A study of off-response using *in vivo* whole cell patch clamp recording in rat auditory cortex

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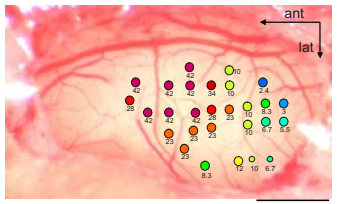
Introduction

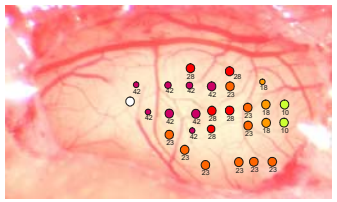
Many neurons in the primary auditory cortex (AI) respond robustly to the onset of tone pips (on-response). This property has been exploited extensively to characterize the receptive fields of auditory cortical neurons. However, auditory cortical neurons respond not only to the onsets of tone pips but also to their terminations (off-response). We are interested in how the magnitude and latency of the off-response depend on the stimulus parameters. Do off-responses suppress on-responses to subsequent tones? What are the mechanisms underlying this off-response? In this study we use *in vivo* whole-cell patch clamp recording along with other techniques to address these question.

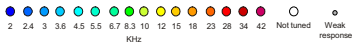
1. Cortical map for best frequency --- local field potential (LFP)

a. On-response



b. Off-response

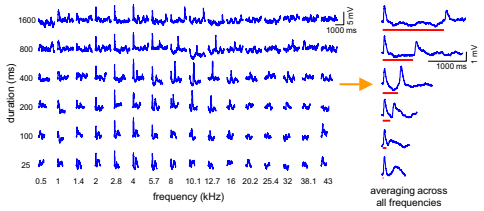




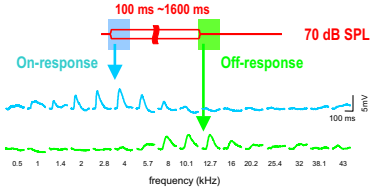
The cortical map of best frequency for local field potential response to pure tones. The stimuli are 500 ms pure tones of 2~42 kHz at 10~70 dB SPL. Circles represent the recording sites. Note that the map for off-response shifts toward higher frequencies when compared to the map for on-response.

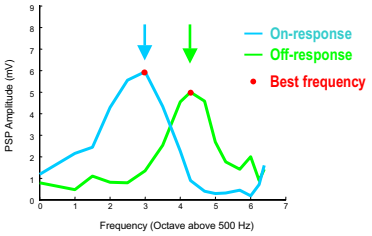
2. Tuning of On and Off-responses

a. Off-response post-synaptic potential (PSP)

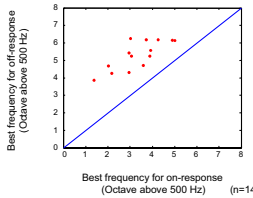


b. Tuning of on-response vs. off-response





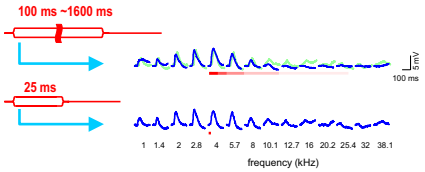
c. Best frequency for on-response vs. off-response



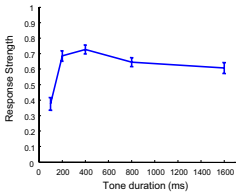
* http://zadorlab.cshl.edu/tai/tai_2002ns_poster.pdf

3. Off-response and tone duration

a. Short tone pips do not elicit strong off-response



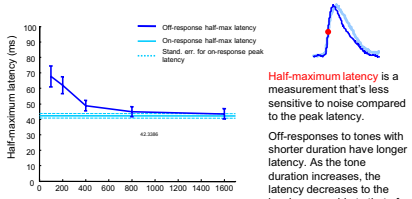
b. Off-response amplitude as a function of tone duration



The peak amplitudes of off-responses first increase with tone duration and reach a maximum at 400 ms. For some cell-frequency combinations, the peak amplitudes stay at the same level with longer tone duration while others start to decline.

Responses are normalized to maximum PSP amplitude for each cell.

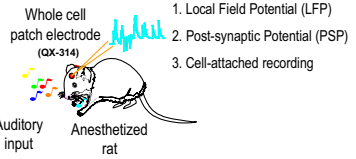
c. Off-response half-maximum latency as a function of tone duration



Half-maximum latency is a measurement that's less sensitive to noise compared to the peak latency.

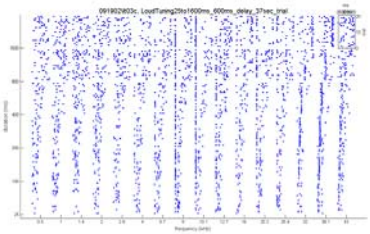
Off-responses to tones with shorter duration have longer latency. As the tone duration increases, the latency decreases to the level comparable to that of the on-responses. (42.3 ms)

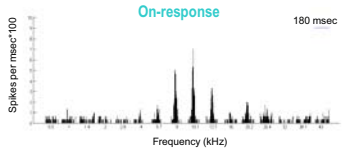
Methods

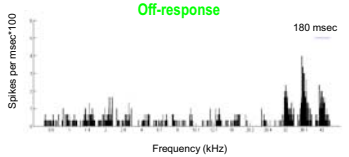


Anesthesia: Ketamine (60 µg/kg) + Medetomidine (0.5 mg/kg),
Animals: Sprague-Dawley rats p17-p 22
Stimulus: 25 msec tones, 5 msec rise/fall times, 10 frequencies between 2 to 40 kHz, Max: 70 dB, 1 sec inter-trial interval, random order; TDT RP2 delivery system, freefield stimulation

4. Off-response and spike activity







Conclusions

1. The cortical map for off-responses in AI were tonotopically organized, but shifted towards higher frequencies compared with the tonotopic map for on-responses.
2. The tuning of on-responses v.s. off-responses in individual recordings was consistent with a shift in the cortical map toward higher frequency.
3. The off-response PSP amplitude typically increased with increasing tone duration. Occasionally, the PSP amplitude decreased for tone durations longer than 400 msec.
4. The half-maximum latency of off-response PSPs was slower than that of the on-response at short tone duration.
5. Off-responses recorded using whole cell recording are comparable to those recorded using cell attached mode, whereas whole cell recording provides a more detailed view into the underlying excitatory and inhibitory mechanism.