In vivo whole cell recording of synaptic responses underlying two-tone interactions in rat auditory cortex

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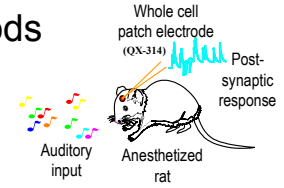
Introduction

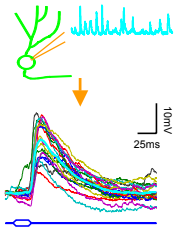
Neurons in the primary auditory cortex respond preferentially to tones within their excitatory receptive fields. These responses are modulated by the previous history of acoustic input. We have used in vivo whole cell patch methods to record the synaptic response to two-tone stimuli[1,2] in the primary auditory cortex of anesthetized rats. We found that: 1. the amplitude of the postsynaptic potentials (PSP) evoked by the second tone varies as a function of both the frequency and intensity of the first tone. 2. the amplitude of the PSP evoked by the second tone also varies as a function of the frequency of the first tone and the intervals between the two tones. These synaptic components provide insight into the balance of excitatory and inhibitory mechanisms that underlie the processing of spectro-temporally complex acoustic signal in the auditory cortex.

Methods



Anesthesia: Ketamine (60 μg/kg) + Medetomidine (0.5 mg/kg),
Animals: Sprague-Dawley rats p17-p 22
Stimulus: 25 msec tones, 5 msec rise/fall times, 10 frequencies between 2 to 40 kHz, Max: 70 dB, 1 sec inter-trial interval, random order; TDT RP2 delivery system, freefield stimulation

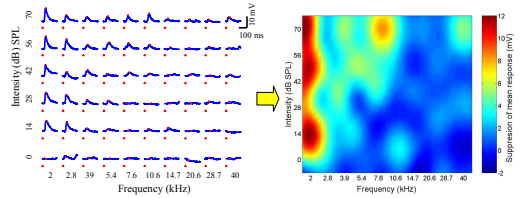
1. Postsynaptic response to pure tone



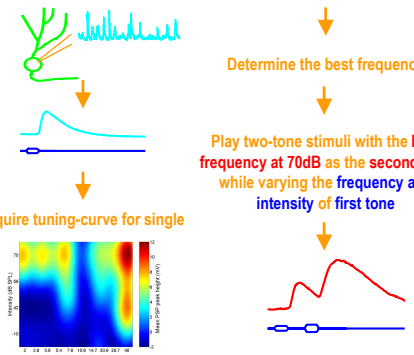
The neuronal response to a pure tone. The stimulus is a 25 ms pure tone of 7.57 kHz at 70 dB SPL. Stimulus onset is 10 ms in each trial. The light blue line represents the mean response.

1. Brosch and Schreiner (1997) Time course of forward masking tuning in cat primary auditory cortex. *J. Neurophysiol.* 77:923-943
2. Brosch and Schreiner (2000) Sequence sensitivity of neurons in cat primary auditory cortex. *Cerebral Cortex 10:1155-1167*

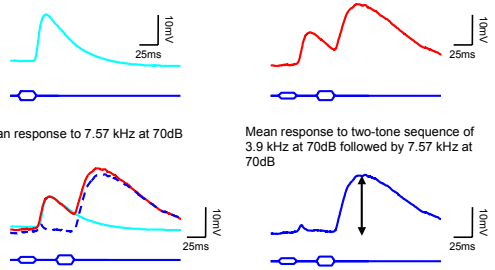
2. Tuning curve for single-tone response



The neuronal response to single pure tones. This neuron preferentially responds to low frequency and loud tones. The red triangles (▲) represent the stimulus onset.

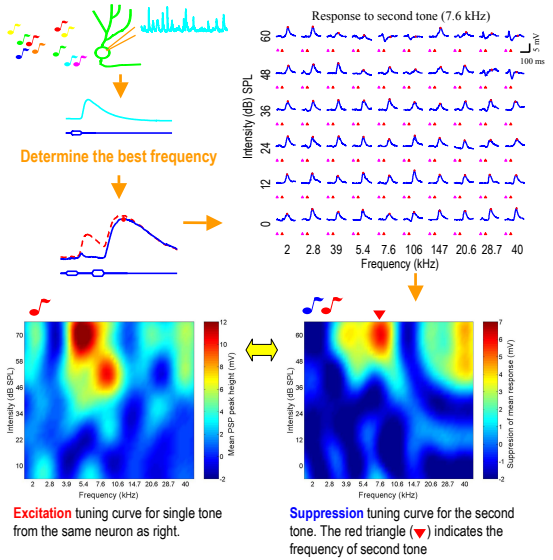


3. Postsynaptic response to two tones



4. Tuning curve for two-tone responses

There is a **strong correlation** between the excitatory tuning curve for single tone and the inhibitory tuning curve for the second tone.

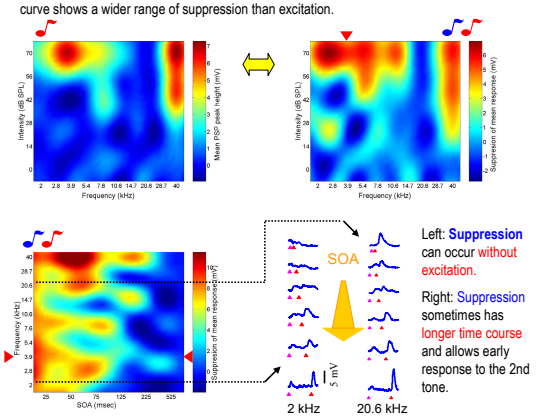


Excitation tuning curve for single tone from the same neuron as right.

Suppression tuning curve for the second tone. The red triangle (▼) indicates the frequency of second tone

5. Excitation and suppression are distinct

Excitation (left) and **suppression** (right) tuning curve for another neuron. The suppression tuning curve shows a wider range of suppression than excitation.

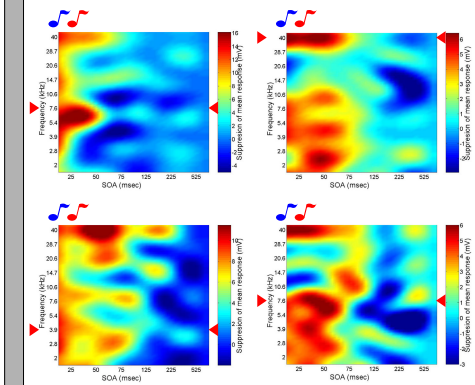


Left: **Suppression** can occur without excitation.

Right: Suppression sometimes has longer time course and allows early response to the 2nd tone.

6. Time course of two tone interaction

The neuronal responses to the second tone are plotted in relationship to the frequency of the first tone and the stimulus onset asynchrony (SOA) between the first tone and the second tone. Suppression can last from 25 msec to 200 msec with maximal around 50 to 100 msec.



Conclusions

1. Tone pips pairs elicit a stereotyped sequence of stimulus-locked PSPs.

2. The first tone usually suppresses the response to the second tone.

3. Suppression depends on the characteristics of the first tone, including frequency and intensity.

4. The amount of suppression induced by the first tone is usually correlated with the excitation elicited by that tone. However, suppression can occur in the absence of excitation, indicating that distinct mechanisms underlie them.

5. Suppression is maximal 50-100 msec after the first tone. Suppression can last longer than excitation.