Creating Pathways to Language Development through the Use of Cochlear Implants and Music

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“When music and song are not made available to them, the experience of children who are deaf or hard of hearing is unnecessarily restricted.”

~Daniel Ling
Course Outline

- Music development
- Music and Early Intervention
- Cochlear Implants and Music
- Resources to support Music
Why Music Matters ♫

When humans come together for any reason, music is there...
Music Development

• Birth to 6 months
  • Discriminate frequencies
  • Prefer soothing music in a high pitch voice
  • 3 months will “coo” and “sing” in response to music
• 6 months to 1 year
  • Respond to music by moving but not in synchrony
  • Process differences in rhythm
  • Singing to babies can help regulate affect
• 1 year to 18 months
  • Attempt to match movements to music
  • Spontaneously dance to music
  • Vocal range expanded and there is much more “singing” to music
• 18 months to 36 months
  • Toddlers will make up own songs while they play
  • Song lyrics are learned before the rhythm or melody

Music and Spoken Language

- Music, like language, follows a time-ordered, sequential developmental path
- Children are born with the capacity to learn music and language
- Environment, especially early on, is crucial to the development of both language and music
“Why Music?”

• Take advantage of music’s large sound spectrum
• Reinforce active listening skills
• Stimulate motor responses
• Easily adapted to age, ability, or culture
• Release and nurture creativity
• Offer a non-verbal/pre-verbal means of communication
• Teach social skills
• Foster oral speech, language and auditory development
Infant-Directed Singing

- Earliest form of music
- Universal caregiving behavior
- Attracts and maintains infant attention
- Conveys emotional information (motherese)
- Helps infants regulate affective state
- Creates bond between mother/child
Musical Aspects of Language

- Melodic contour, timbre variations
- Inflection comes naturally through music
- Motherese speech (communicative intent)
- Rhythm
- Conversational turn-taking
- Language confrontational/Music invitational
- Acoustic highlighting
Music in Intervention

- Use of pre-composed songs and piggy-backing
- Direct training tool for speech/language therapy
- Improvised music for an immediate need or interest
“Music does not sound like I remember when I had hearing. I try to avoid those situations”
~CI recipient

Easy to Connect to Music  Support Music (Re)Habilitation  Improve Music Sound Quality
Easy to Connect to Music ♪

- **Direct Connect** Earhook provides hardwired connection to commercial music players and other audio devices
- **T-Mic** provides easy wireless connection to commercial music players (iPods, MP3) and other audio devices via headsets/earbuds
- Easy to **connect to music in the real world**—at work, on the airplane, in the classroom, in the music store
Success requires that the **intensity**, **spectral** and **temporal** patterns which occur in the normal ear be duplicated as closely as possible.
Intensity

- Normal Hearing Ear has a wide dynamic range - ~100 dB able to accommodate the wide IDR of music
- Conventional CIs have a narrow IDR limited to 30 dB
- HiRes Harmony has a programmable wide input dynamic range (IDR) - up to 80 dB
- Intensity Domain addressed
- What About Temporal?
Temporal Domain

- Normal Hearing nerve uses envelope and fine time information
- Conventional CIs only code the speech envelope
- HiRes Harmony preserves envelope and fine time cues (rate pitch)
  - 5,200 Hz sampling
  - 83,000 pulses per second
16 channel Chimeras

S1 Fine Structure: “The clown has a funny face”
S2 Envelope: “The car is going too fast”

M1 Fine Time Twinkle Twinkle
M2 Envelope Frere Jacques

If *speech* transmission is the primary goal of cochlear implants, then envelope seems most important to transmit. But when *music* becomes a goal, fine structure is also relevant.
Temporal

- Normal Hearing nerve uses envelope and fine time information
- Conventional CIs use low resolution filtering and slow stimulation rates
- HiRes Harmony preserves envelope and fine time cues (rate pitch)
  - 5,200 Hz sampling
  - 83,000 pulses per second
- Intensity addressed
- Temporal addressed
- What about spectral?
Spectral Domain

- Normal Hearing ear is tonotopically tuned to place of stimulation
- The spectral resolution of conventional CIs is limited by the number of electrodes
- HiRes 120 provides 120 spectral bands via current steering (place pitch)
Conventional Spectral Resolution

Filter response

Filter 1

Filter 2
Unresolved

Filter 3
Resolved

Filter 4

16 18 20 21 23 25 27 28 30 32 33 37 39 42 44 45 47 49 52 54 56 57 59 61 63 64 66 68 69 71 73 75
HiRes 120 via Current Steering

How do we do it?

- Multiple current sources
- Active current steering is designed to deliver added spectral information between adjacent pairs of electrodes through accurately weighted simultaneous stimulation
HiResolution Spectral Resolution
• Normal Hearing ear is tonotopically tuned to place of stimulation
• Conventional CIs are limited to # of electrodes
• HiRes 120 provides 120 spectral bands via current steering (place pitch)

• Intensity Addressed
• Temporal Addressed
• Spectral Addressed
Better Hearing for Music ♫

- **Intensity Domain**
  - Programmable wide IDR (up to 80 dB)

- **Time Domain**
  - Fine Time Resolution (rate pitch)
    - 5,200 Hz sampling
    - 83,000 pulses per second

- **Frequency Domain**
  - Fine Spectral Resolution (place pitch)
    - HiRes 120 option

90% prefer HiResolution

Does it achieve better sound for music?
“I especially enjoy percussion performances... I've been to a few concerts and I enjoy trying to pick out which instrument is making a particular sound. Flutes are especially wonderful to my ears. Even bagpipes sound good. ~Doug Roberts

As a musician, hearing is a major part of my livelihood. As my hearing loss progressed, hearing aids just couldn’t do enough, so I lost something very important. After I got implanted, I listened to a Beethoven CD and said, “That’s it! Wow! It sounds perfect!” ~John Redden
Even though he’s deaf, I’d have to say that Brandyn has quite an ear for music. I wouldn’t be surprised if he grows up to be a professional musician. ~Melissa Li, Mother of Brandyn
Summary ♫

- Music matters
- Harmony makes it easy to connect to music
- HiResolution offers better hearing for music
- Music should be incorporated into Early Intervention
- AB provides rehabilitation resources to support your intervention efforts
  - The Listening Room
  - Tune Ups
Not sure where to begin?

• The Listening Room Infants and Toddlers
  • Music has been incorporated into a child’s daily routine
  • You can download the songs, lyrics and instructions on how to use during your home visits and demonstrate to the families you support
• Visit us at www.BionicEar.com today!

0 to 6 months  6 months to 1 year  1 year to 18 months  18 months and up