Modeling Responses to Social Vocalizations in the Inferior Colliculus of the Mustached Bat

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Introduction

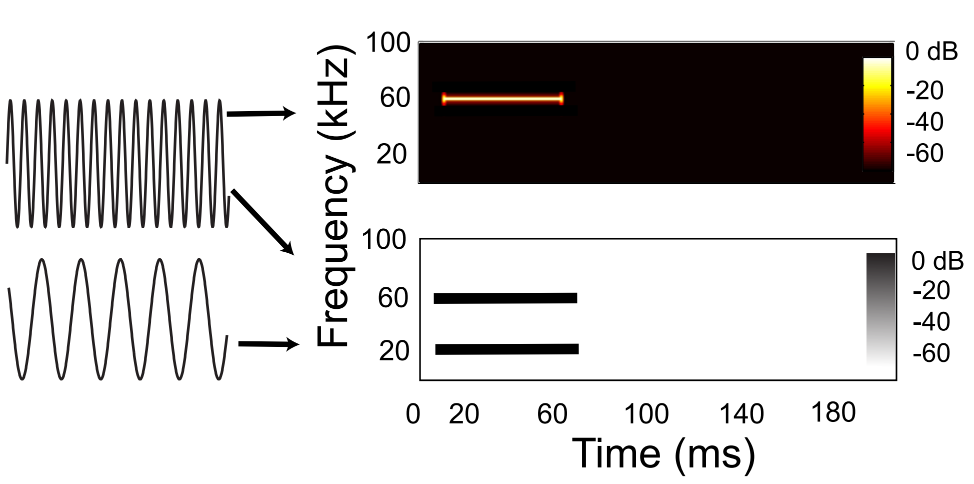
The inferior colliculus (IC) is believed to respond to complex features of auditory stimuli by integrating sensory input from multiple frequency bands and time delays. In the mustached bat, neurons that integrate frequency information in complex signals are involved in encoding echolocation signals. It is hypothesized here that neurons that integrate frequency information are also important for encoding social vocalizations. The mustached bat emits a varied repertoire of social vocalizations and most of these vocalizations are complex in frequency and time. In this study we modeled responses of IC neurons to social vocalizations to quantify the contribution of frequency interactions in eliciting neural responses.

Recording Responses from Single Neurons

We used micropipette electrodes to record single unit responses in the IC of awake mustached bats to single tones, two-tone combinations and social vocalizations. The suite of social vocalizations consisted of those that mustached bats readily emit in captivity. These calls were provided by J. Kanwal. Each neuron was presented with at least 10 different vocalizations at different intensities.

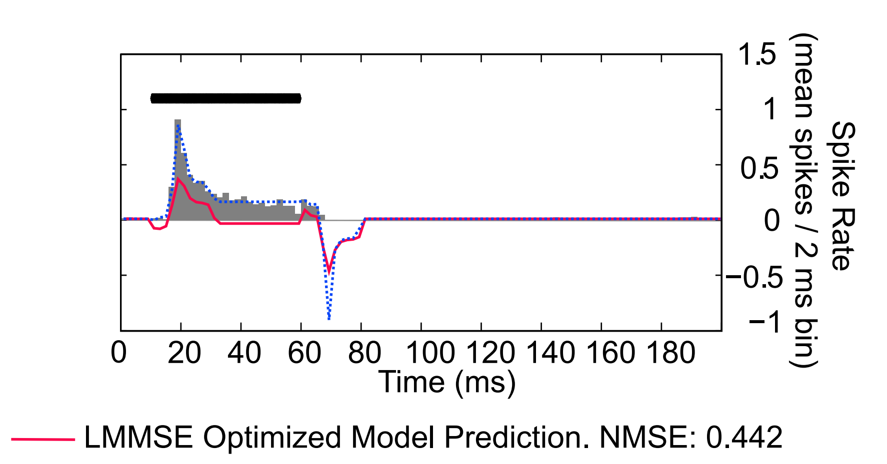
Building the Stimulus-Response Model

All the frequencies presented in the one and two-tone tests were the inputs to the model.
Stimuli were represented in spectrographic format.



The PSTHs recorded from each neuron for the same frequencies used as input were used to tune the model output.

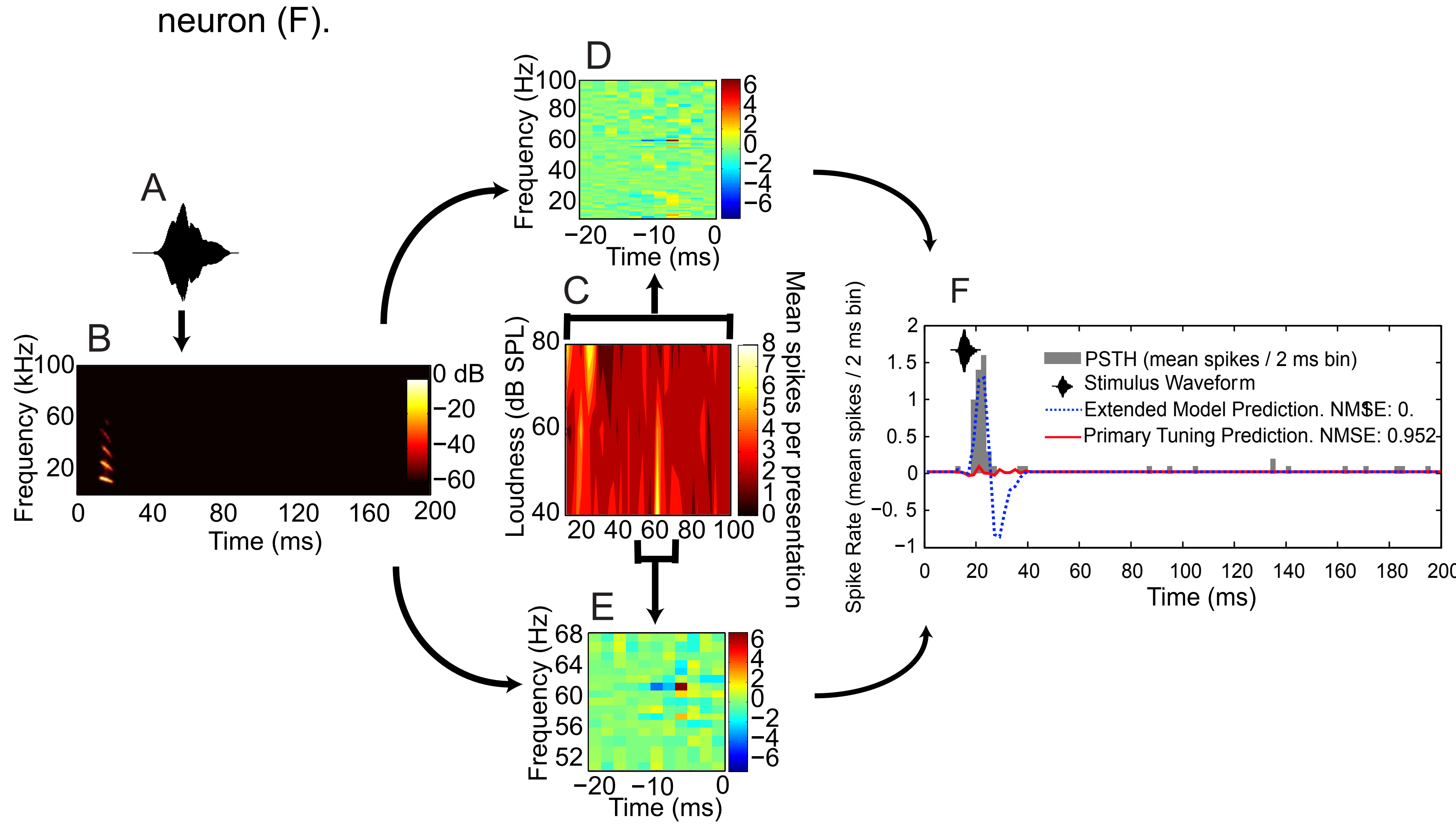
The model was first fit using an LMMSE algorithm and then refined using a gradient descent algorithm after introducing a non-linearity in the optimality criteria. The non-linearity fit model provided a better prediction of the tone responses.



Using the Stimulus-Response Model to Predict Responses to Social Vocalizations

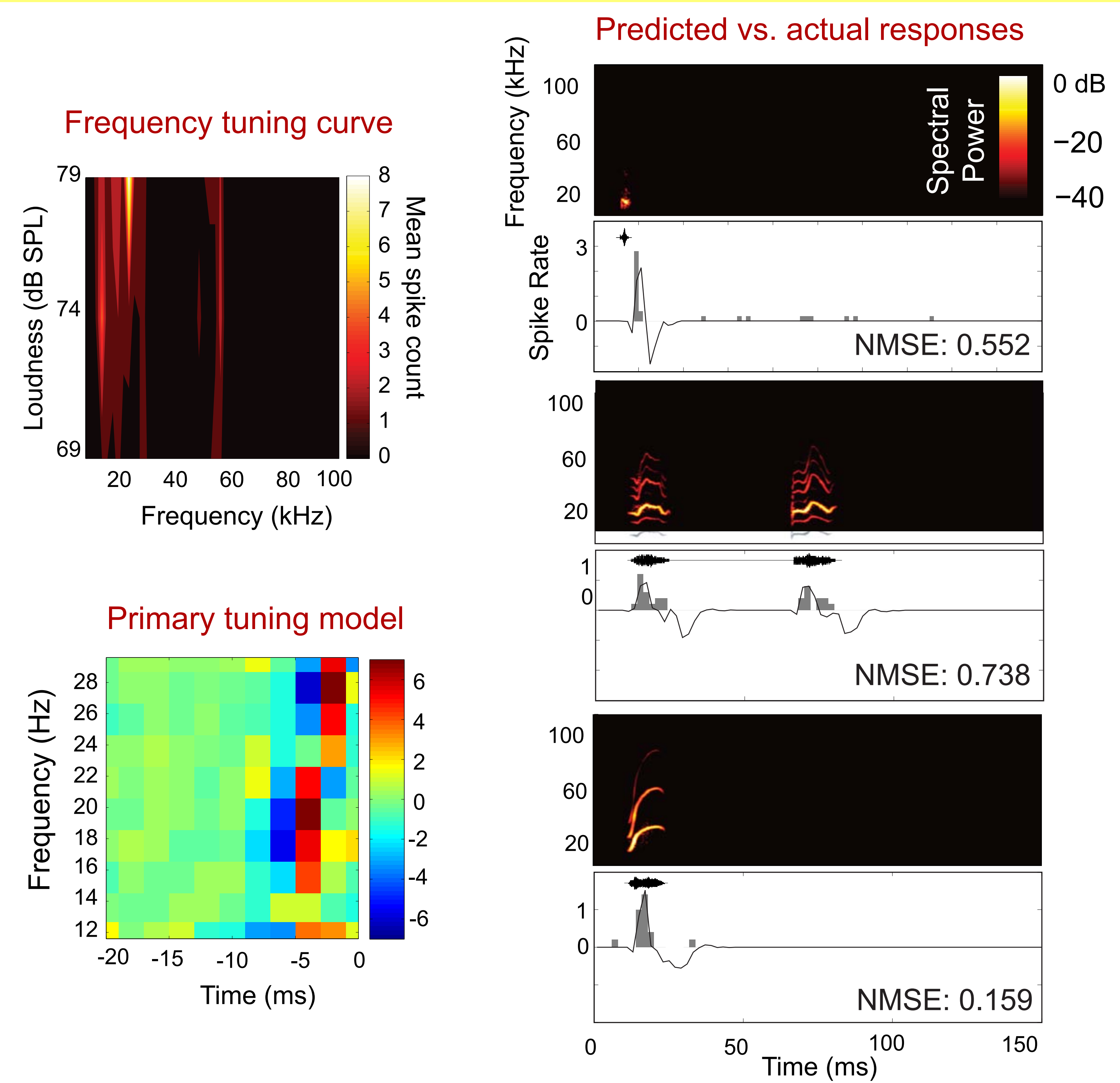
After training on the pure tone stimulus, the model was used to predict responses to social vocalizations.

The vocalization waveform (A) was converted into a spectrographic representation (B). The frequency tuning curve of the neuron (C) was used to tune the extended model (D) and determine the frequency range for the primary tuning model (E). The predictions from the two models were compared to the actual response of the neuron (F).



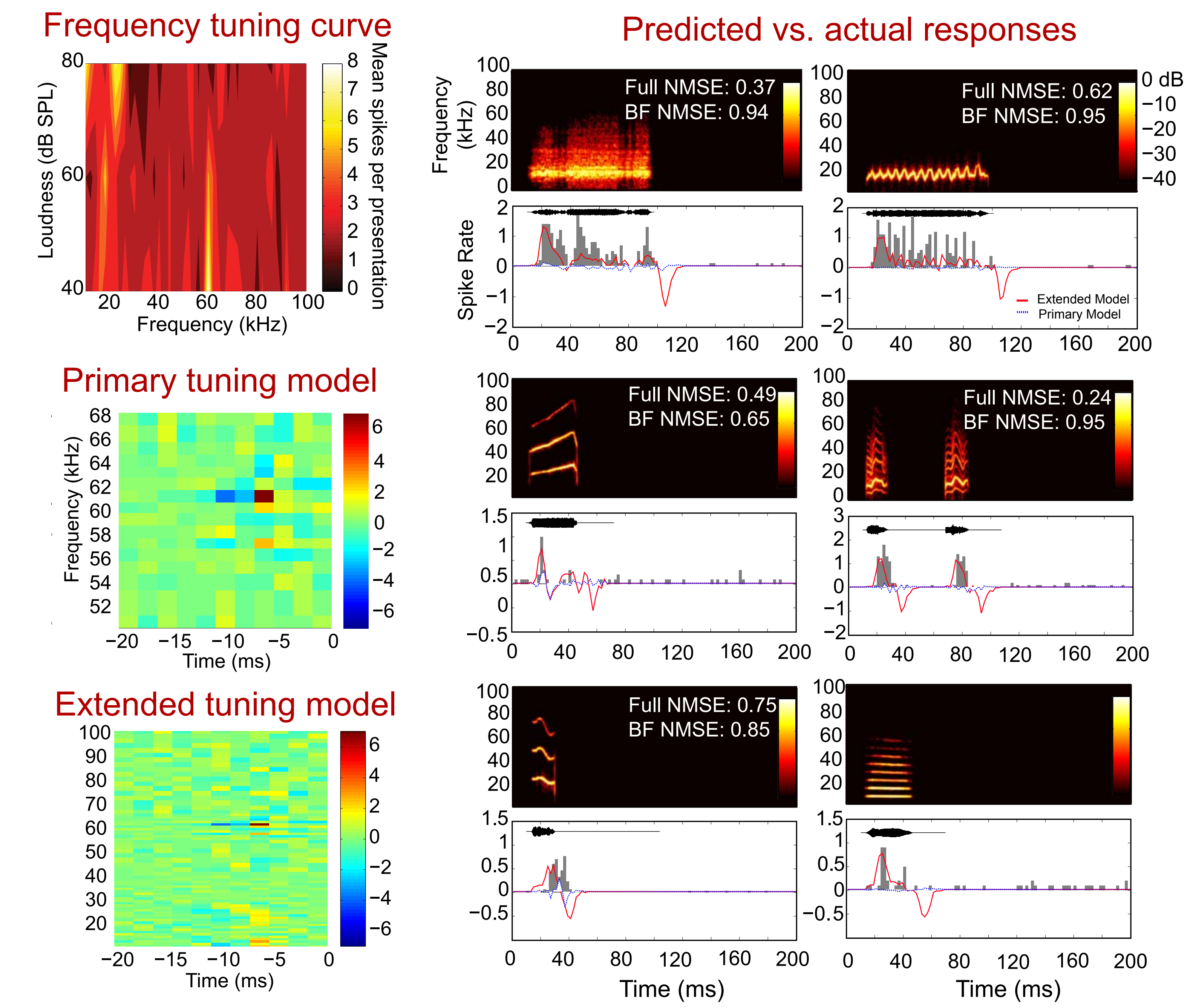
In this example, the extended model closely predicted the significant response to the vocalization while the primary tuning model predicted little or no response to the vocalization.

Responses of Some Neurons to Vocalizations were Determined by their Primary Tuning Curves

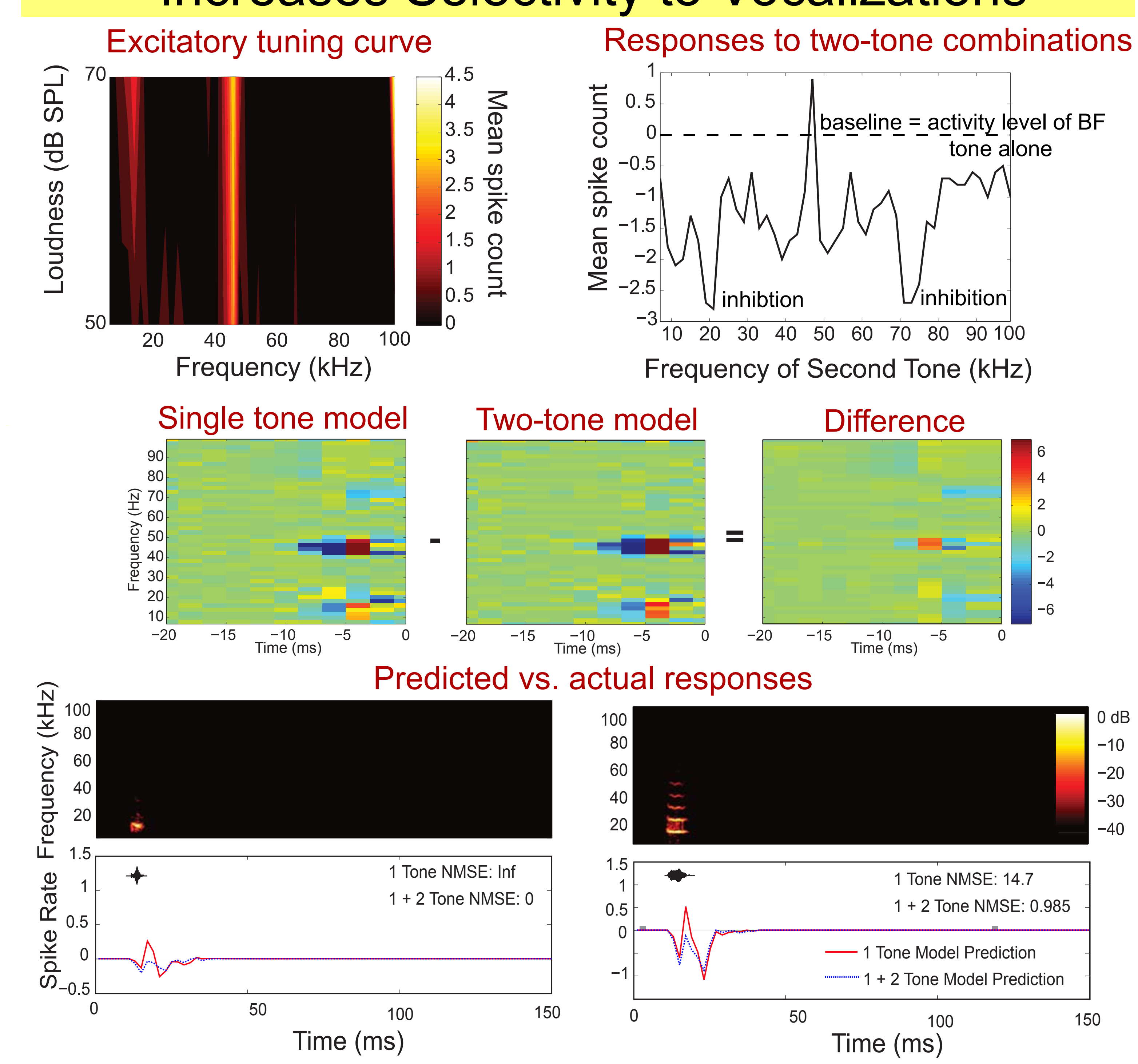


Secondary Frequency Tuning Curves Determine Responses to Vocalizations in Many Neurons

37 of the 50 modeled neurons were tuned to multiple frequencies. Eleven of these neurons had a best frequency of ~60 kHz and a secondary tuning curve in the 10-30 kHz range. These neurons responded well to many vocalizations and the responses were accurately predicted by the extended model.



Inhibition Far Away from the Excitatory Region Increases Selectivity to Vocalizations



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