What is the Neural Basis of Rhythm?

MERIT FAIR
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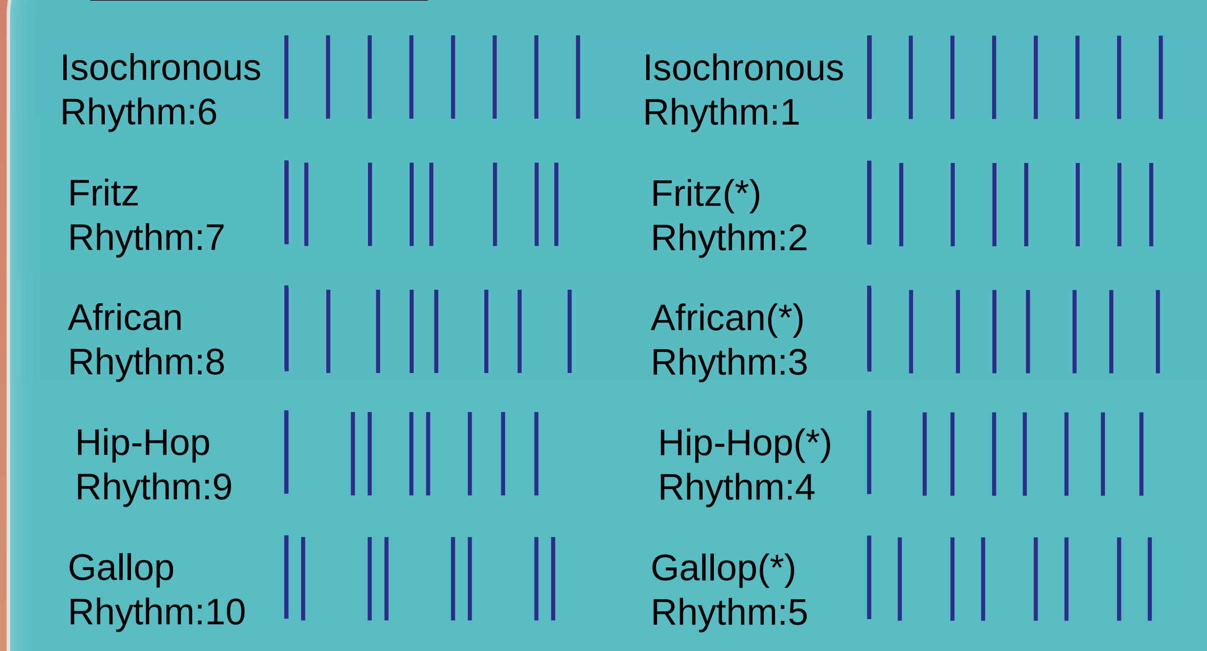
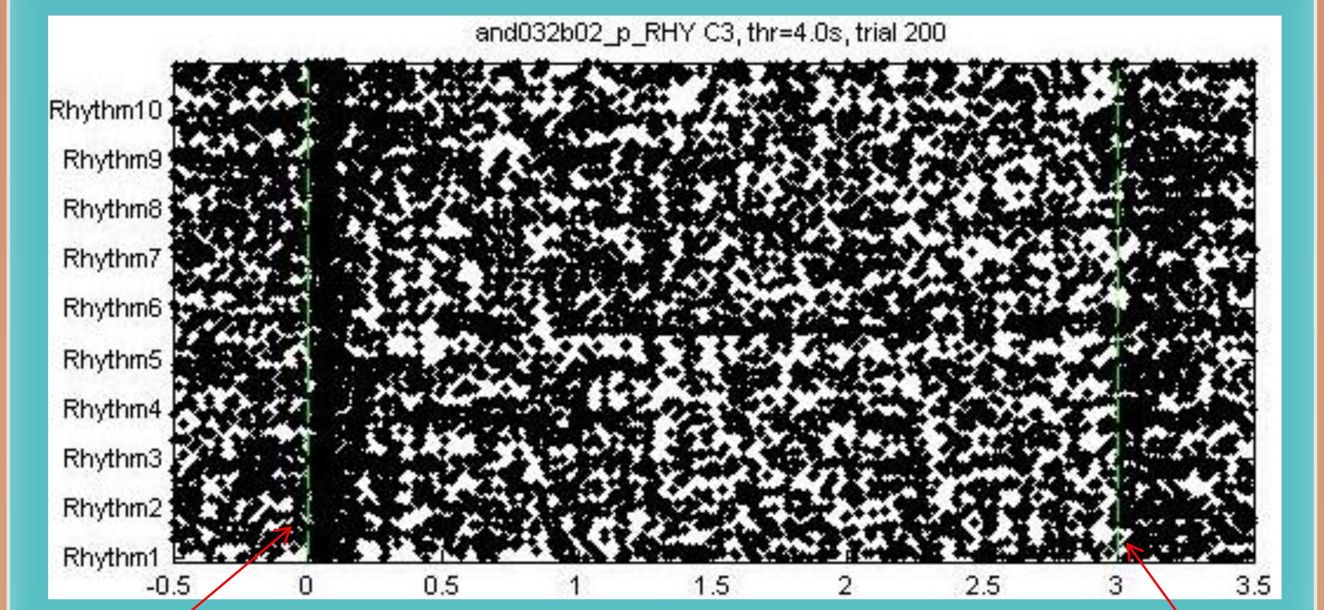
Purpose:

To compare neural responses during passive listening to rhythmic acoustic stimuli to gain better insight into the neural basis and perception of rhythm .

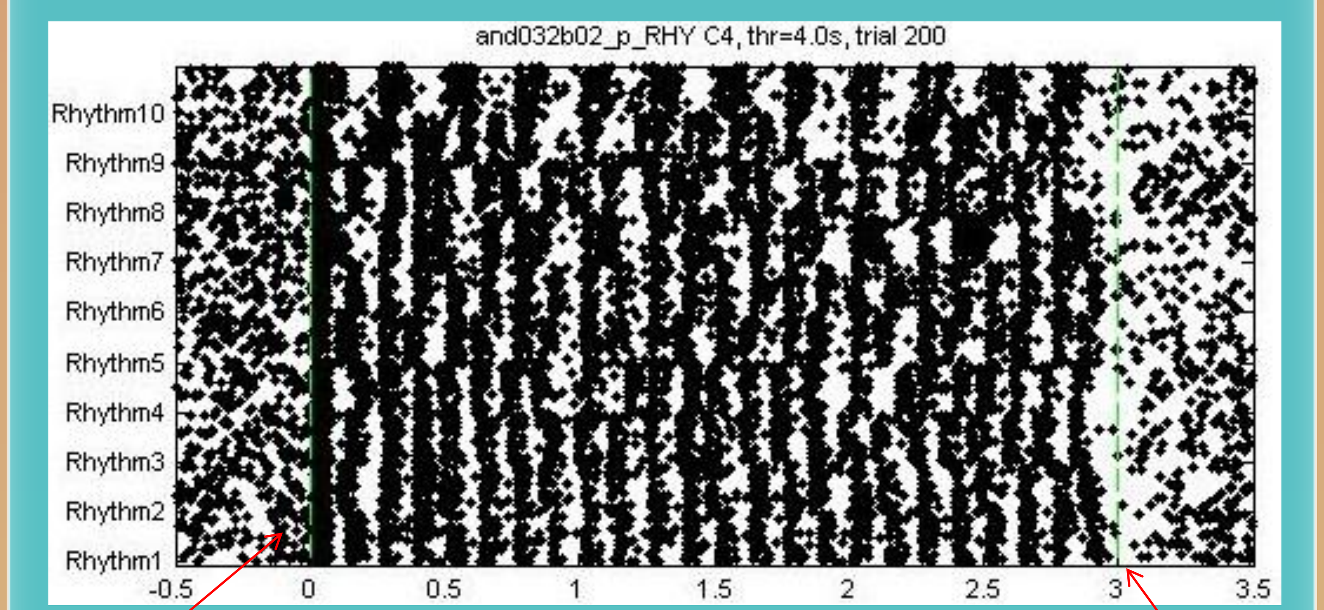
Stimulus:

(*): Averaged w/ Isochronous





Stim. Onset — Neuron firing displaying strong onset response to stimulus — Stim. Offset



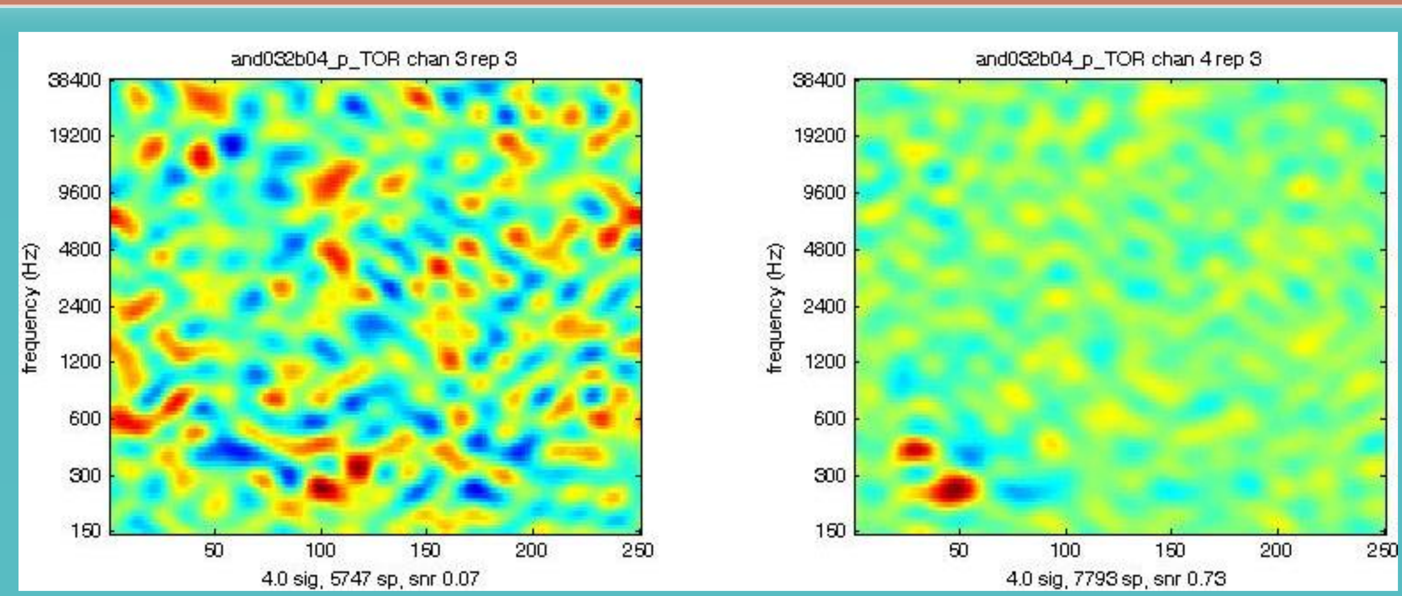
Stim. Onset — Neuron firing that appears in direct correlation to stimulus — Stim. Offset

Methods:

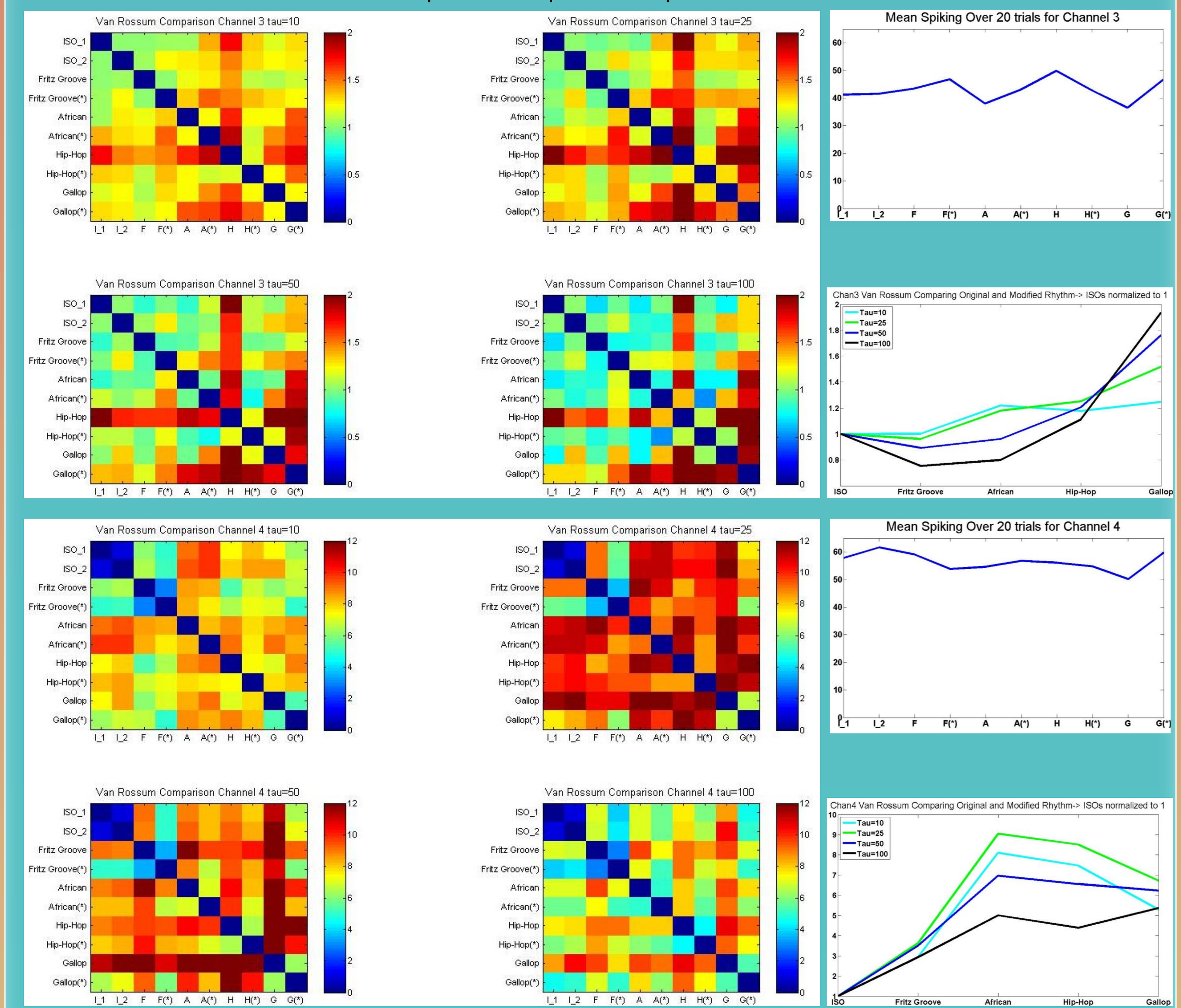
Recordings were taken in a double walled sound insulated room, with tungsten electrodes inserted into Auditory Cortex. Tuning curves and cell responses were measured. An in ear speaker was used to play the stimulus to two female ferrets who had been previously trained on auditory discrimination tasks independent of rhythm. There was one recording session for each animal. One recording used an independently moveable four electrode array. The other recording used an implanted thirty two electrode array. The electrodes used were tungsten. Data was recorded from 11 tuned and characterized cells using all rhythm stimuli MATLAB.

Naïve Animal Data:

Through presenting differing rhythm stimulus passively to a ferret, comparisons of neural spike trains to physical can display differences in the processing of rhythms. Comparing these unique spike trains unique rhythms can aid to display how the rhythms are represented in A1.



Spectro-Temporal Receptive Fields



Analysis of cells on the left using van Rossum techniques in a comparison matrix

Results:

Different neuronal populations provided an array of responses. This varied from a delayed onset response to direct firing correlation to inhibitory responses. Even cells that displayed comparable STRF had dissimilar responses. However, within-cell comparisons are made between stimulus, with two isochronous rhythms played to display inner cell variability. It's possible that each cell has a preferred integration window when responding to stimuli. This would defend why van Rossum integration times do not show a definite positive trend displaying stimuli approaching equality.

Analysis:

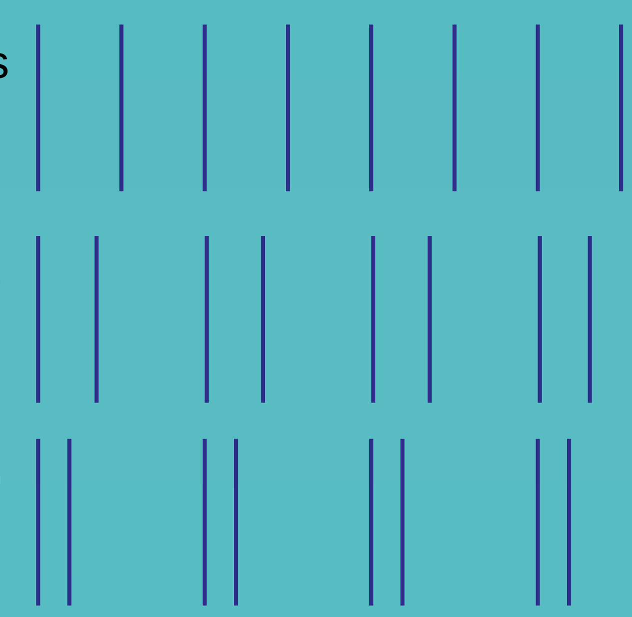
Van Rossum Spike Comparison: Involves convolving a neural spike train with an exponential decay function. To calculate the difference: $(1/t_c)\{F(x)-G(x)\}^2$ The variability of the exponential decay is proportional to the importance of grouping and absolute timing of the spikes

Firing Rate Comparison: Summing the total number of spikes over a short trial period to determine if spiking variability is dependent upon timing or spike number.

Physical v. Brain Processed Separation

$G[*]=(G[\ ]+I[\ ]/)2$

Inner-click-interval vectors

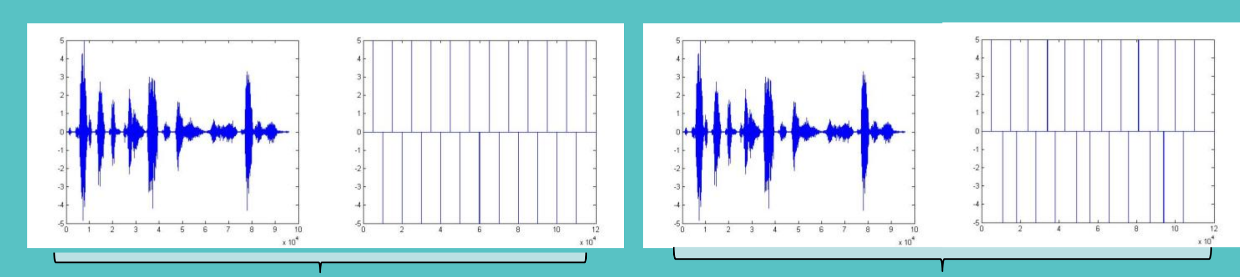


Physically the distance from G(*) to G and I is identical. However cell 3 displays dissimilarity, that is G(*) has a greater spike train difference across the wide range of tau tested.

Conclusion & Future Studies:

In Auditory Cortex there is not a direct correlation between the neurons firing and the physical rhythmic stimulus presented. Given the values of tau it's reasonable to assume that Primary Auditory Cortex(A1) may integrate the sound over a longer interval than the presented stimulus. It is quite possible that because of the nature of the timing mechanisms involved, there is rhythmic parallel processing that occurs prior to information reaching A1.
A study should be conducted with sufficient time to acquire behavioral and neurological data consecutively so inner-cell variability can be classified as more than noise(i.e.: animal attention or relative sound importance). Also data collected from known secondary auditory areas and simultaneous recordings from timing networks can give greater insight into how the mind processes rhythm. Preliminary behavioral data was collected using below method:

Reference: Naturalistic modulated band-pass noise and click train interweaved
-Provides temporal response properties
Target: Click train with a distinct rhythm



References:

Hackett, Troy A. "Information Flow in the Auditory Cortical Network." *Hearing Research* (2011): 133-46. *Elsvier*. Web.
Rossum, Van. "A Novel Spike Distance." *Neural Comp* 13.4 (2001): 751-63. *PubMed.org*. Web.
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