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

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- Lyrics in vocal music

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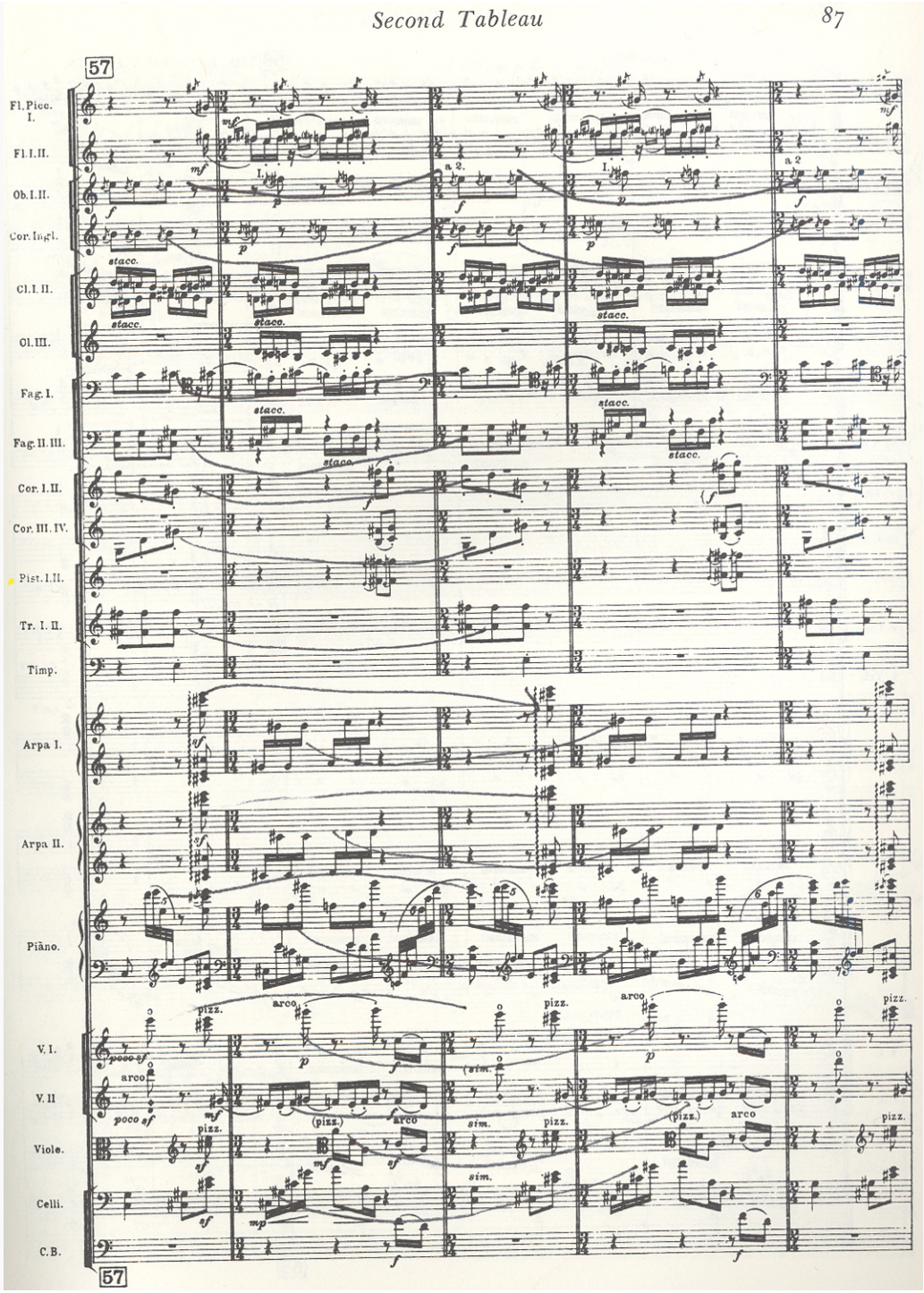


Technical Issues: Music vs. Speech

- 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

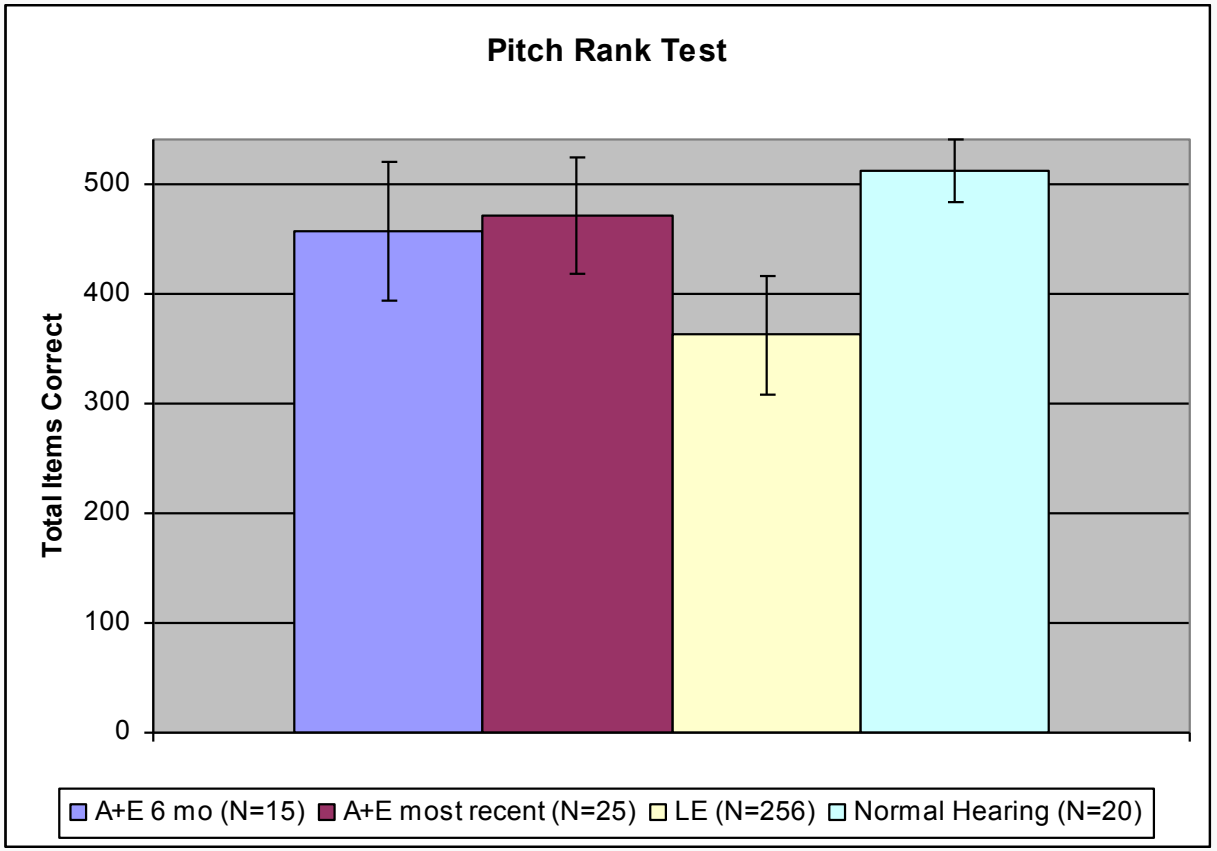
Stimuli

- Isolated structural features
  - Pitch, timbre, duration
- Computer-generated combinations
  - e.g., pitch + rhythm
- Real-world combinations
  - pitch (melody, harmony), timbre, duration, amplitude, lyrics.

Measure

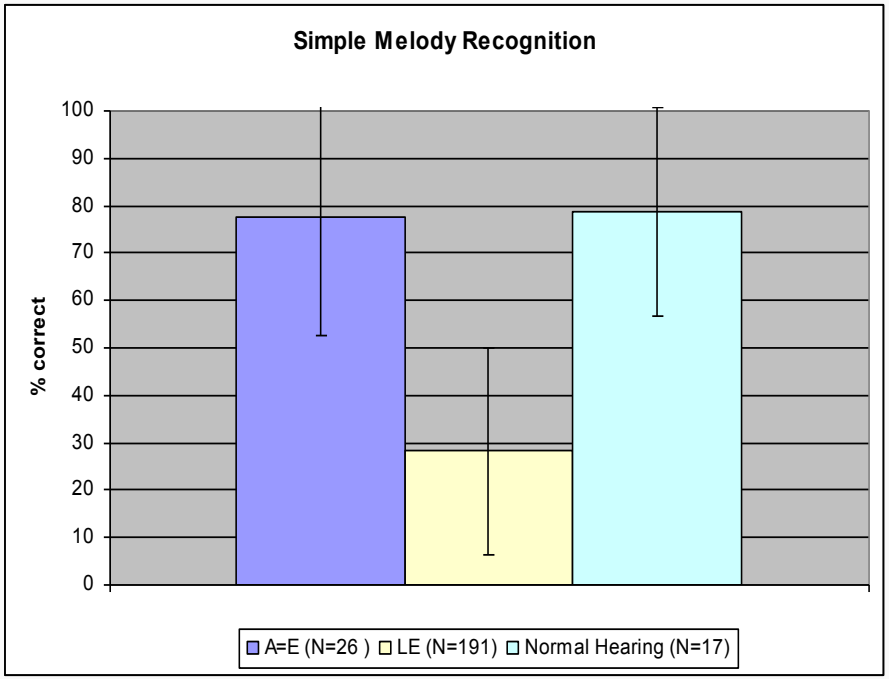
- Perceptual accuracy
  - Detection, discrimination, recognition
- Appraisal
  - Sound quality and enjoyment

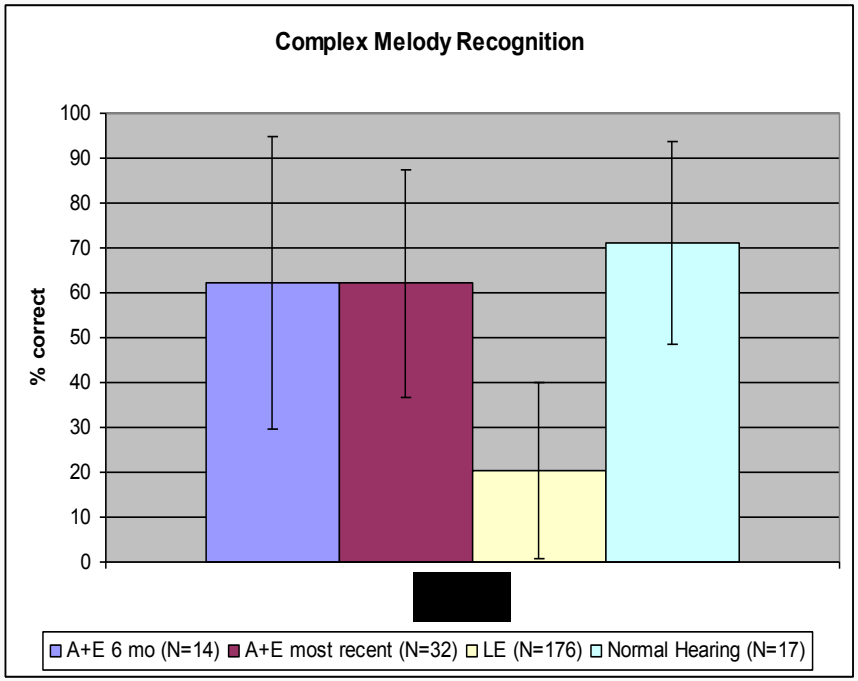
Pitch Ranking



Gfeller et al., 2007

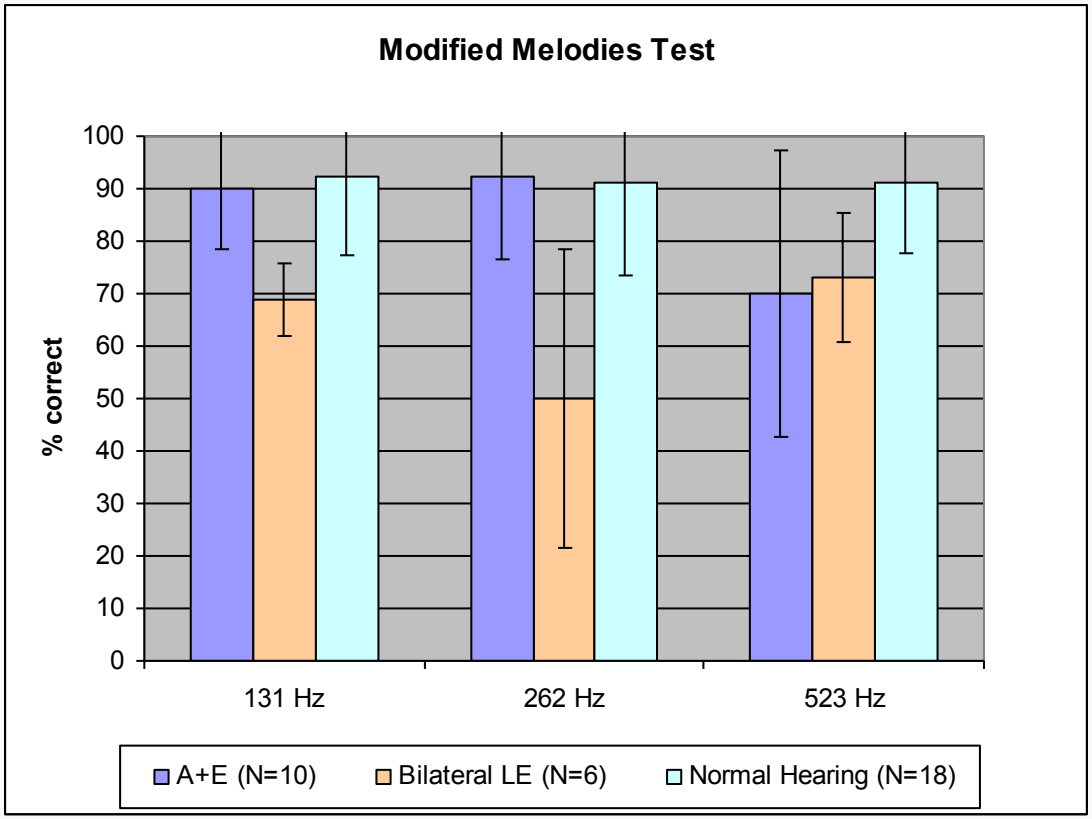
Melody Recognition



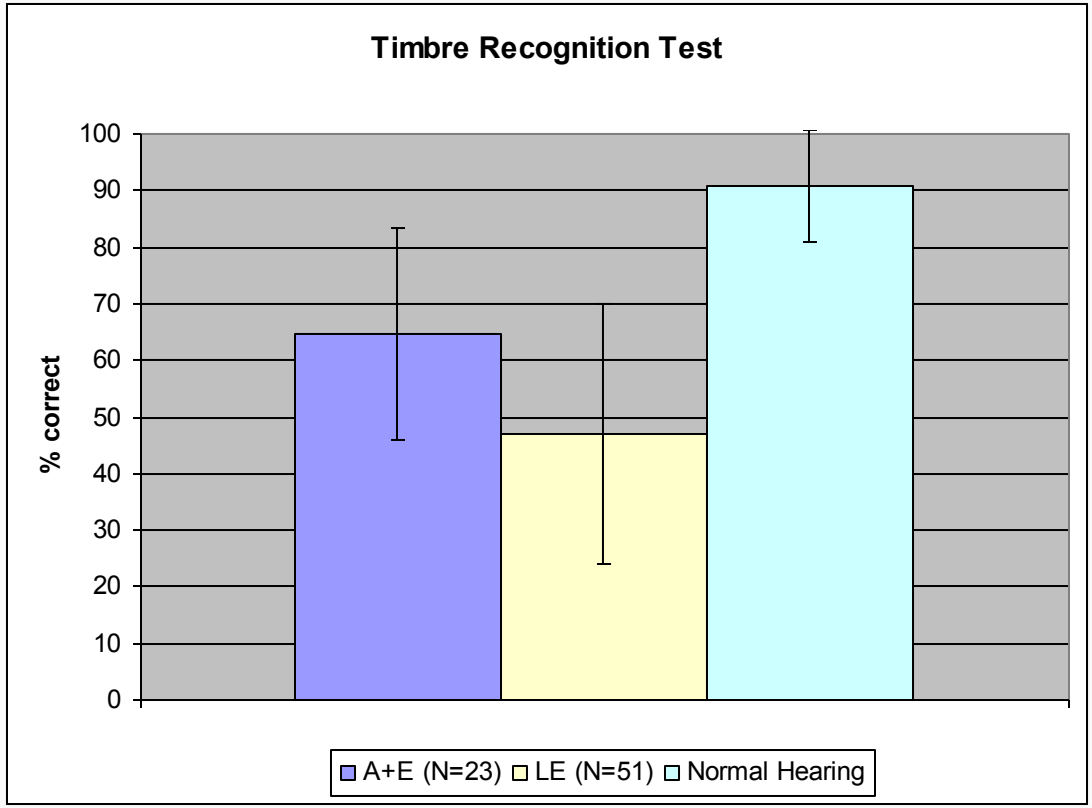


(Gfeller et al., 2006, 2007, 2010)

Interval Normalization

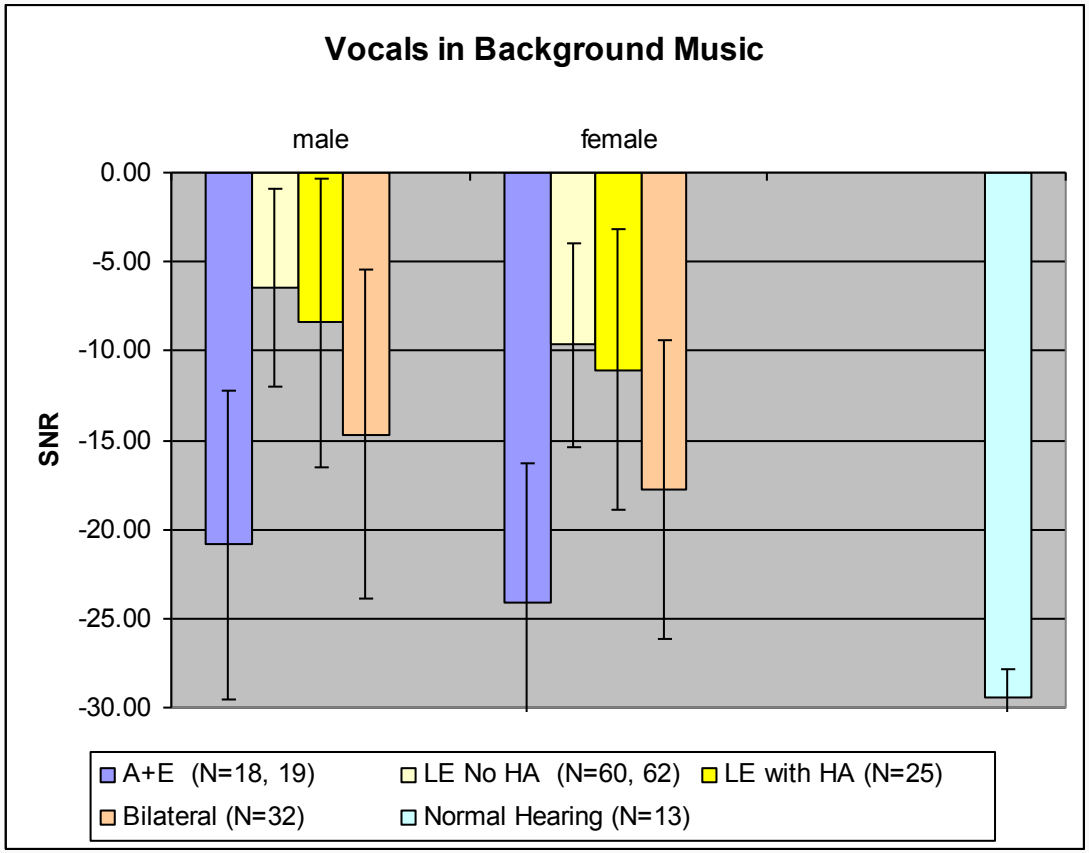


Timbre Recognition



Gfeller et al., 2006

Lyrics Recognition



Gfeller et al., 2009

Music as Background Noise

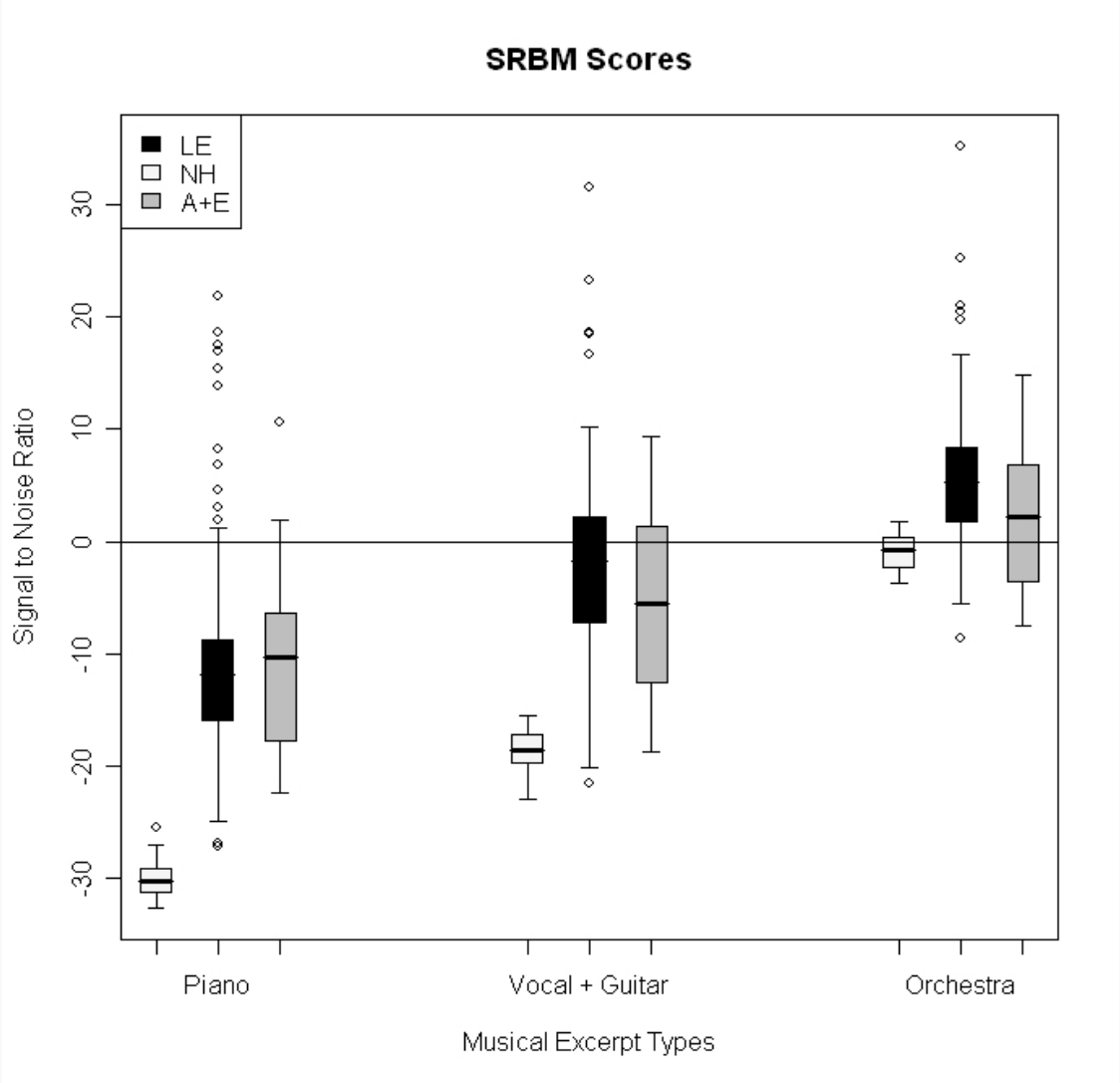
- Music functions as a masker of speech sounds in many real-life situations (e.g., music at a party, MUZAK, music scores in movies).

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

	SRBM
Pitch Ranking (N=165)	-.26 (p<.001)
Spectral Ripple (N=15)	-.60 (p<.02)

Gfeller et al., 2012

SRBN X SNR: Noise, Babble

SNR (N=124)	**SRBM**
Noise	.72 (p<.001)
Babble	.66 (p<.001)

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

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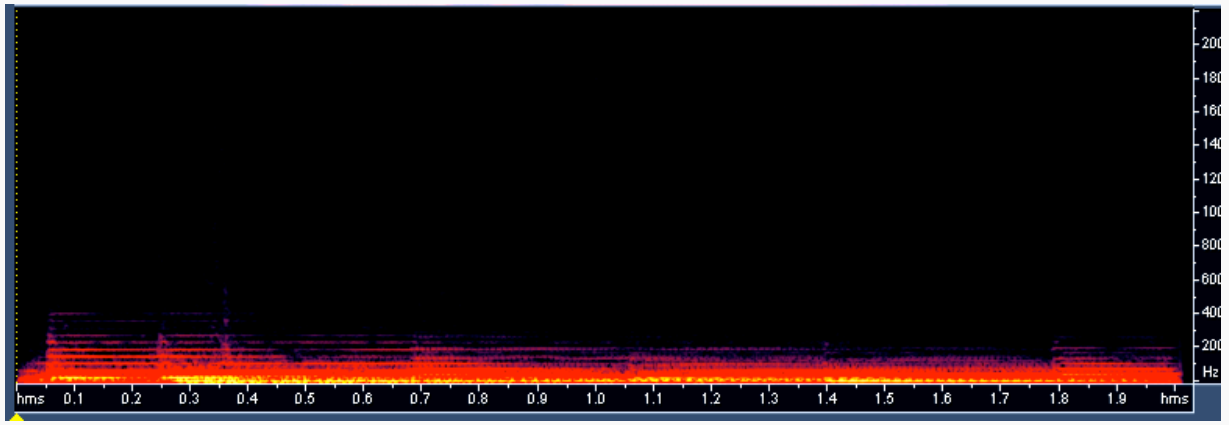
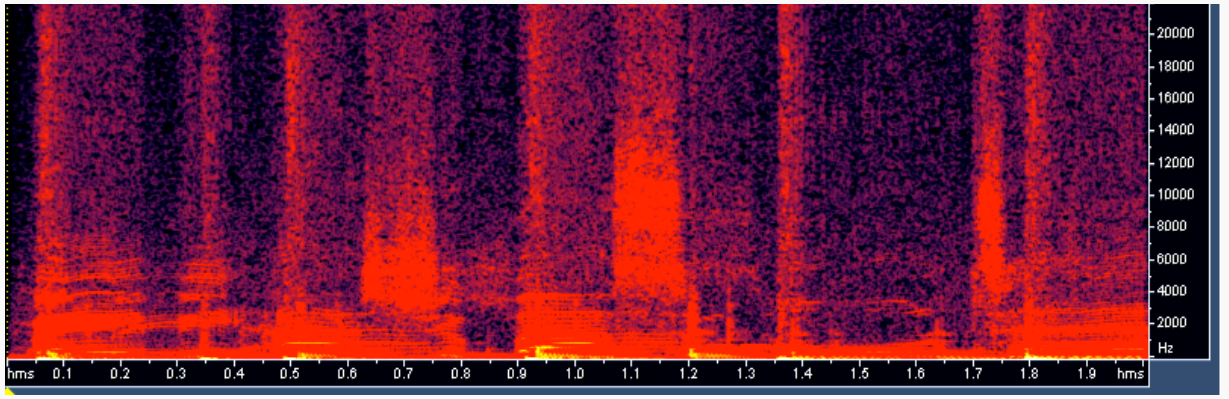
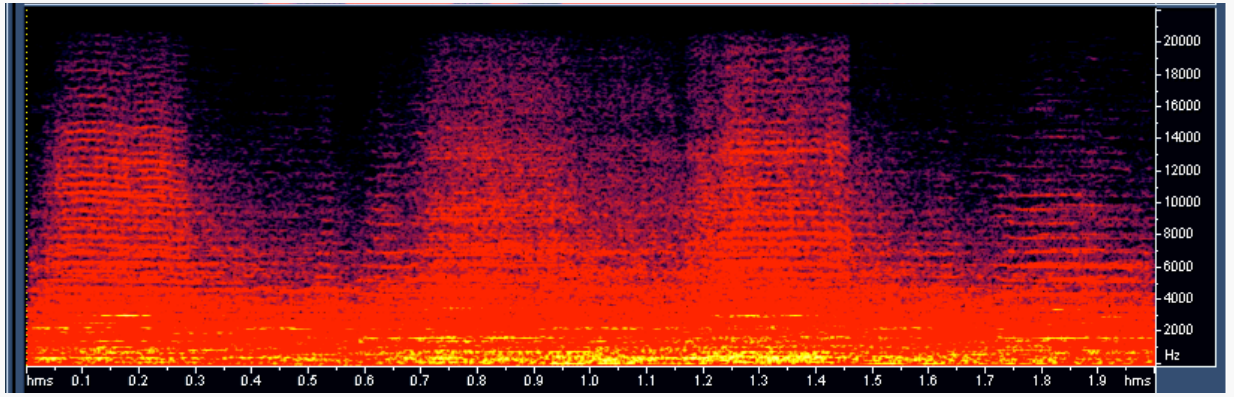
Spectral Analyses of Musical Stimuli



Piano solo



Vocal solo + guitar



Orchestra