Music Perception with Combined Stimulation

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Background

- Low-frequency information available through preserved acoustic hearing can assist CI recipients in segregating the target speech signal from background noise.

  (Gantz & Turner, 2003; Gantz et al., 2006; Turner et al., 2004)
• Low-frequency information available through preserved acoustic hearing can also assist CI recipients in perception of salient features of music (Dorman et al., 2008; El Fata et al., 2009; Galvin et al., 2009; Gantz et al., 2006; Gfeller et al., 2006, 2007, 2009; Kong et al., 2004; Turner et al., 2005, 2007)
Salient Features of Music

- Rhythm
  - Tempo, basic beat
  - Duration of individual notes

- Timbre
  - Identification of voices, instruments, blends
  - Sound quality

- Pitch
  - Interval size, direction of pitch change = melody
  - Concurrent pitches=harmony
Salient Features of Music

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• Lyrics in vocal music
Technical Issues: Music vs. Speech

- Differences in acoustic input of speech and music
  - Frequency range
    - Speech: 250-8000 Hz
    - Music: 27-well above 8000 Hz
  - Spectrum
    - Speech: well controlled spectrum
    - Music: highly variable and rapidly changing spectrum.
  - Intensity
    - Speech: 53-83 dB SPL
    - Music: 10-120 dB SPL; rapid changes in amplitude

- Music requires better resolution of pitch/spectral shape
# Music Perception

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>Measure</th>
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</table>
| • Isolated structural features  
  • Pitch, timbre, duration | • Perceptual accuracy  
  • Detection, discrimination, recognition |
| • Computer-generated combinations  
  • e.g., pitch + rhythm | • Appraisal  
  • Sound quality and enjoyment |
| • Real-world combinations  
  • pitch (melody, harmony), timbre, duration, amplitude, lyrics. | |
Pitch Ranking

Gfeller et al., 2007
Melody Recognition

(Gfeller et al., 2006, 2007, 2010)
Interval Normalization

Modified Melodies Test

% correct

100
90
80
70
60
50
40
30
20
10
0

131 Hz
262 Hz
523 Hz

A+E (N=10)
Bilateral LE (N=6)
Normal Hearing (N=18)
Timbre Recognition

Gfeller et al., 2006
Lyrics Recognition

Gfeller et al., 2009
Music functions as a masker of speech sounds in many real-life situations (e.g., music at a party, MUZAK, music scores in movies).
Speech Recognition in Background Music Test (SRBM)

• Recognition of 12 spondees (as described in Turner et al., 2004)
  • against 3 types of background music
    – piano solo
    – vocal solo + bass and guitar accompaniment
    – large orchestra

• Participants
  • 154 long electrode CI recipients (LE); 21 Hybrid recipients (A+E); 49 normal hearing adults (NH)
Speech Recognition in Background Music

Gfeller et al., 2012
Pitch and Speech

- Pitch perception correlated with
  - Speech in background noise (Gantz & Turner, 2003; Gantz et al., 2006; Gfeller, Turner, et al., 2012; Turner et al., 2004)

- Recognition of prosody marking linguistic contrasts (See, Driscoll, Gfeller et al., 2013)

- Tone discrimination in Mandarin Chinese (Xu, 200x)

- Talker discrimination (recognition) (Johnson, Driscoll, Gfeller et al., 2011)
Correlations:
SRBM X Pitch Ranking, Ripple Test

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<tr>
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<th>SRBM</th>
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<tr>
<td>Pitch Ranking (N=165)</td>
<td>-.26 (p&lt;.001)</td>
</tr>
<tr>
<td>Spectral Ripple (N=15)</td>
<td>-.60 (p&lt;.02)</td>
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Gfeller et al., 2012
SRBN X SNR: Noise, Babble

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<tr>
<th>SNR (N=124)</th>
<th>SRBM</th>
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<tr>
<td>Noise</td>
<td>.72 (p&lt;.001)</td>
</tr>
<tr>
<td>Babble</td>
<td>.66 (p&lt;.001)</td>
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Gfeller et al., 2012
Conclusions

- Preserved residual hearing benefits
  - perception of pitch (melody), timbre
  - better extraction of a target speaker from background noise or music
Spectral Analyses of Musical Stimuli

Piano solo

Vocal solo + guitar

Orchestra