The Effects of Differing Spectral Envelopes and Ambiguity on Perceived Pitch

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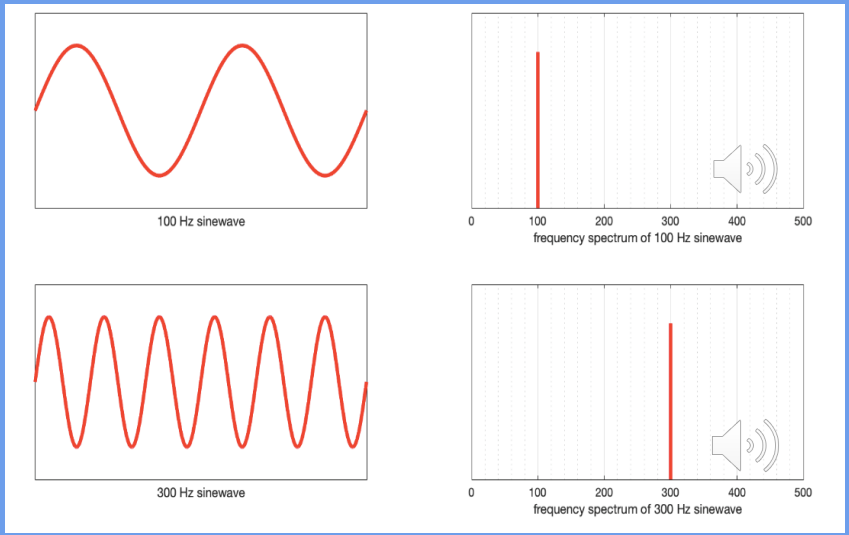
Overview

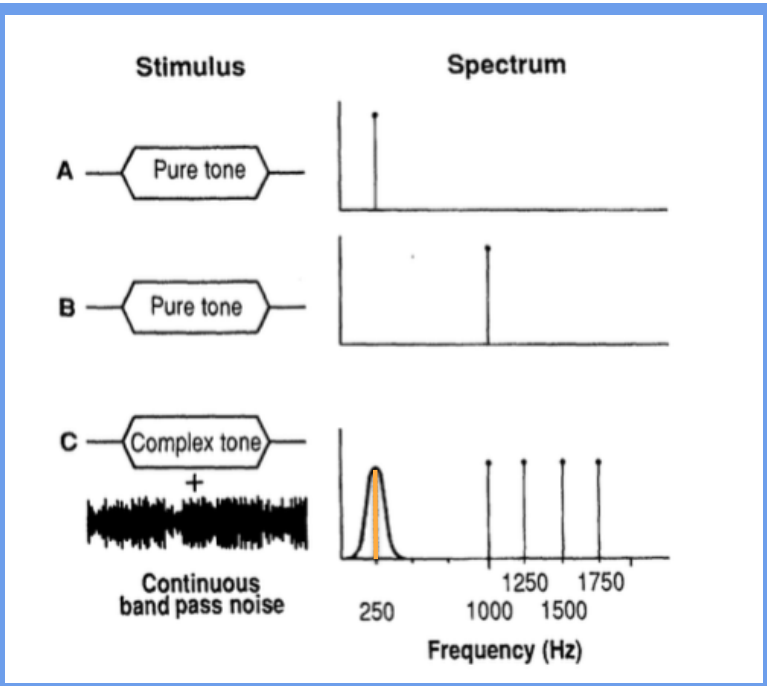
- How does the brain respond to auditory stimuli that are physically different but sound similar?
- Applications
  - Better understanding of the neurological basis of language and speech, but at the fundamental, most basic components

Sound Waves

- Pure Tones
  - Perceived Pitch = Spectral Envelope
- Region of auditory cortex reflects perceived pitch, rather than physical (Pantev et al., 1989).



Missing Fundamental Effect



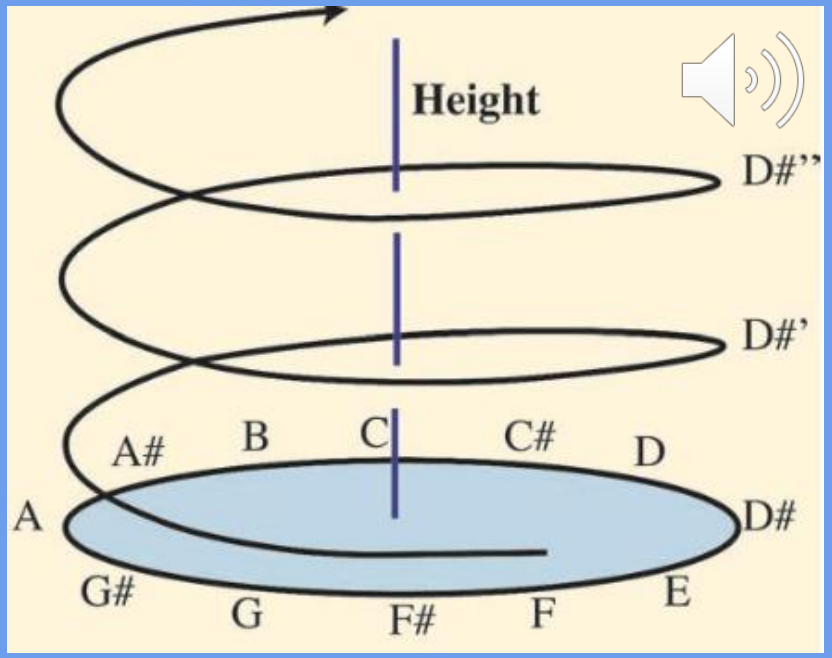
(Pantev et al., 1989)

with 250 Hz tone:

without 250 Hz tone
(missing fundamental effect):

Shepard Tones

- Different spectral envelope
  - Ambiguous
- Two types
  - Circular = 7 tones, no pauses
  - Scaled = 8 tones, ambiguous intermediate tone



(Deustch,

MEG

- Magnetoencephalography (MEG)
  - neuroimaging technique
  - measures magnetic fluctuations of brain
- MEG signals give us a measure of brain activity that correlates with the stimulus
  - Different tones, different signals

Retrieved from https://www.natureasia.com/en/nmiddleeast/article/10.1038/nmiddleeast.2012.88

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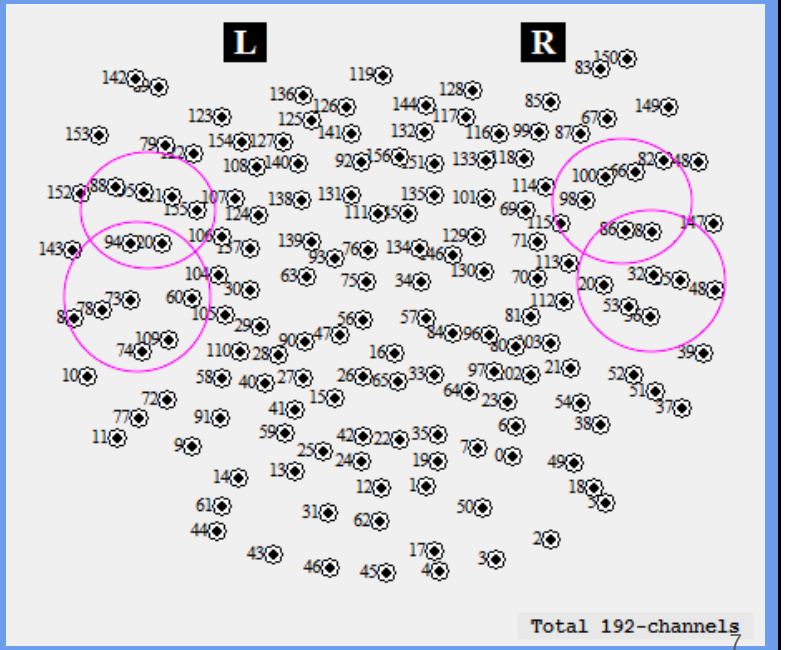
Pilot Study

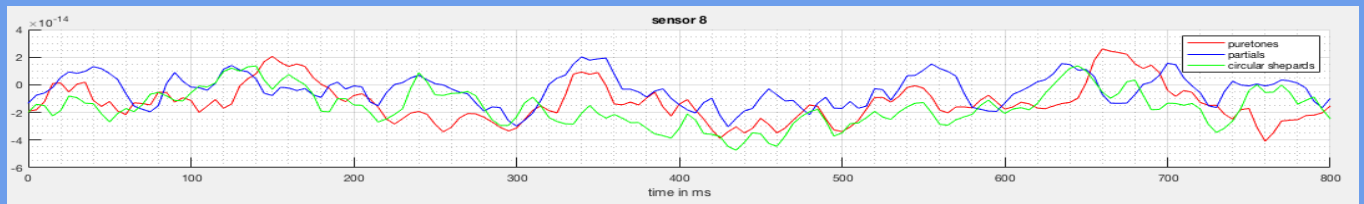
- 20 relevant sensors
- 3825 Trials of 400 ms
- 4 Stimuli
  a. Pure tones
  b. Complex tones composed of upper partials
  c. Shepard tones in 2 contexts
     i. Circular
     ii. Scale



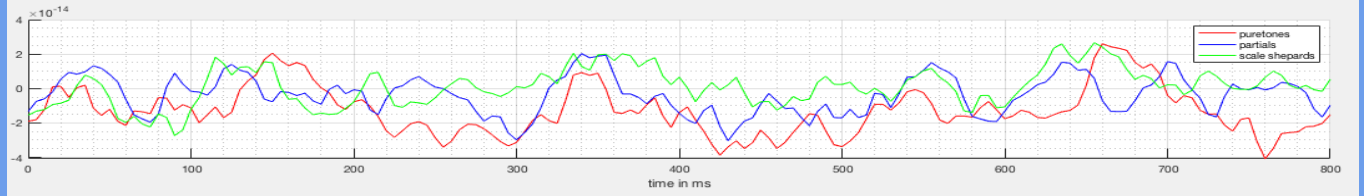
Sensor Analysis

- MATLAB
  - Average, baseline corrected, graphed
- Qualitative analysis of trends within and between sensors

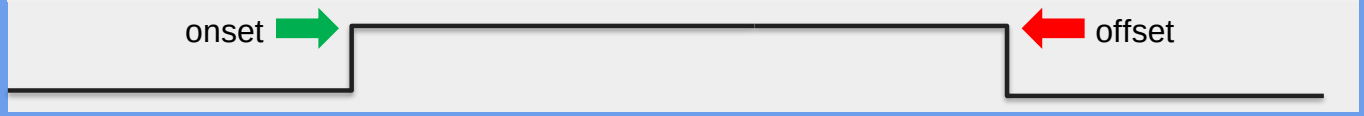
Shepard tone in circular context



Shepard tone in scale context

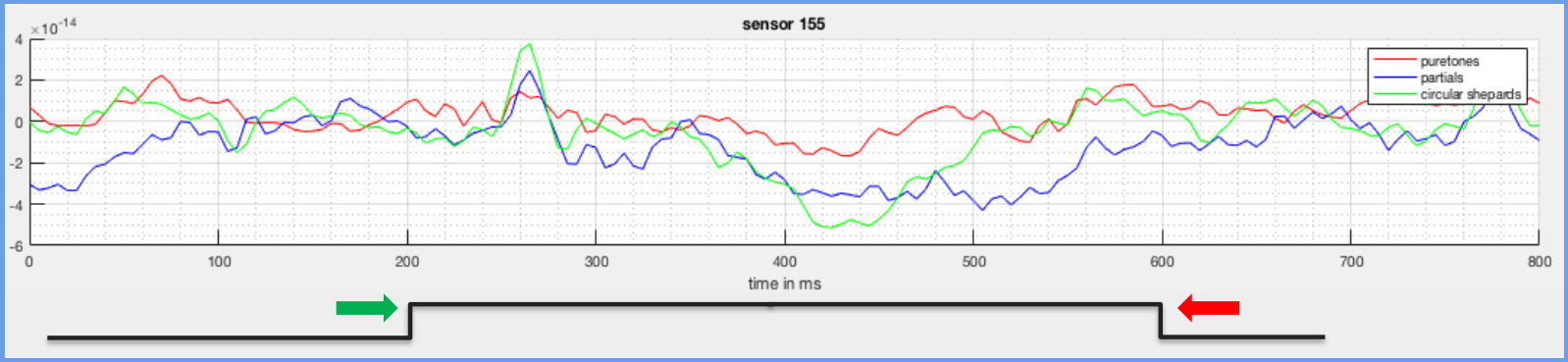


Audio



Data Trends of Shepard Tones

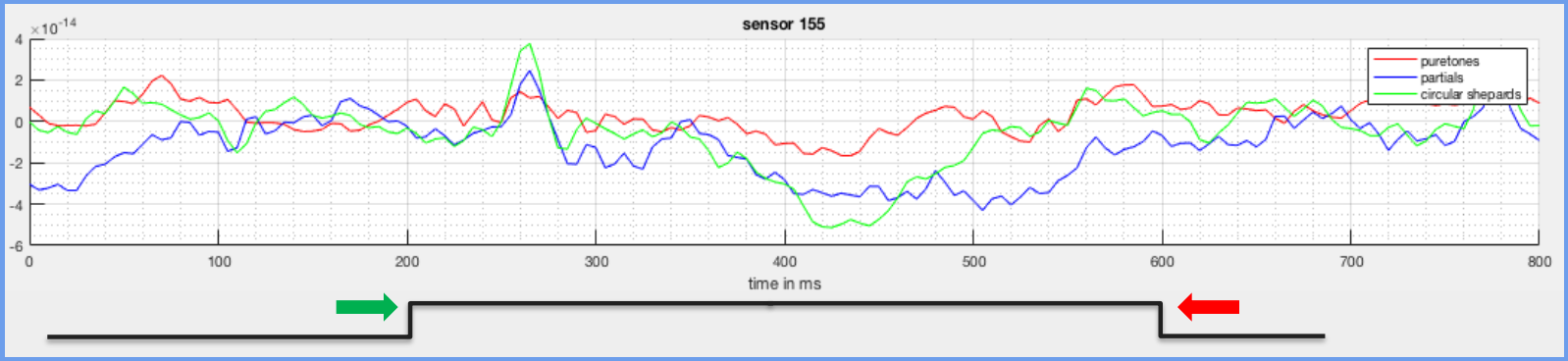
1. Shepard tones (G) follow Partials (B), then follows Pure tones (R) at 200ms.



2. Shepard tones (G) has properties of both.
3. Shepard tones alternates between following Partials (B) and Pure tones (R).
4. Shepard tones (G) are independent and random.
5. Shepard tones (G) predominantly follows Partial tones (B).

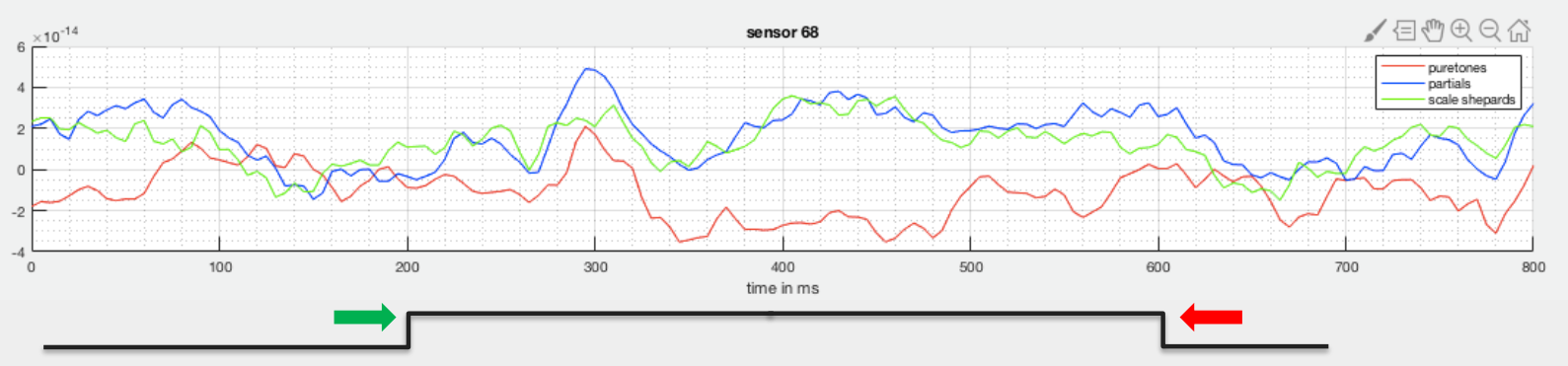
Results

- *Within Sensors*
  - Circular Shepard tones tends to follow the first trend.
    - 1st trend: Shepard tones (G) follow Partials (B), then follows Pure tones (R).



Results

- *Between Sensors*
  - In right hemisphere, Shepard tones (G) follows Partials (B) much more closely.



Key Findings

- Generally, pure tones and complex tones are represented differently.
- Difficult to predict which trend the Shepard tones will follow.
  - Context related ambiguity
- Ambiguous Shepard tones:
  - Tend to be most similar to ‘Partials’
  - However, in right hemisphere they tracked pure tones after about 200 ms.

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