Music and CI Listeners: Overcoming Obstacles and Harnessing Capabilities

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Iowa Cochlear Implant Clinical Research Team

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Thanks!

- To the many recipients of cochlear implants and their families who have helped me better understand their musical experiences.
Obstacles

• The CI has been designed to convey salient features of speech.

• Music is made up of rapidly changing complex sounds that are difficult to convey through cochlear implants.
Narrow frequency range

Degraded representation of the fine, complex elements of music

Distribution of Frequencies to Electrodes (#22-1)
Obstacles

• The CI has been designed to convey salient features of speech.

• Music is made up of rapidly changing complex sounds that are difficult to convey through cochlear implants.
Speech vs. Music

“When are you going to the store?”
Problematic Features of Music

- Harmony
- Timbre
- Melody
- Harmony

(Looi, Gfeller & Driscoll, 2012, Limb & Roy, 2014)
Pitch Ranking

Adults: n=165
Pediatric: n=77
Recipients of CIs
congenital loss, implanted age 5.6
Postlingual loss
• “I can hear the music, but it doesn’t make any sense to me.”
• “Music sounds like a cage full of squawking parrots.”
• “The organ at church sounds like a train coming through the sanctuary.”
• “I cannot recognize a violin vs. a flute or any other instrument. It sounds like a bunch of sounds kind of thrown together.”
Q. What have we learned from recipients of CIs?
Congenital loss, implanted age 3
Postlingual loss
• “I love good folk music. My husband and I are members of a close-knit folk community, and we meet in each other’s homes weekly.”
“I try to listen to music daily. If I don’t, I miss it. It satisfies a deep hunger of mine. I now prefer Baroque music most of all.”
Harnessing Capabilities

Q. What have we learned from recipients of CIs?

A. Music can be enjoyed and perception can improve.
Harnessing Capabilities

• Focusing on accessible features of music
• Using accommodations
• Training
• Realistic, individualized expectations
Accessible Features of Music

• **Rhythm**  (Gfeller & Lansing, 1991, 1992; Olszewski et al., 2006; Limb & Roy, 2014)

• **Song Lyrics**  (Olszewski et al., 2005; Gfeller et al., 2008, Hsiao, 2008)

“Old Macdonald had a farm, e-i-e-i-o. . . .”
Accessible Features

- Follow lyrics: 75%
- Distinct rhythm: 79%
- Simple melody/rhythm: 75%

n=179
Accommodations

• Good listening environment, signal input

• Strategic use of memory, accessible cues
Listening Environment: Avoid Noisy Rooms, Loud Music

- Noisy room: 92% response
- Echo in room: 90% response
- Loud music: 66% response

n=179
Better Listening Environment, Signal Input

- **specific coding strategy**: 28% response, 38% no experience
- **optimal concert seating**: 55% response, 29% no experience
- **direct audio input**: 18% response, 75% no experience
- **headphones**: 18% response, 78% no experience
- **quality recording**: 76% response, 11% no experience

\[ n = 179 \]
Accommodations

• Good listening environment, signal input
• Strategic use of memory, accessible cues,
Helpful Accommodations?
Familiarity, Accessible Cues

- familiar music: 88%
- knowing song title: 78%
- watch performer: 81%

n=179
Listening to Familiar Music

• “It does help . . . if I know what it’s supposed to sound like. For example, the ‘Star Spangled Banner’ started to sound fairly normal about a week into the Olympics, but I think this is my brain filling in the missing pieces.”
What Helps?
More Listening Experience

Practice Listening
- 43% response
- 40% no experience

Implant Experience
- 76% response

Percent Response
Long Term Music Training
Music Training

Music enjoyment

Perceptual Accuracy: behavioral outcomes

Neural Efficiency
Enjoyment and Perception

• Music training can improve
  – timbre quality and recognition
  – pitch perception and melody recognition

(Chen et al., 2010; Driscoll, et al., 2009; Fu and Galvin, 2007; Galvin, Fu & Nogaki, 2007; Galvin et al., 2009; Gfeller et al., 2000a, b, 2002 Loebach & Pisoni, 2008; Loebach, Pisoni, & Svirsky, 2009; Olszewski et al., 2005, 2006 Rocca, 2012)
Results of Training

Behavioral Outcomes

Complex Song Recognition

Gfeller et al., 2001
• “I came home and found my husband enjoying a symphony concert on PBS for the first time in years. I have my husband back.”
• “For the first time in years, we went to a movie and my husband enjoyed the sound. We’re going to go to the movies again!”
• “I just returned from a Christmas concert last night. When they sang, ‘Do you hear what I hear?’ . . .I was overcome with emotion!”
Neural Efficiency: Training Effects

- Preliminary data: long-term musical training results in more robust change responses.
Comparisons with Users of CIs

- **Listeners-Typical Hearing (TH):**
  - Responses to changes of < 1 semitone typical.
  - Training effects evident

- **Users of CIs:**
  - 3 AB, 4 Cochlear
  - Normalized amplitudes smaller.
  - Larger pitch changes needed to evoke change response
  - 1 has change responses similar to TH listeners!
Transfer of Music Training to Speech Perception

• Overlap in brain networks that process acoustic features in music and speech

• Music training benefits cognitive and linguistic functioning in NH listeners
  – phonological processing, verbal memory, speech perception in background noise, language learning

  (e.g., Musacchia et al., 2007, 2008, Wong et al., 2007; Strait et al., 2009; Moreno et al., 2009; Parbery-Clark et al., 2009; Kraus & Skoe, 2009; Kraus, Skoe, Parbery-Clark, & Ashley, 2009; Kraus and Chandrasekaran, 2010)
Music Therapy for Children with CIs
Practical Training Considerations

• Focused practice in a ‘clean’ listening environment
• Repetition distributed over time
• Judicious selection of musical materials
  • Start with accessible features of music; gradually increase difficulty
• Use contextual non-auditory cues
• Trial and error

Realistic, Individualized Expectations

• Balancing optimism with realism

“Initially it was very disappointing to listen to music with my CI. . . . . I have had to adapt. [After] accepting a ‘new sound' . . . . it can be extremely enjoyable to listen to music now. . it’s just different.”
Accuracy ≠ Enjoyment

• Better perceptual accuracy does not guarantee music enjoyment.
  
  (Gfeller, Oleson et al., 2008, 2010, Wright & Uchanski, 2012; van Besouw et al., 2011)

  – Recipients with below-average perception can still enjoy listening to music.
Extent of Interest in Music: Children with CIs from our Center

Gfeller et al., 2000
Adolescents with CIs: Importance of Music in Your Life?

Gfeller et al., 2012
Individualized Needs and Interests
One Approach Fits All
Conditions Required to Achieve Benefit from Music Training
(Patel, 2011)

• Overlap in brain networks that process acoustic features in music and speech
  • Music requires greater precision of processing on shared networks

• Music associated with strong positive emotion

• Music involves considerable repetition

• Music associated with focused attention
Is Music Training Suitable for Me (My Child?)

• Can I hear some differences in musical sounds?
• Are some aspects of music interesting or enjoyable to listen to/play? Can it hold my attention?
• Is music enjoyment a high priority for me, my family? Is it worth some time and effort?
• What resources are available in the home, school, community?
Harnessing Capabilities

- Accessible features of music
- Accommodations
- Training
- Realistic, individualized expectations
Questions?