Buildup to stream segregation: physiology and statistics

Review of Micheyl et al, 2005; intro for Steele, Tranchina, & Rinzel

Sara Steele

Challenges for elucidating neural mechanisms of stream segregation

- perceptual report vs. localized brain activity: can't win 'em all

- stimuli that consistently evoke different percepts will also recruit different populations of sensory neurons

- correlation vs causation: similar changes found as early as auditory brainstem as those found in A1 (Pressnitzer et al, 2008)

Neuron, Vol. 48, 139–148, October 6, 2005, Copyright ©2005 by Elsevier Inc. DOI 10.1016/j.neuron.2005.08.039

Perceptual Organization of Tone Sequences in the Auditory Cortex of Awake Macaques

Christophe Micheyl,[1,*] Biao Tian,[2] Robert P. Carlyon,[3] and Josef P. Rauschecker[2,*]
[1]Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
[2]Department of Physiology and Biophysics
Georgetown Institute for Cognitive and Computational Sciences
Georgetown University Medical Center
Washington, District of Columbia 20007
[3]MRC Cognition and Brain Sciences Unit
Cambridge CB2 2EF
England

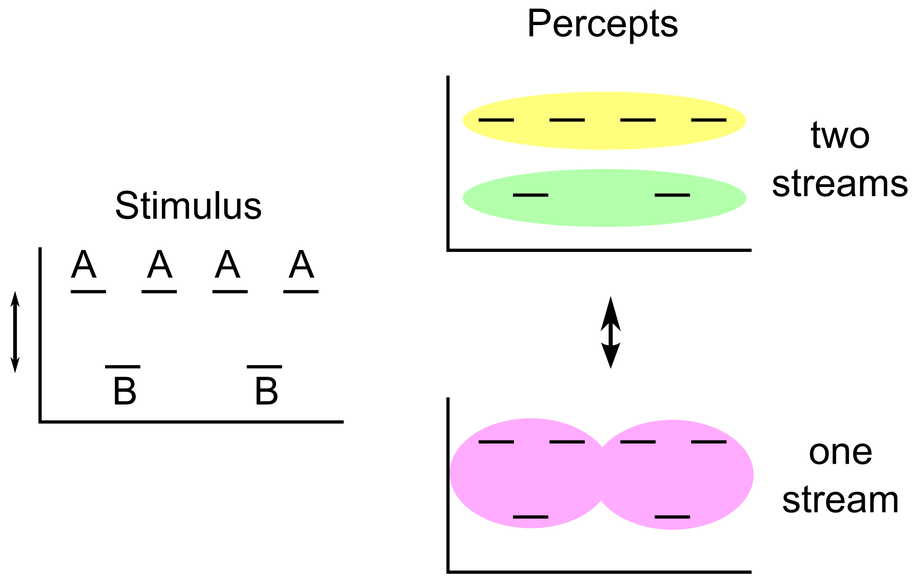
diverse ecological environments where multiple sound sources are often present and need to be parsed.

In the laboratory, the formation of auditory streams can be demonstrated simply by using repetitive sequences of tones alternating between two frequencies, A and B, as illustrated in Figure 1A. When the frequency separation (ΔF) between A and B is small and the tones alternate slowly, listeners hear a coherent sequence of tones whose pitch jumps up and down. In contrast, when ΔF is large and/or the repetition rate (RR) is fast, two parallel but separate streams of constant-pitch tones are heard.

While various theories and computational models have been proposed to explain auditory stream forma-

- constant stimuli + buildup = good guess as to percept
- use same stimuli for psychophysical (human) and electrophysiological (macaque) experiments

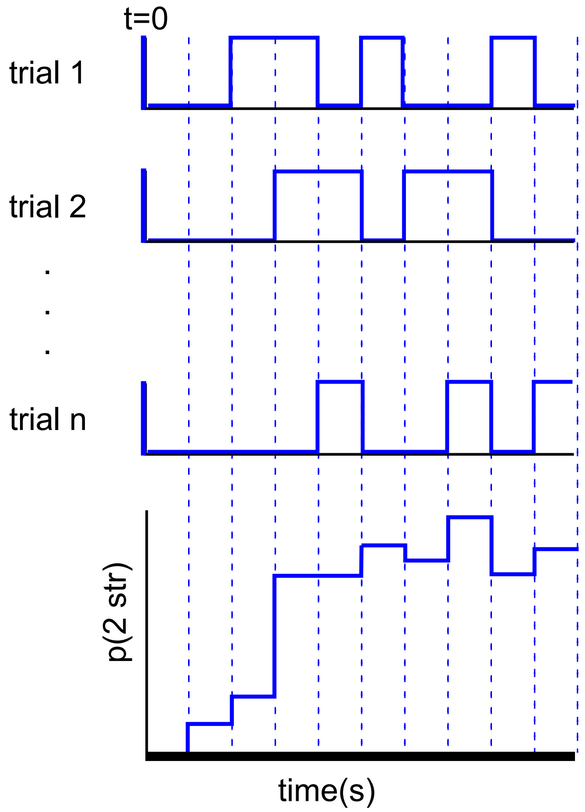
Stimuli

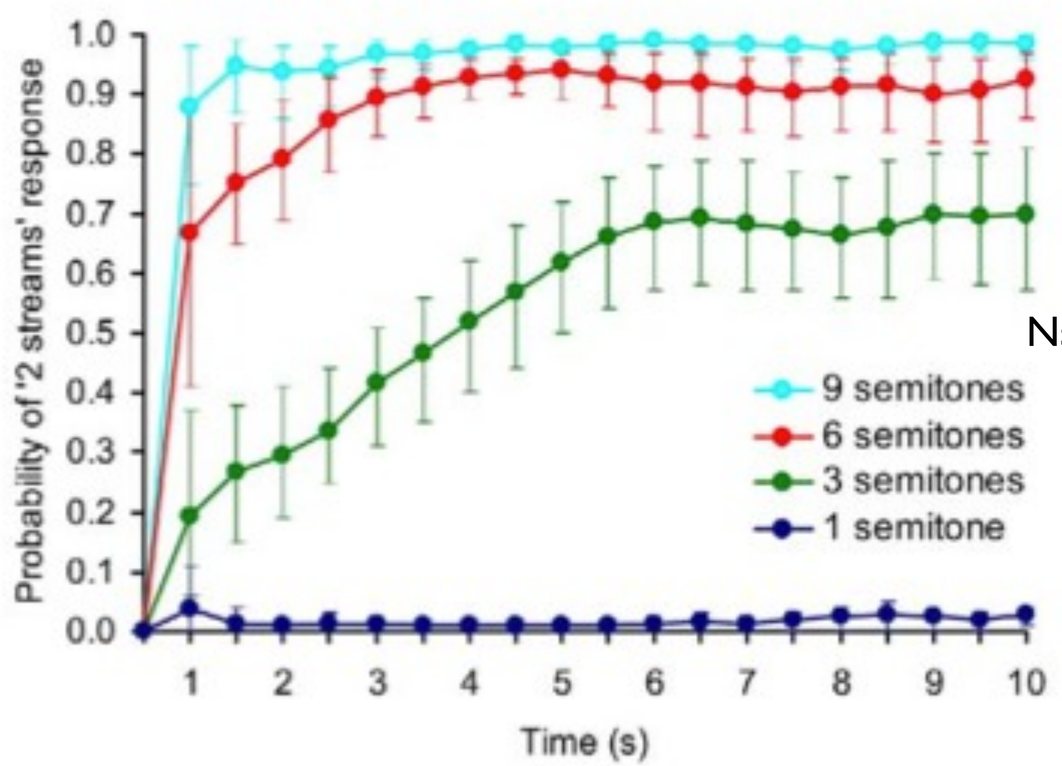


4 frequency separations:
1,3, 6, & 9 semitones
Absolute fq. of the A tone varied from 500 to 4000 Hz for humans

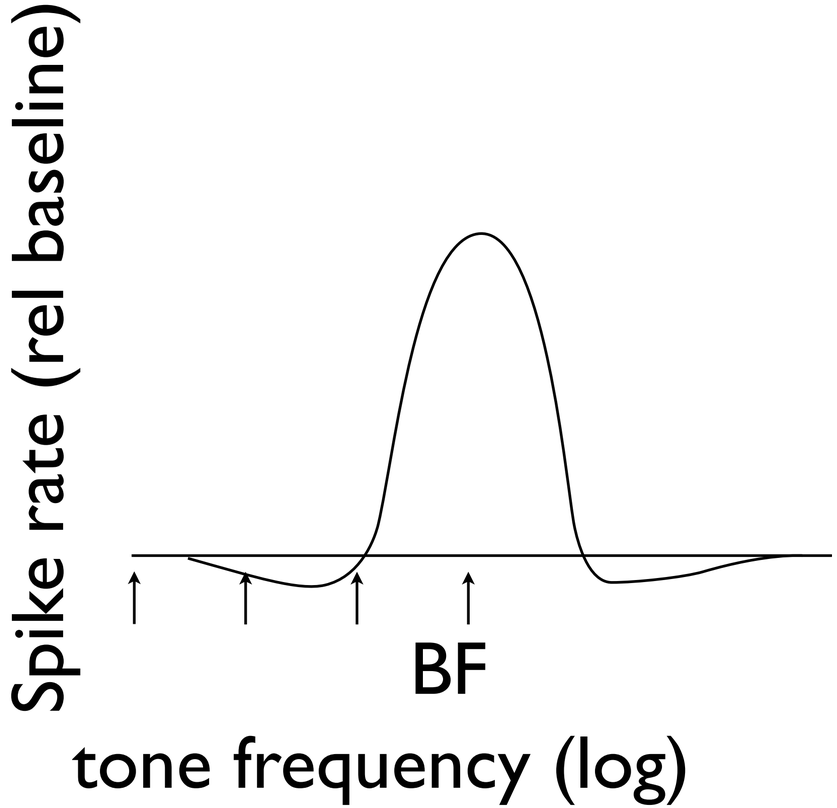
For monkeys, A tone set to be the best frequency (BF) of the neuron being recorded from. ~80% units BF between 500 & 4000 Hz.

Constructing psychometric functions (human)

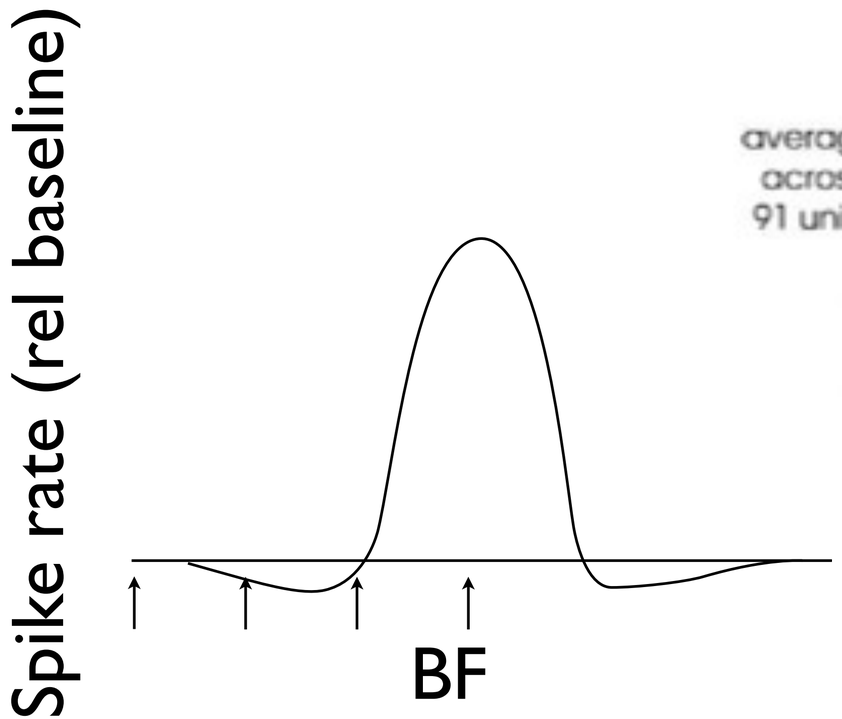


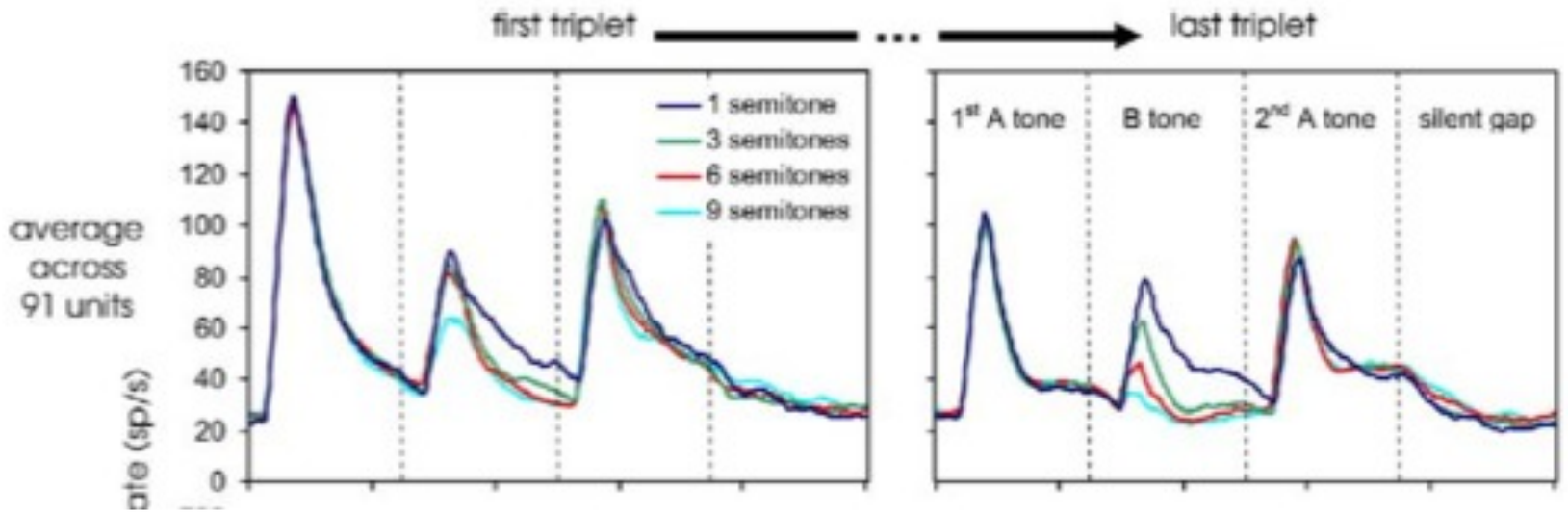


Neural responses

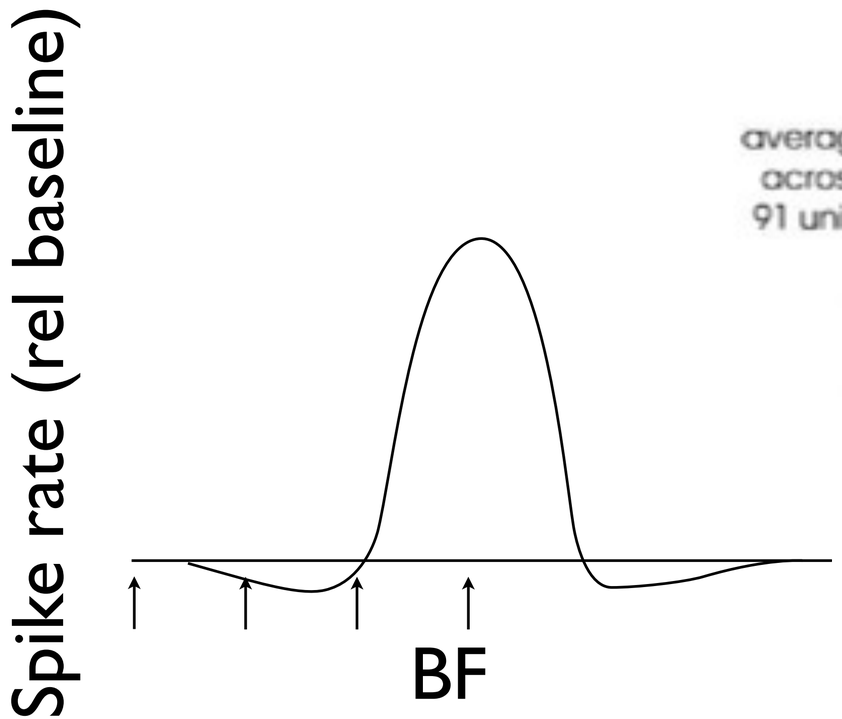


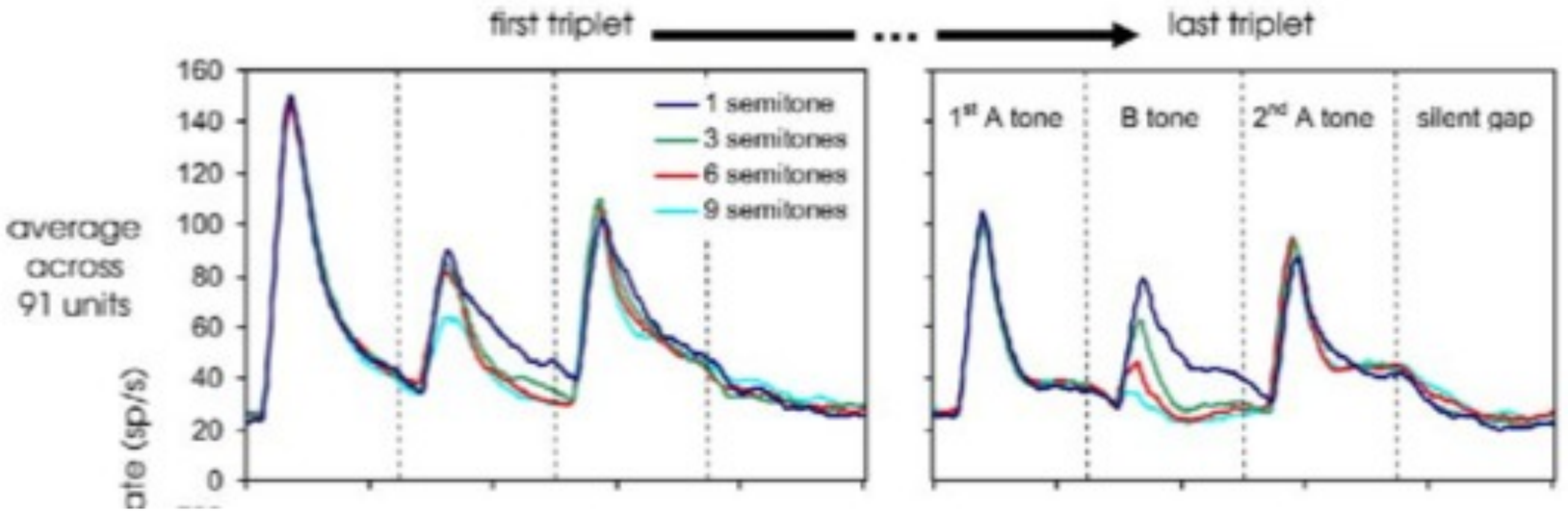
Neural responses





Neural responses

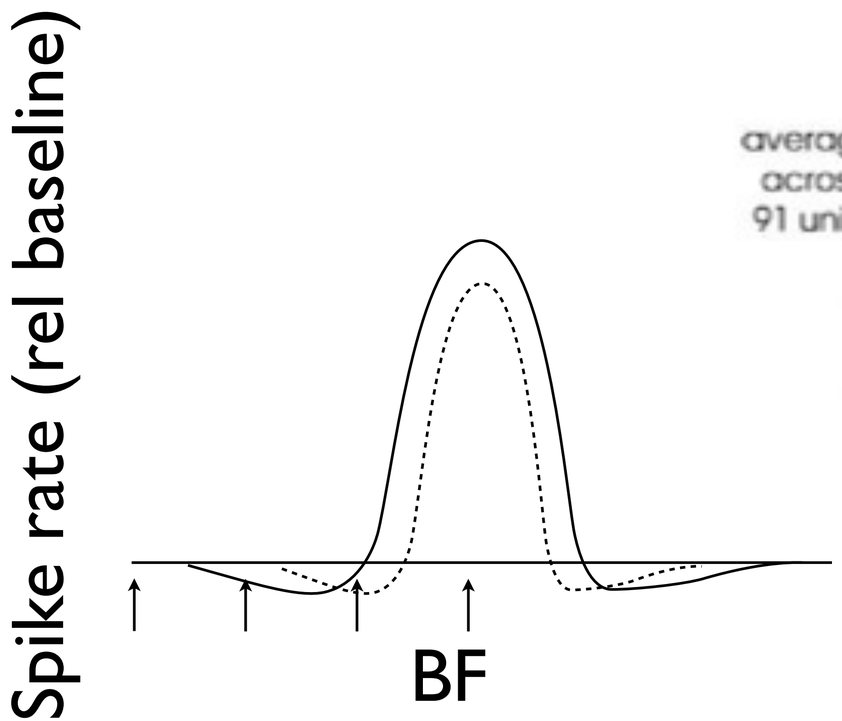


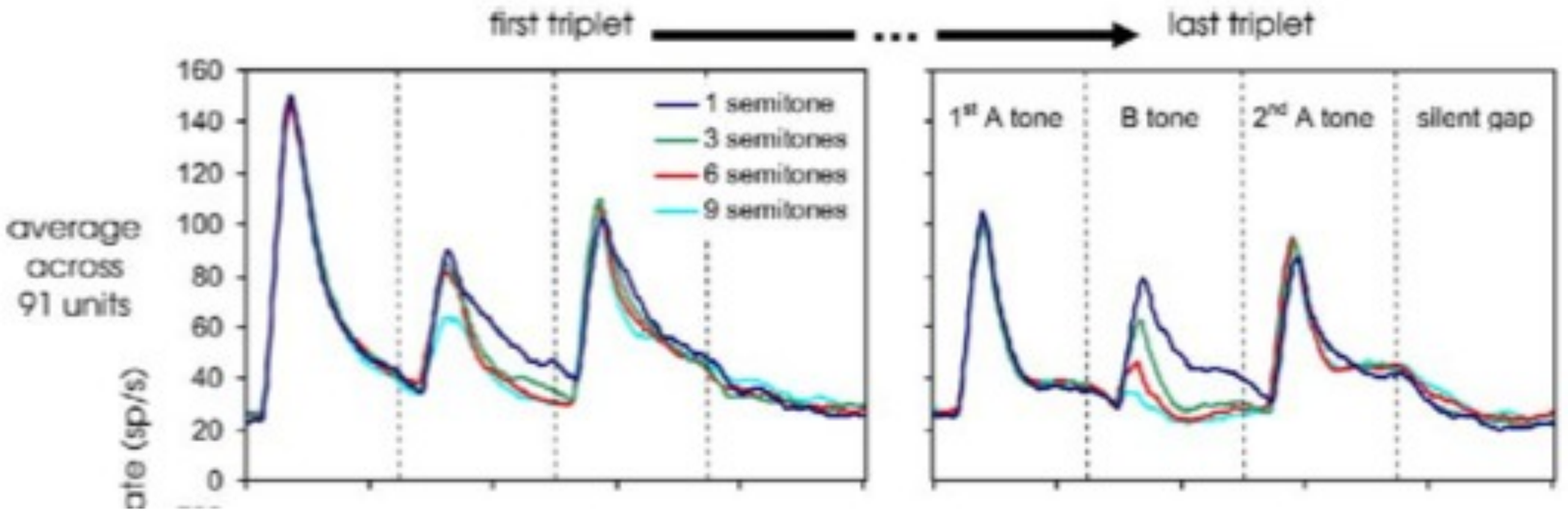


2 effects:

- lower response to B tones with higher dF --> selectivity, forward suppression
- lower responses to last triplet than first --> habituation

Neural responses

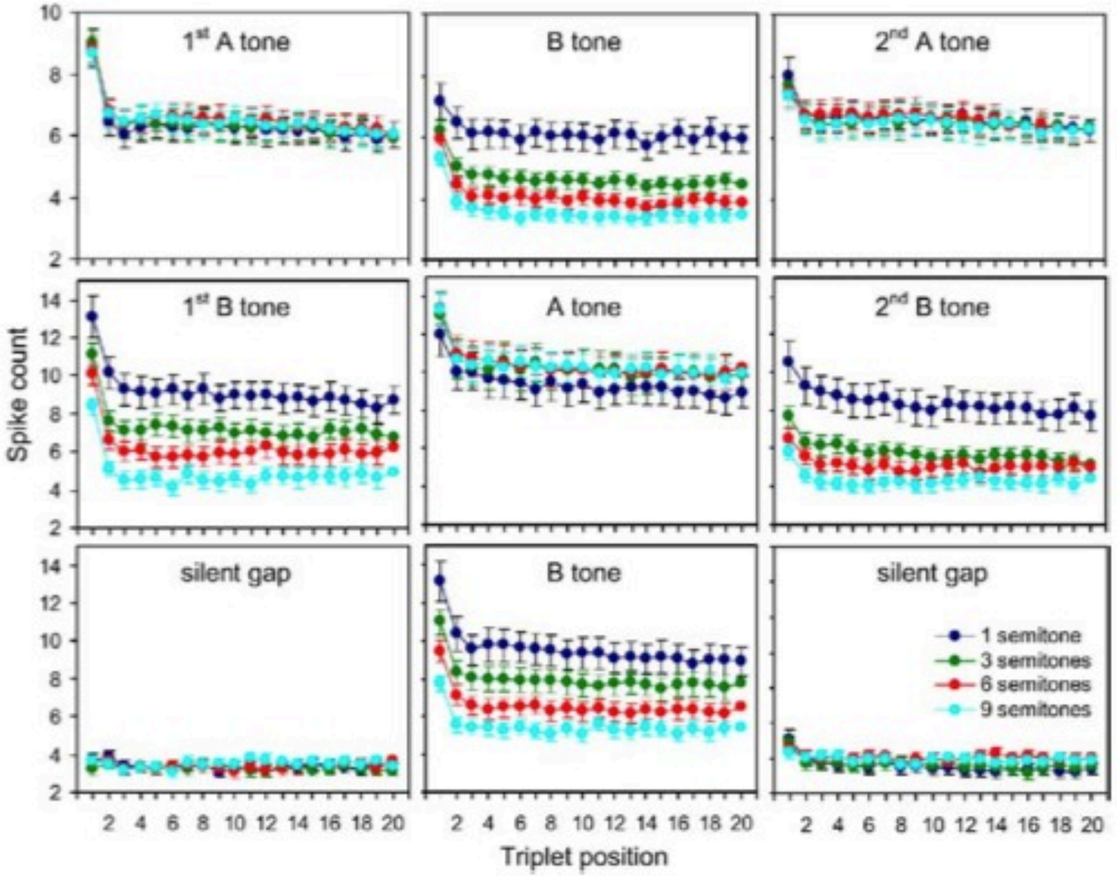




2 effects:

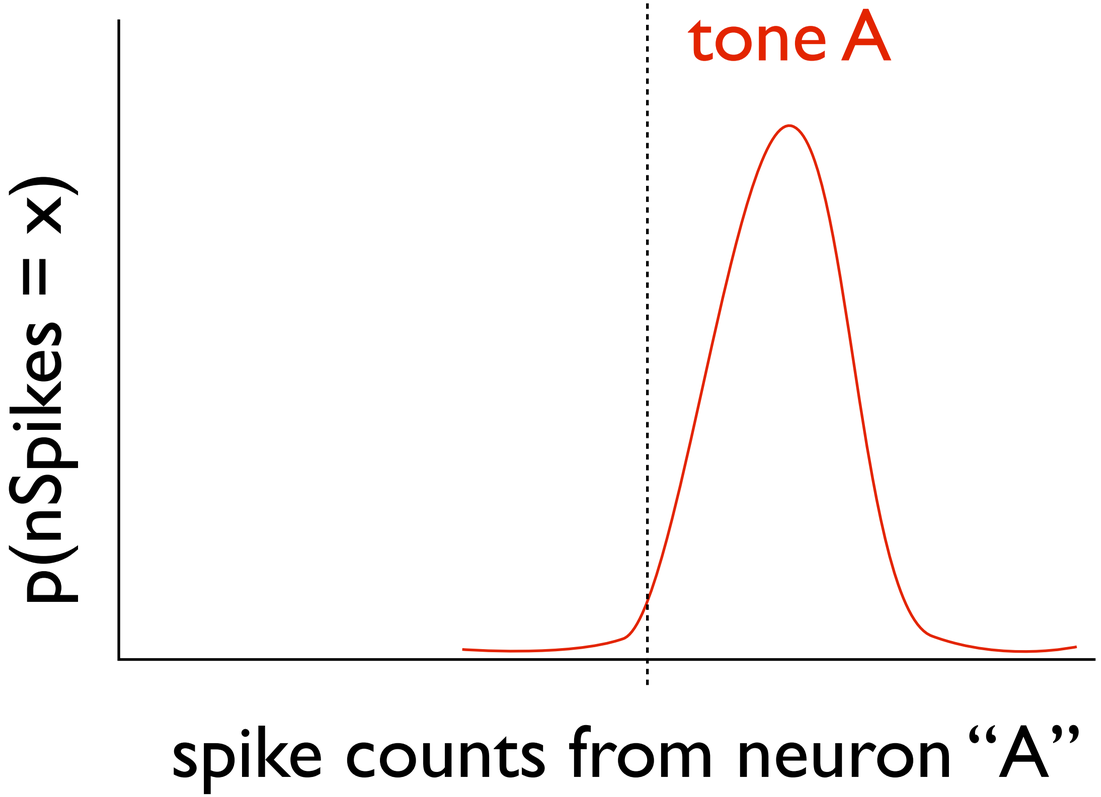
- lower response to B tones with higher dF --> selectivity, forward suppression
- lower responses to last triplet than first --> habituation

Spike counts: toward a neurometric function

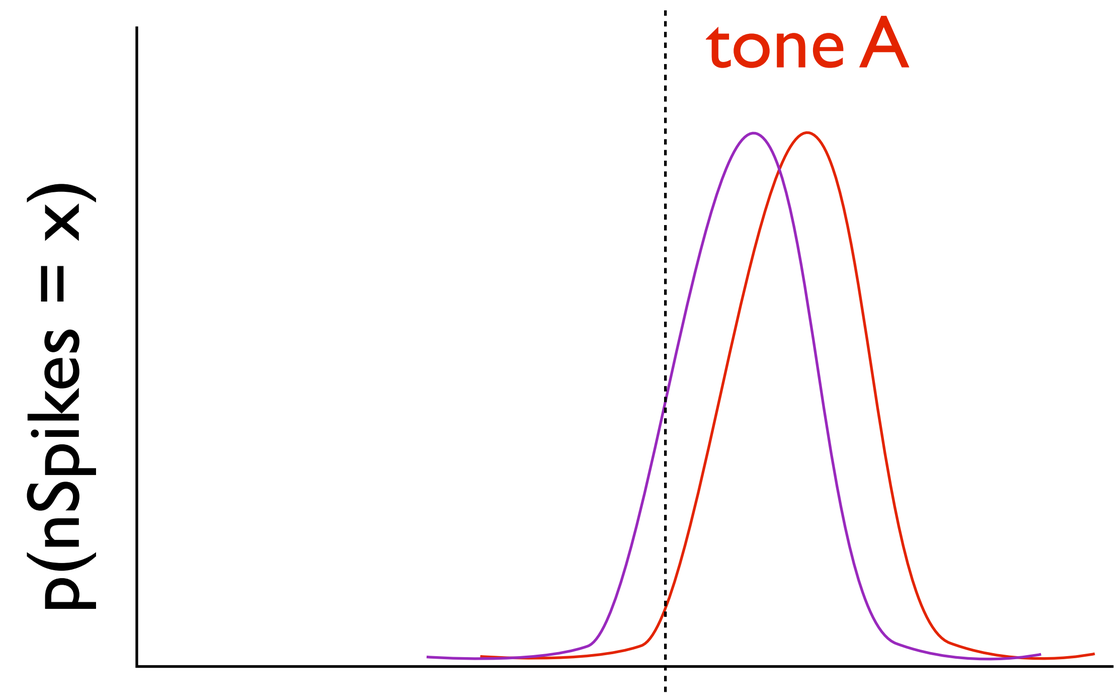


- habituation largest between first and second triplet
- B tone responses released by absence of A tone (bottom)
- A & B tone responses higher when A occurs less frequently

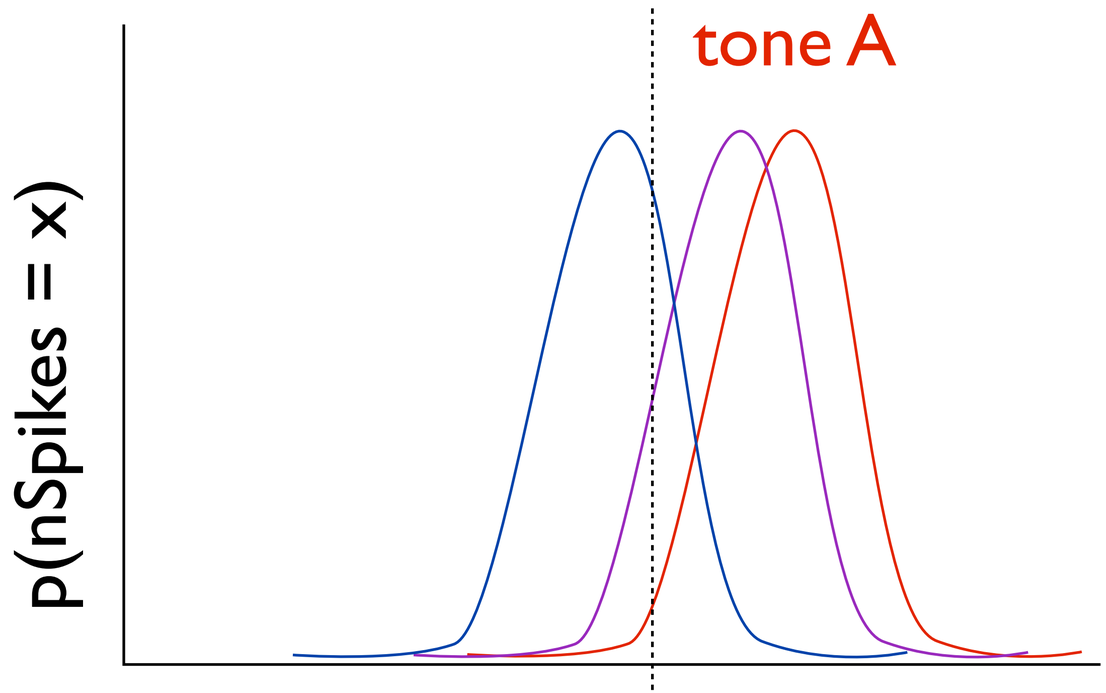
Neurometric function: Grouping by Coactivation + SDT



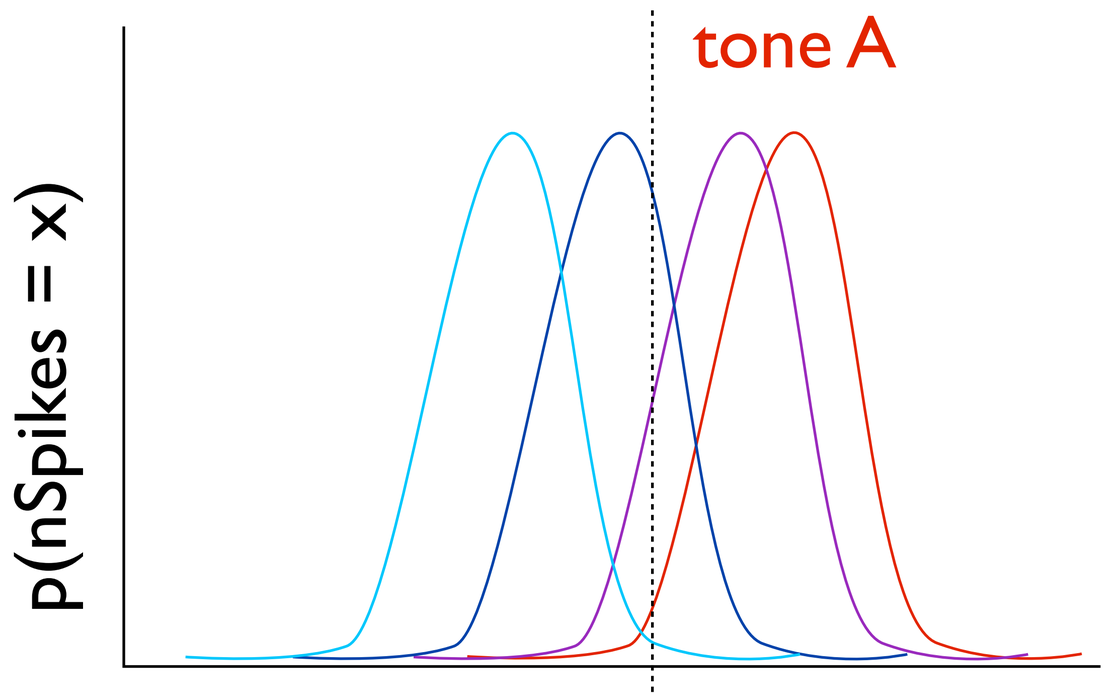
Neurometric function: Grouping by Coactivation + SDT

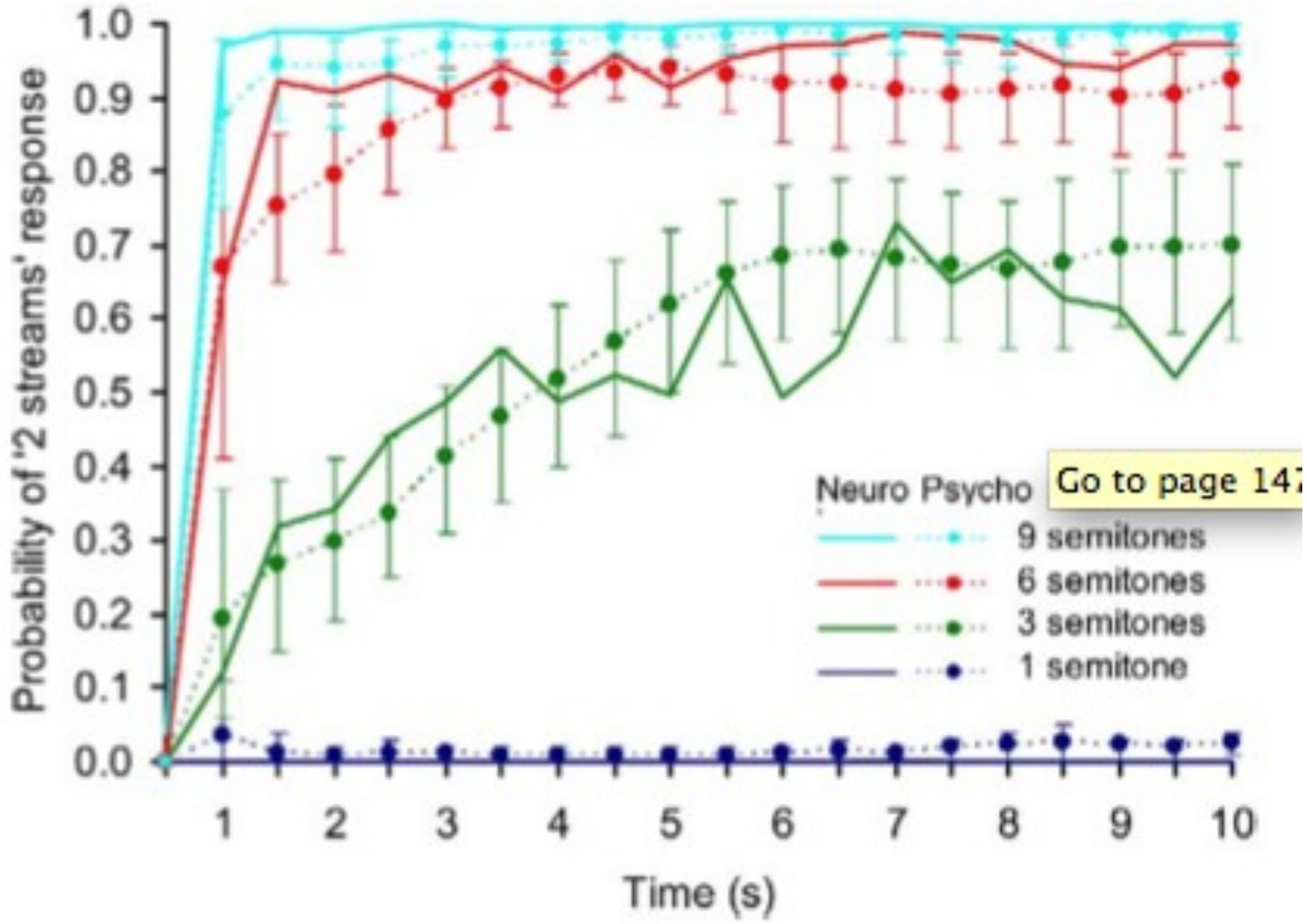


Neurometric function: Grouping by Coactivation + SDT

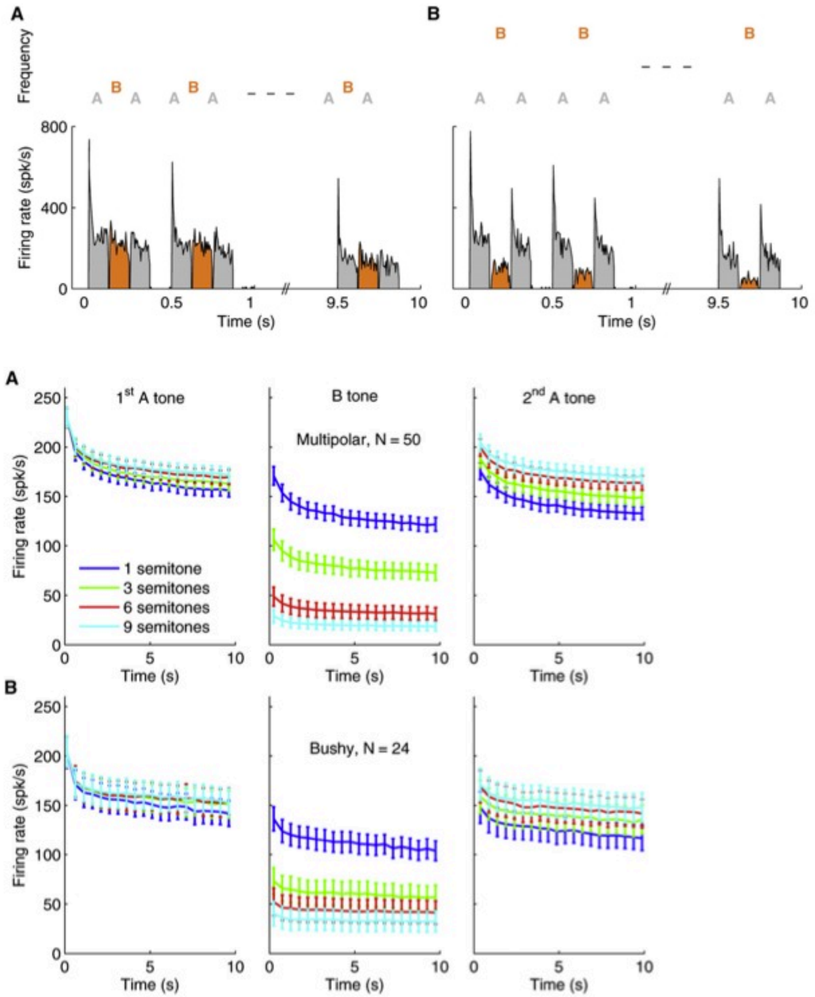


Neurometric function: Grouping by Coactivation + SDT



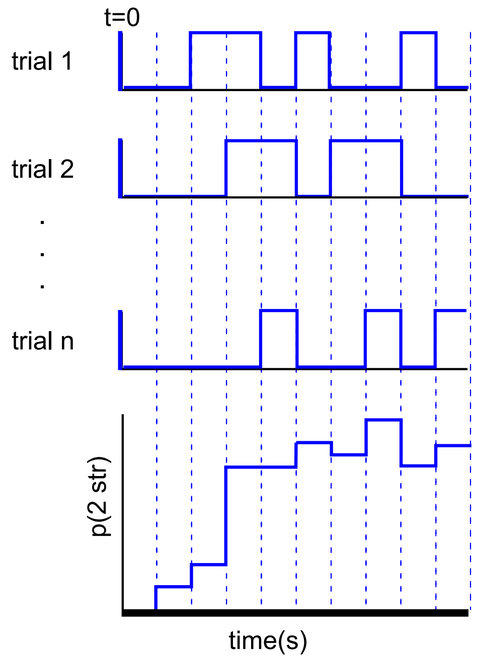

Probability of "2 streams' response
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1
2
3
4
5
6
7
8
9
10
Time (s)
Neuro Psycho
Go to page 147
9 semitones
6 semitones
3 semitones
1 semitone

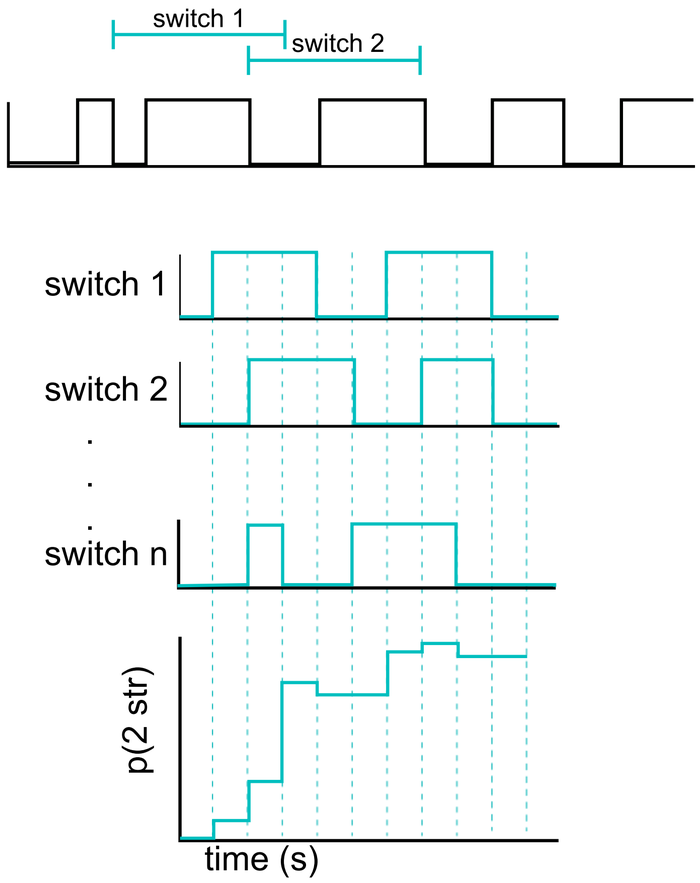
But what about alternations?



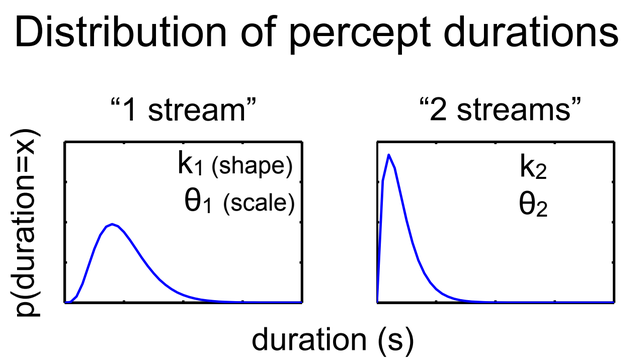
- identical findings in auditory brain stem
- accumulation of adaptation can explain integrated--> segregated switch, but not the switch back
- can buildup be described in a framework that accounts for alternations?

Constructing psychometric functions from long trials



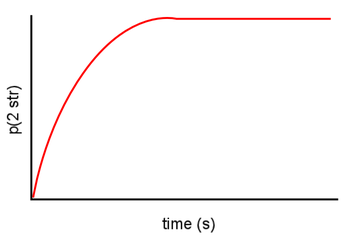


Alternating renewal process



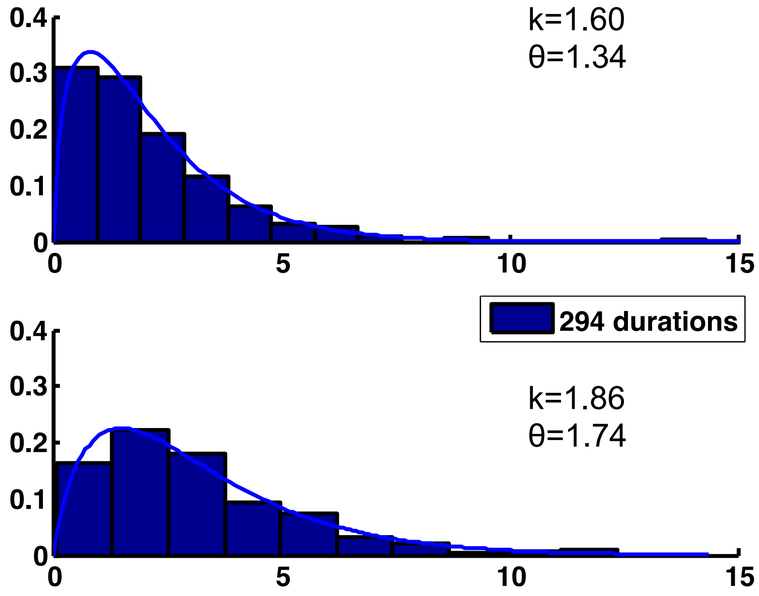
Alternating renewal process model (ARP)

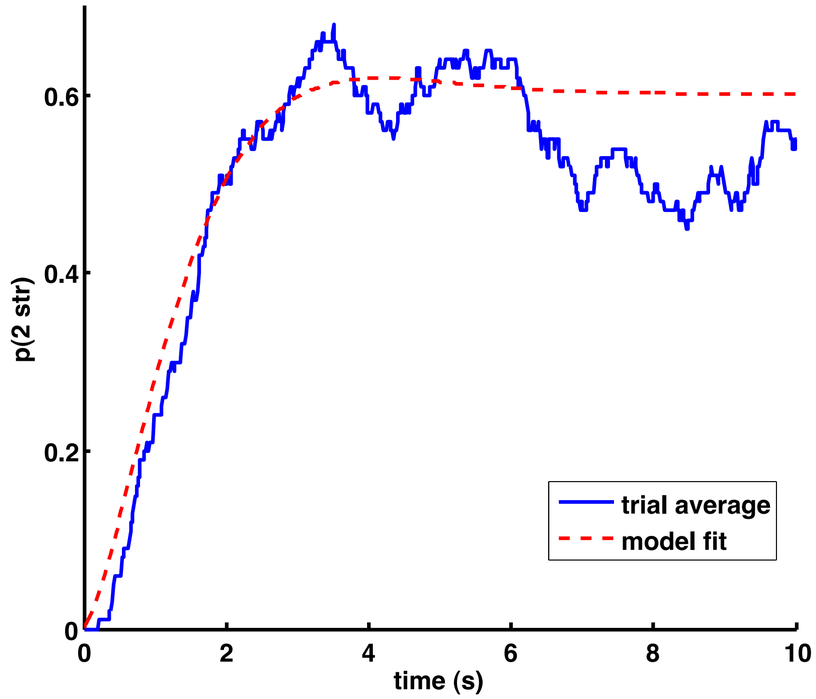
$p(2\ str|t) = f(k_1,\theta_2,k_2,\theta_2$



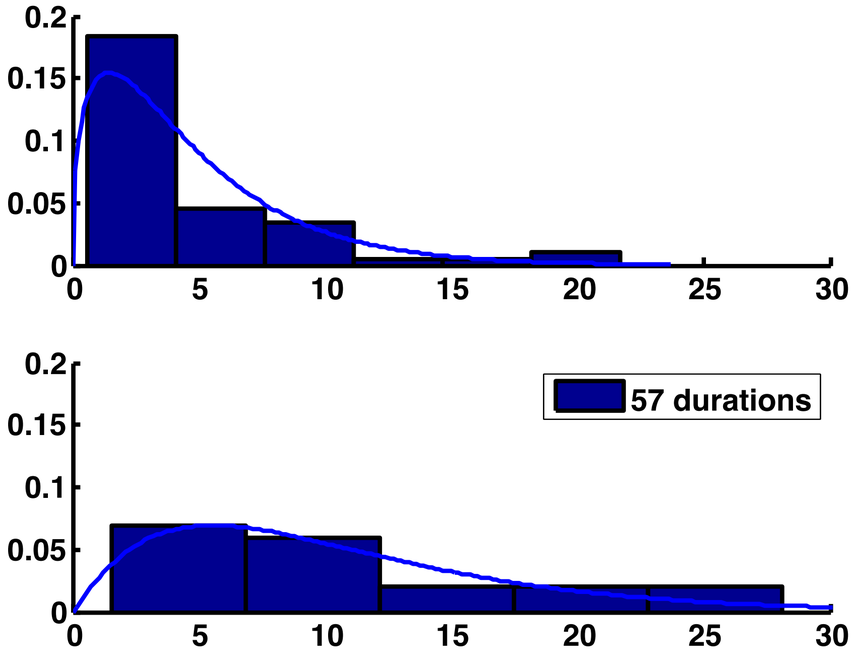
- A system alternates between two states, with known distributions of dwell times
- The system is known to always start in a particular state

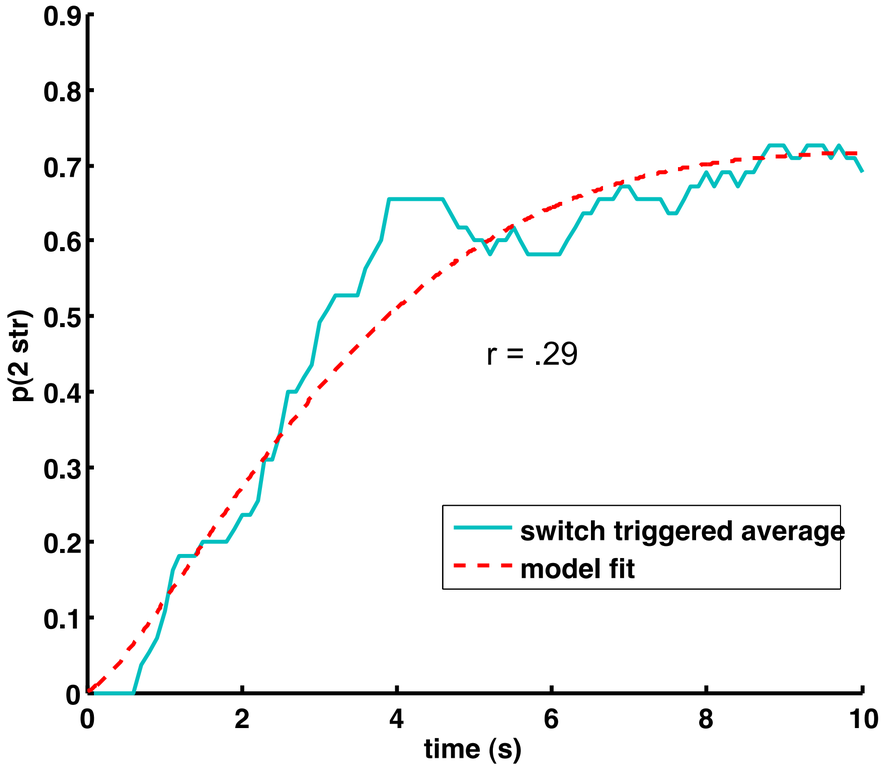
Short trials- like Micheyl et al





Long trials- many alternations

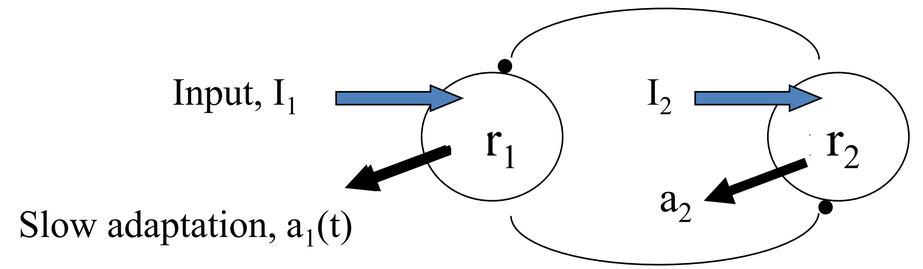




Neural networks that achieve alternation

- Feedforward architecture explains coh-->seg, but not alternations

- Require competition between neural populations to achieve alternations



Competition model simulations