PS198: Promotion of Stream Segregation by Deviants and Distractors

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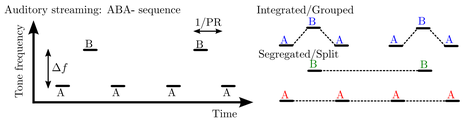
Motivation and previous results

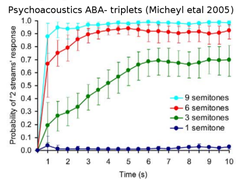
Poster summary. Sequences of repeating, interleaved high and low tones are perceived to separate into distinct streams in a process known as build-up of stream segregation. Sudden changes in the sound sequence can cause a reset to the integrated percept. Previous studies have shown resets can occur with changes in location or loudness of the streams. With induction sequences, resetting has been reported for deviant tones in timing, frequency or loudness, or with pauses in the tone sequences. Using a modified stimulus paradigm we found that, contrary to previous work, distractor or deviant tones can *promote* segregation during build-up. Our neuromechanistic model, previously used to study perceptual alternations for long stimulus presentations, is adapted to study build-up and allows for interpretation of our new experimental findings.

Auditory streaming paradigm

A widely studied psychoacoustics stimulus (van Noorden 1975, Bregman 1978, Anstis & Saida 1985):



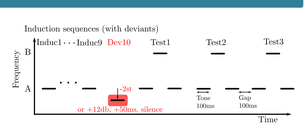
- First percept is typically Integrated
- Segregation increases with time

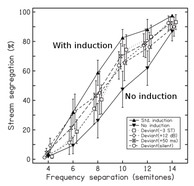


For build-up behavioral studies have characterized effects of:
- attention (Carlyon etal 2003, Macken etal 2003, Snyder etal 2006)
- context (Snyder etal 2008, Rahne & Sussman 2009)
- temporal coherence (Shamma etal 2011)

Reset to integrated with sudden stimulus changes

Induction sequences can bias segregation; effects are undone by:
- Changes in location (Rogers & Bregman 1993) or loudness (Roger & Bregman 1998)
- Introduction of deviant tones in timing, frequency or loudness (Haywood and Roberts 2010, 2013)





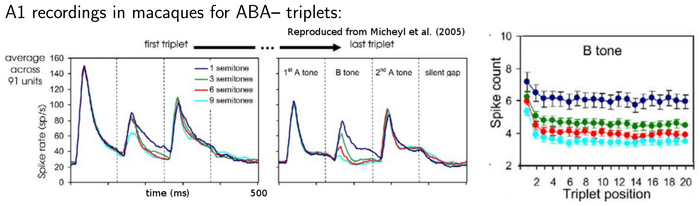
During build-up, a reset to integrated has been shown to occur for:
- Change in ear of presentation (Anstis & Saida 1985)
- Pause in presentation (Cusack etal 2004, Snyder etal 2008, Beauvois & Meddis 1997, Denham etal 2010)

Our goals

1) Do resetting effects further generalize beyond an induction sequence, i.e. for ongoing triplet sequences?
2) Use neuromechanistic model & psychoacoustics to study build-up, pauses, distractors and deviants

Further background: rapid adaptation of Δf-dependence of A1 responses to triplets

A1 recordings in macaques for ABA– triplets:

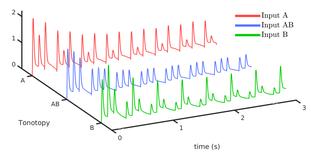


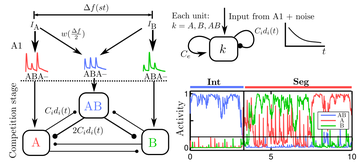
- Amplitude (# of spikes) of responses reduces over first 1-3 triplets
- Effective DF (difference in B-tone responses) is less for first 1-3 triplets

Auditory streaming model and pause experiments

Model competition network is above A1; gets input from A1

We mimic the Δf-dependence of A1 responses:



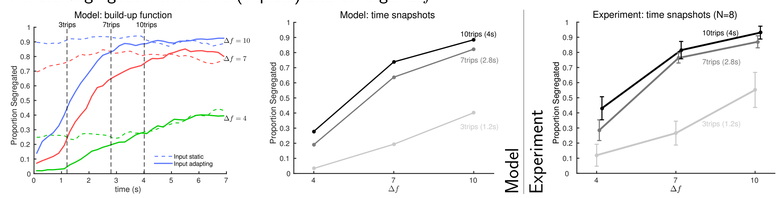


Three unit model (above A1) inspired by Fishman et al (2001):
- Inputs incorporate A1 temporal response properties and Δf-dependence
- Adaptation and noise drive competition (Laing & Chow 2002, Shpiro etal 2009)
- Recurrent excitation on NMDA timescale

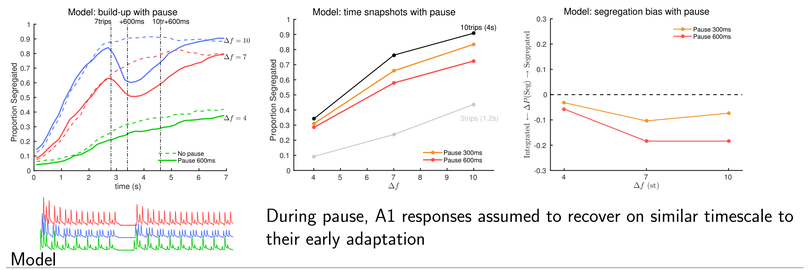
Previously used to study post-build-up alternations (Rankin etal 2015).

Early A1 adaptation and build-up

- Early A1 response properties bias Integration
- Build-up to Segregation through competition mechanisms (adaptation, noise, mutual inhibition)
- More Segregation with time (triplets) and at larger Δf

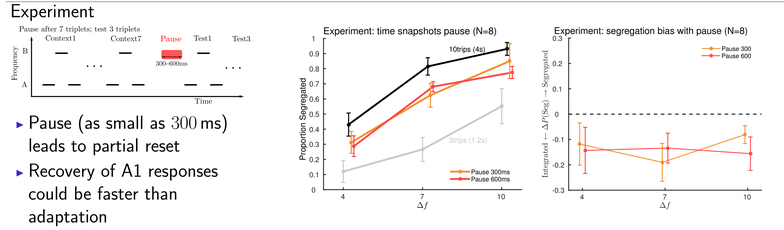


Stimulus pause results in a reset to integrated (reproducing a known effect)



During pause, A1 responses assumed to recover on similar timescale to their early adaptation

- Pause (as small as 300 ms) leads to partial reset
- Recovery of A1 responses could be faster than adaptation

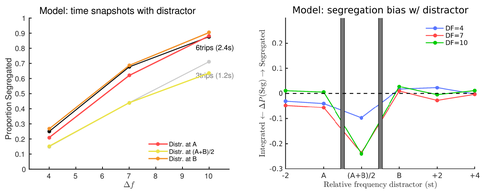


Micheyl C, Tian B, Carlyon RP and Rauschecker JP, **Perceptual organization of tone sequences in the auditory cortex of awake macaques**, *Neuron* 2005
Haywood, NR & Roberts, B, **Build-up of the tendency to segregate auditory streams: resetting effects evoked by a single deviant tone**, *J Acoustical Society of America* 2010
Shpiro A, Curtu R, Rinzel J and Rubin N, **Dynamical characteristics common to neuronal competition models**, *Journal of Neurophysiology* 2007
Rankin, J, Sussman, E and Rinzel, J, **Neuromechanistic model of auditory bistability**, *PLOS Computational Biology* 2015

Distractor & deviants, promotion of segregation

Model prediction for distractor tones: reset to integrated

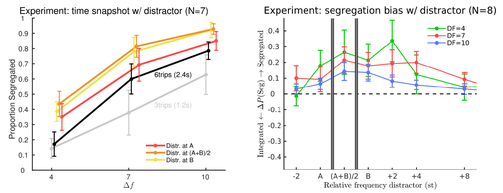
Assumption: inputs for distractor tone obey same rules and Δf-dependency as triplet tones.



- Model predicts reset to integrated for distractor at (A+B)/2

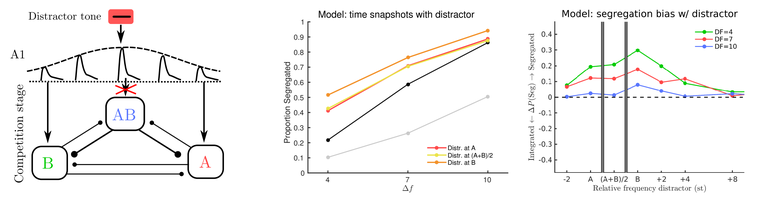
Experiment: distractor tones at different frequencies relative to As and Bs

- Deviant tones **promote segregation** across a wide range of conditions.
- Effect Δf-dependent; decays for distractors away from As and Bs.
- Non-monotonic relationship for Δf at frequencies away from As and Bs.



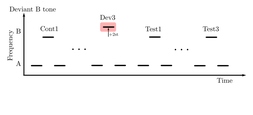
Model: What if inputs to AB population from distractors are gated?

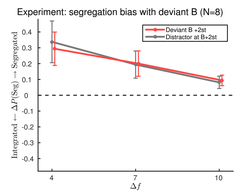
Assumption: Distractor tones not received as inputs to AB population.



Does promotion of segregation generalize to deviant tones?

- What is the effect of a deviant tone in one of the context triplets?





- Equivalent effect to a distractor tone at the same tonotopic location
- Deviant tones at end of induction sequence and in context triplets have opposite effects

Key results:
- Our results challenge existing understanding: **distractor and deviant tones during build-up can promote Segregation**
- Previous results on resetting with deviants at the end of induction sequences do not extend to the ongoing build-up process
- Our modelling suggests isolated tones or deviants do not contribute inputs to the neural population (assumed beyond A1) encoding the Integrated percept
- In our model, rapid **adaptation properties of early A1 responses** ($\tau \approx 500$ ms) can account for initial bias towards Integration
- Recovery of A1 responses on similar timescale can **account for a reset to integrated after a brief pause**

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