Discrimination of short tones in noise by rats

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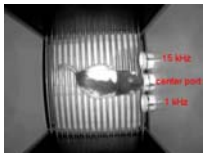
Introduction

How do animals discriminate tones in background noise? As a first step to study neural correlates of auditory perception in rats, we trained Long-Evans rats to discriminate pure tones imbedded in a white noise background in a two alternative forced choice (2-AFC) paradigm, adapted from a similar olfactory task (Uchida and Mainen, 2003). Subjects triggered the auditory stimulus by means of a nose poke to a center nosecone, and were rewarded (~50µl water) if they responded with a second nose poke into the appropriate nosecone (right, 1kHz or left, 15kHz). Training was fast (2-3 weeks), and performance on the easiest discriminations could exceed 95%. Performance deteriorated in a systematic way with decreased signal to noise ratio (SNR) and with decreased tone duration. Typical reaction times were short (~400 ms). Trials with prolonged reaction time are associated with drop in performance. Bias increases as difficulty increases. This paradigm offers an ideal model system for studying the neural correlates of two competing perceptions whose representations are likely to be in distinct areas of any tonotopically organized region of auditory cortex.

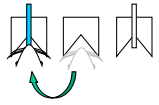
1. Two alternative forced choice task

a.

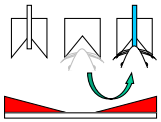


b.

Stimulus 1: 15 kHz + white noise

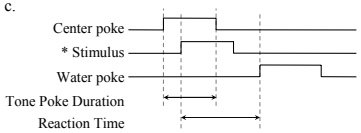


Stimulus 2: 1 kHz + white noise



15 kHz ← white noise → 1 kHz
65~0 dB (60dB) 0~65 dB

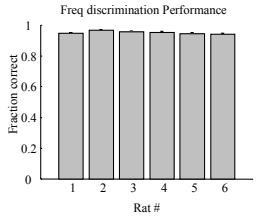
c.



* Stimulus duration is in incremental units of 100ms (rat controlled)

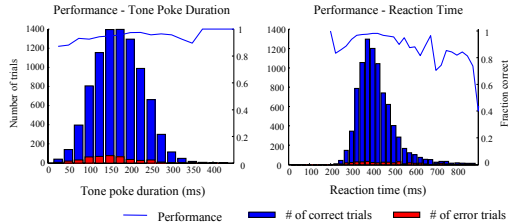
2. Rapid and accurate performance

a. Performance can be extremely good for a easy task



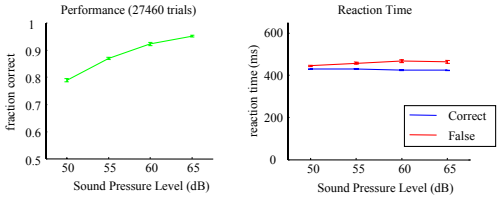
1. Stimulus: 65db SPL + WN
2. Performance: polled result from both frequency of same SNR
3. Only trials with one center poke
4. n = 1409~1687 trials / rat

b. Tone poke duration and reaction time is fast

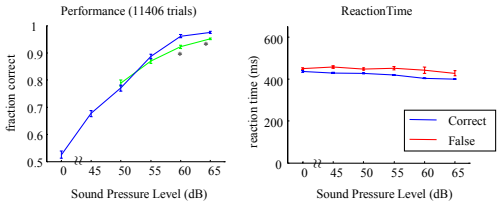


3. Performance vs. signal to noise ratio — rat-controlled stimulus duration

a. Same SNR in each session

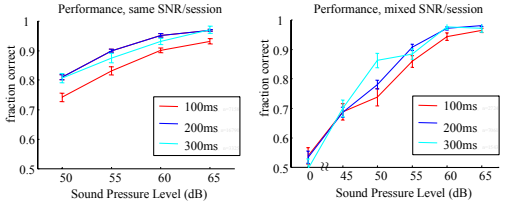


b. Mixed SNR in each session

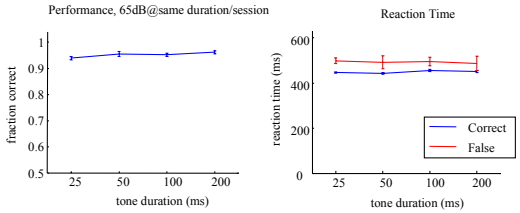


4. Performance vs. stimulus duration

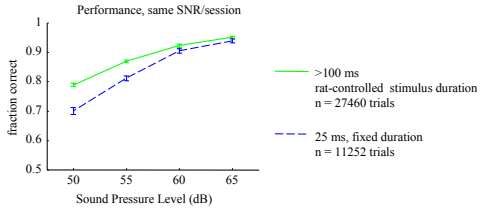
a. Performance decreases with rat-controlled stimulus duration



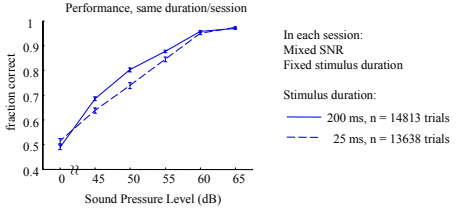
b. Performance does not change with stimulus duration at high SNR



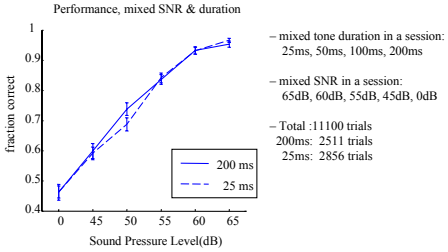
c. Performance is worse with short stimulus duration at lower SNR



d. Performance declines faster with SNR for short stimulus duration

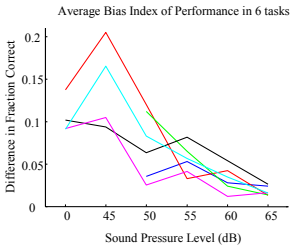


e. Rats adapt different strategy in highly variable situation



5. Bias vs. discrimination difficulty

$$\text{Average Bias Index} = \frac{\sum |performance(15kHz) - performance(1kHz)|}{animal \times sessions}$$



Summary

1. Training is fast and rats can perform many trials.
2. Response is rapid and extremely accurate.
3. Response decreases with signal to noise ratio and drops faster with shortening stimulus duration.
4. Bias increases with increasing task difficulty.
5. Good model for studying neural correlates of auditory perception.

http://zadorlab.cshl.edu/tai/Tai_2004_ARO_poster.pdf