma(\mathbf{t}^m{}_2)<p(\mathbf{t}^M)-\sigma(\mathbf{t}^M)$

MULTIPLICITY OF SPIKES

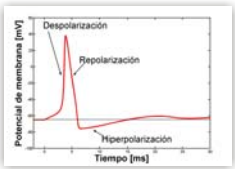
The membrane potential changes when the neuron fires. This is shown in the figure at the left.

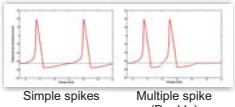
Both the repolarization zone and the hiperpolatization zone are associated with a *refractory period*. In this period the neuron starts to recover his capacity to fire.

A spike will be simple if when it is elicited the neuron has full capacity of firing. This means that the spike is elicited after the refractory period.

The *multiplicity of a spikes* is the number of sussesive spikes elicited inside *refractory pediods*.

The bottom left figure shows simple spikes and the bottom right figure shows a double spike.

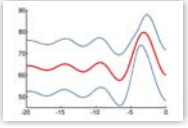


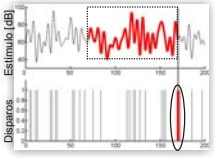


Simple spikes — Multiple spike (Double)

STIMULUS TIME AVERAGE (STA)

This is the mean stimulus that eliicit the neuron to fire a spike.The figure at the right shows the Stimulus Time Average (STA) (red) and the uncertainty (blue).





In order to calculate the Stimulus Time Average we identify a spike (bottom) and take a temporal window before it. Then we associate the stimulus inside this temporal window with the spike.

The Stimulus Time Average is the mean value of all stimulus associated with spikes identified.

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