



# 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



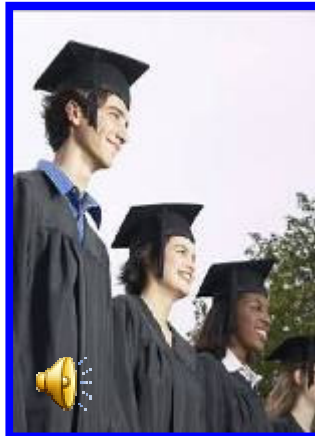
- Music development
- Music and Early Intervention
- Cochlear Implants and Music
- Resources to support Music



# 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 and Cochlear Implants 🎵

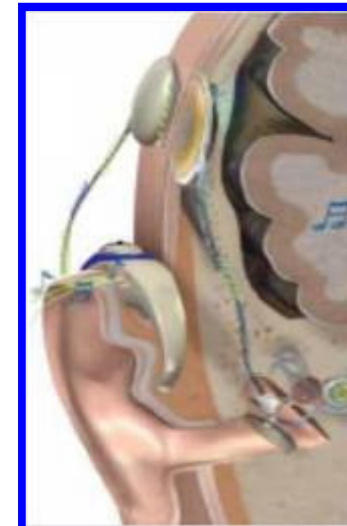
“ Music does not sound like I remember when I had hearing, I try to avoid those situations”  
~CI recipient



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





# Support Music Rehabilitation 🎵

**Music Time**  
A musical resource for deaf children

**Tune Ups**  
A music program designed to foster communication development

Improve Listening Skills With Environmental Sounds and Music

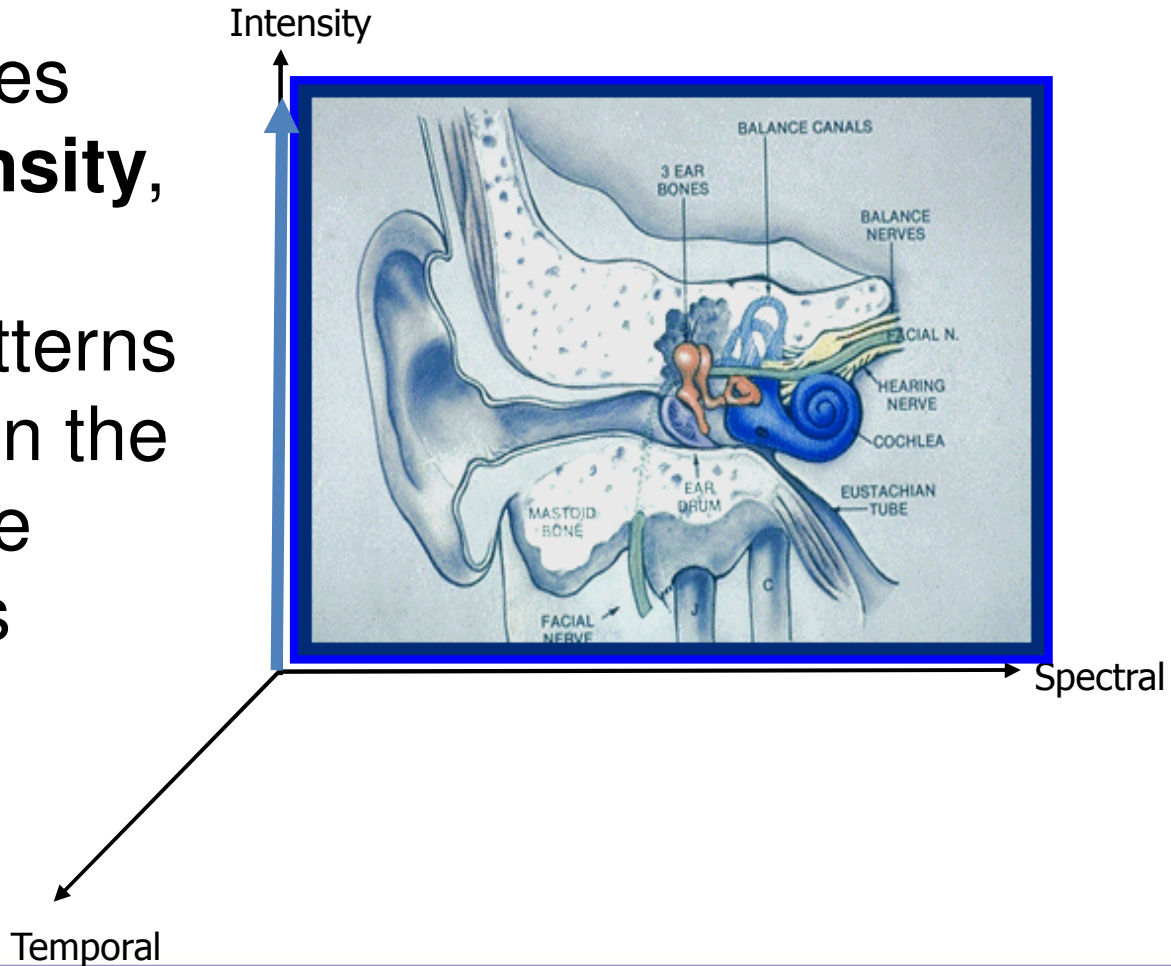
**Loud & Clear!**  
Beyond All else to Tune Deaf Ears: Hearing-aided Preschoolers in Children with Cochlear Implants

**THE Listening Room**  
[www.HearingJourney.com](http://www.HearingJourney.com)



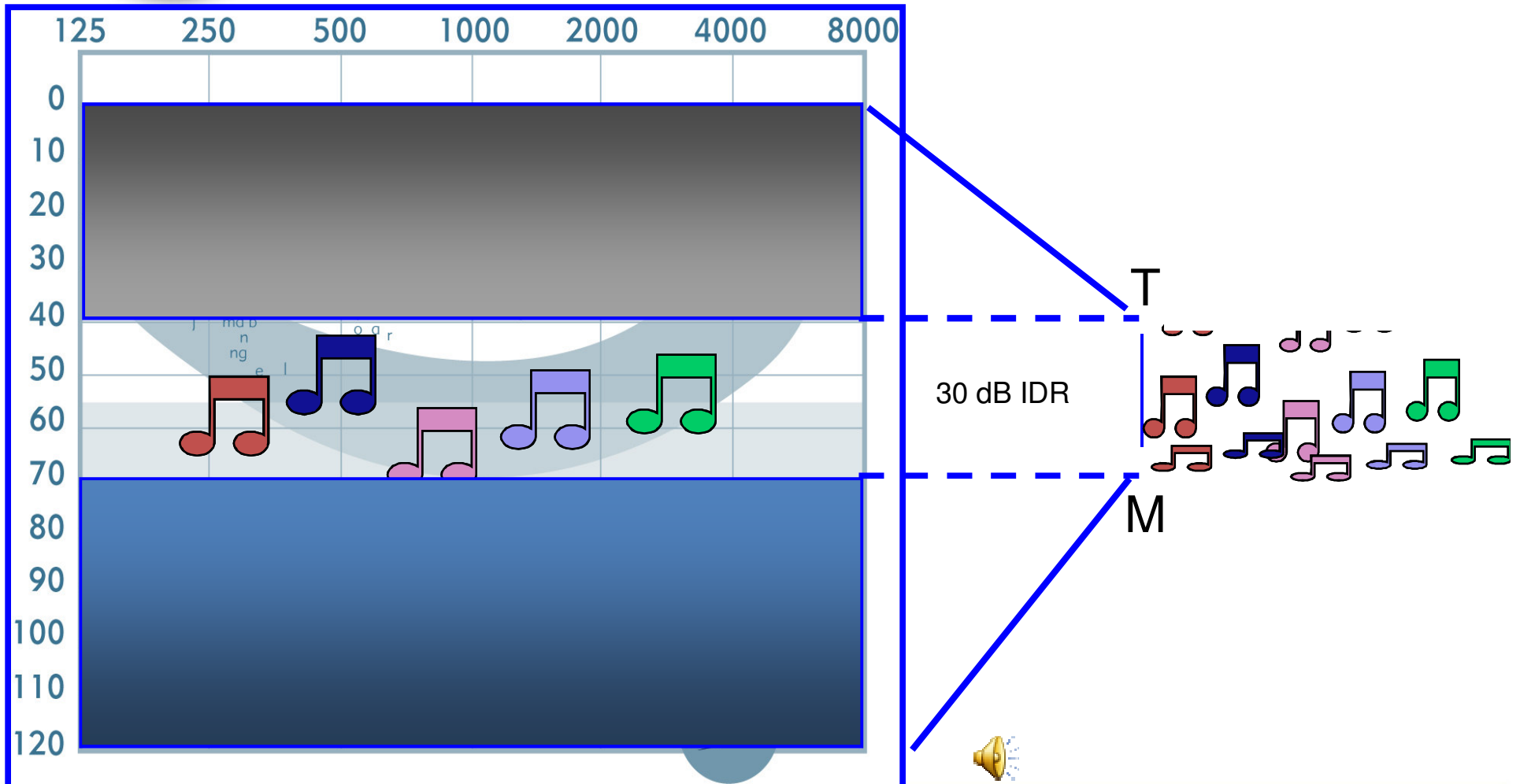
# Sound Coding for Music 🎵

Success requires that the **intensity**, **spectral** and **temporal** patterns which occur in the normal ear be duplicated as closely as possible



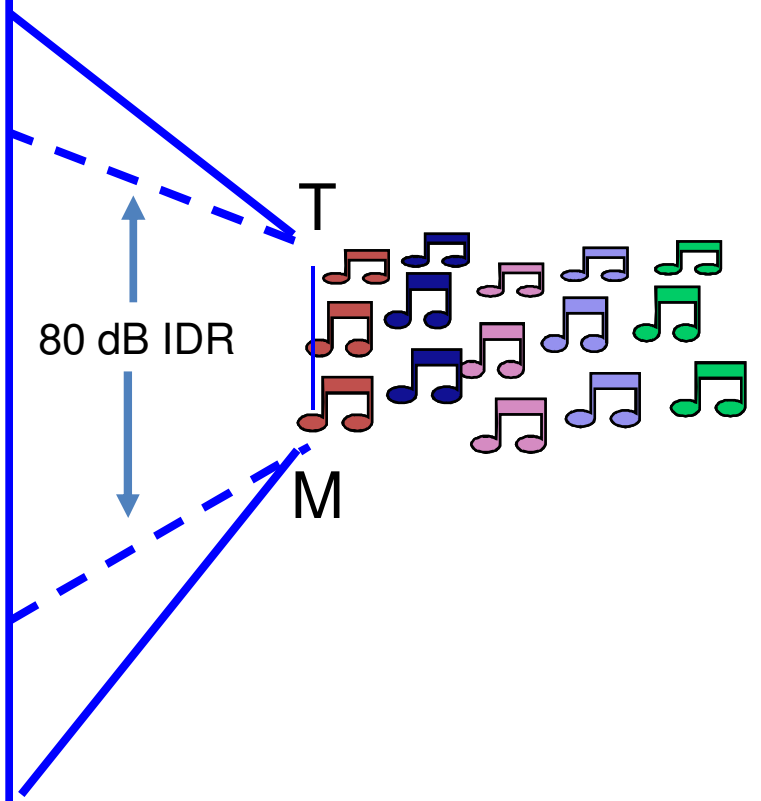
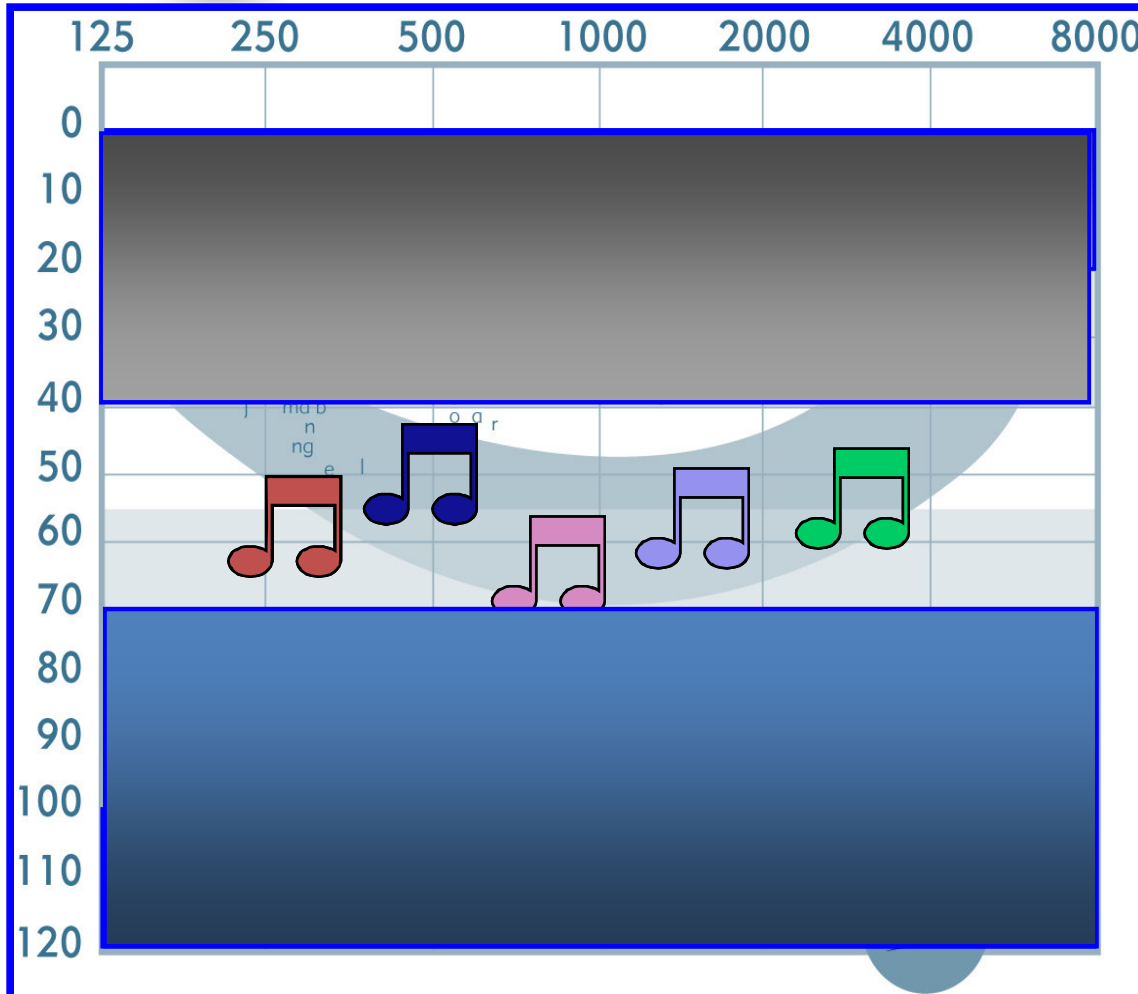


# Intensity – Conventional Processing





# Intensity- HiResolution Processing

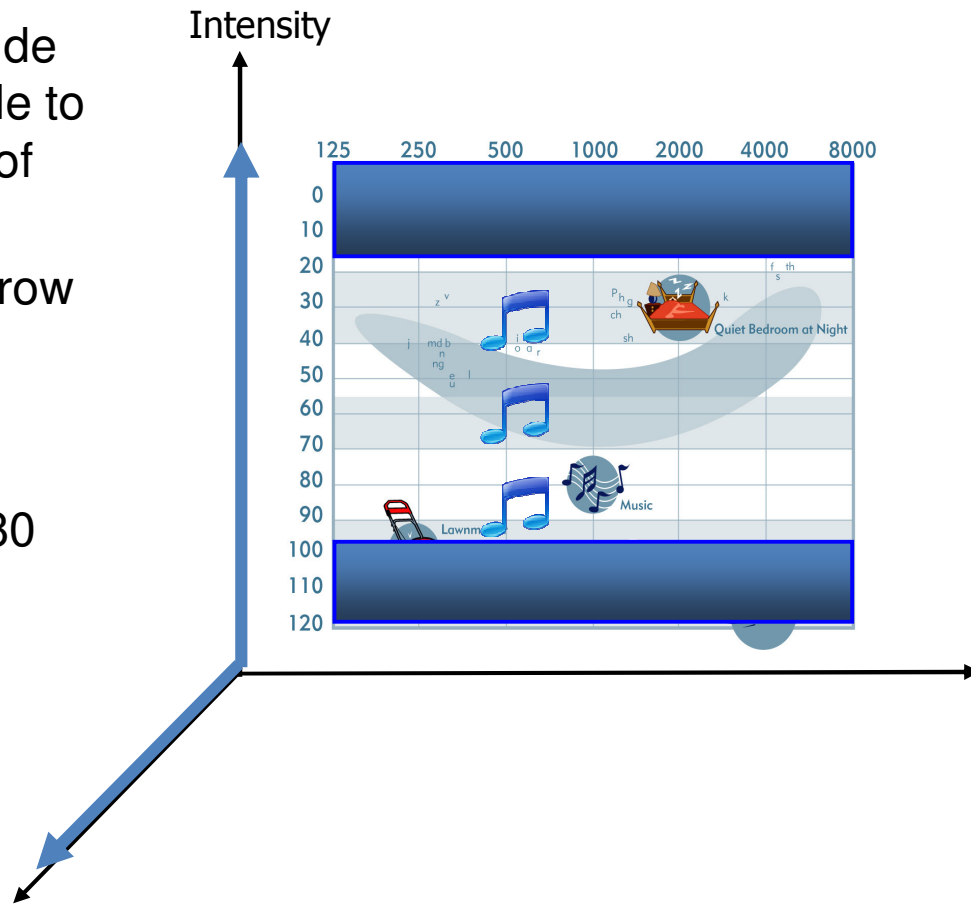






# Intensity

- 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?



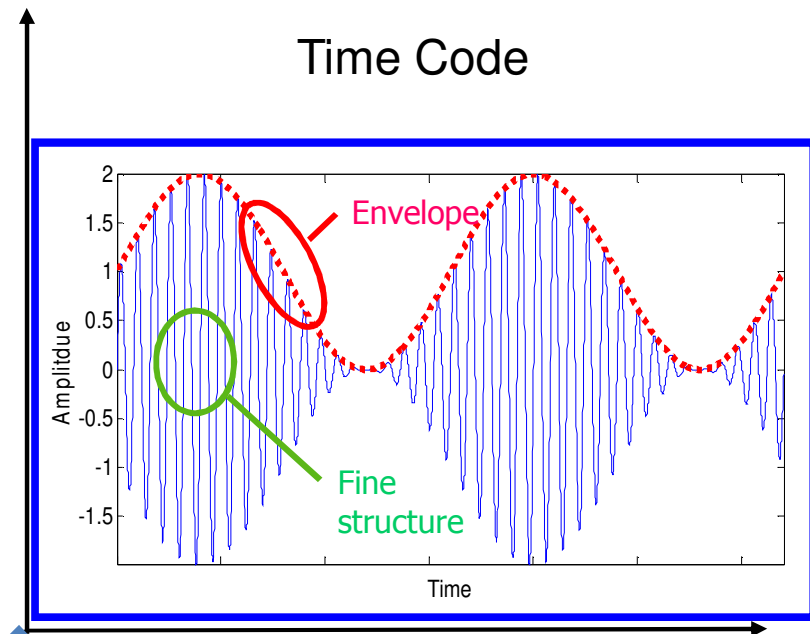


# Temporal

## 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

Temporal





# Temporal

## 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



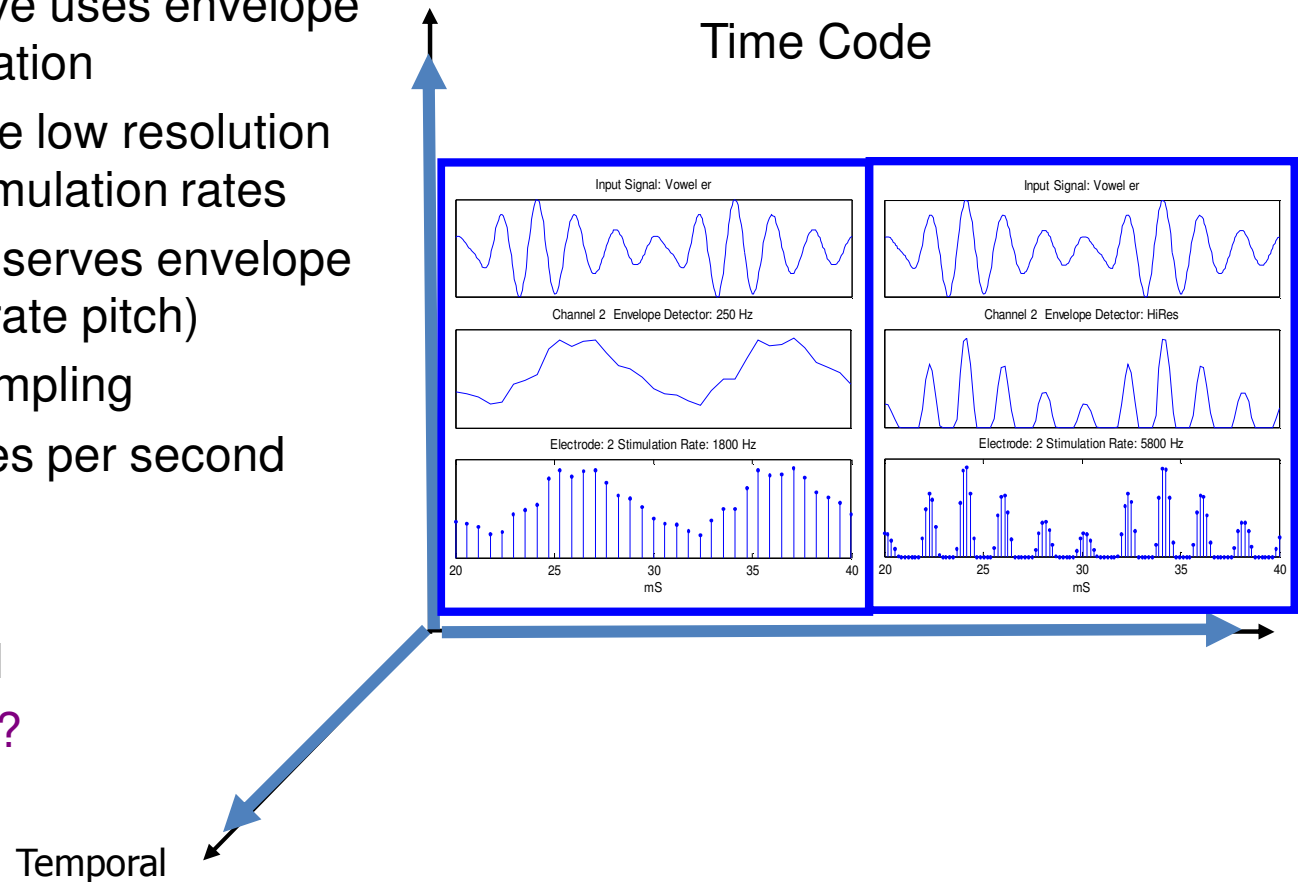
M2 Envelope Frere Jacques

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?

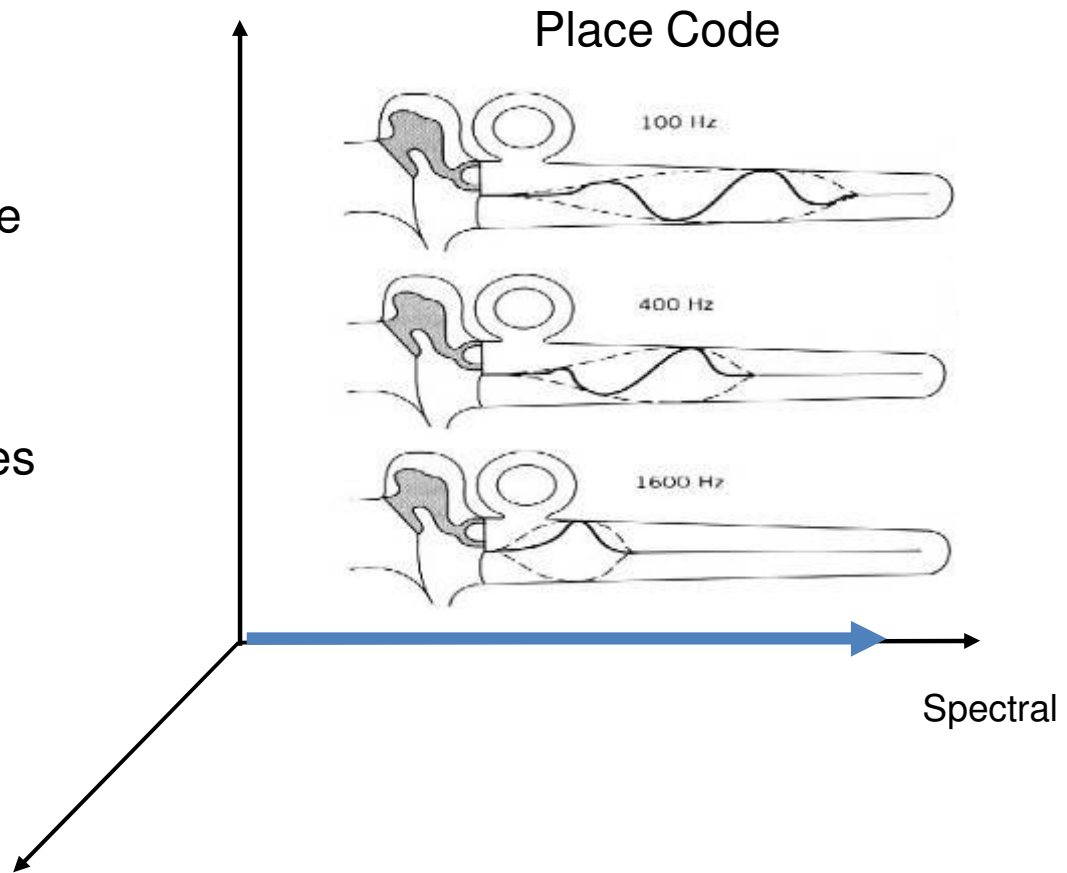




# Spectral

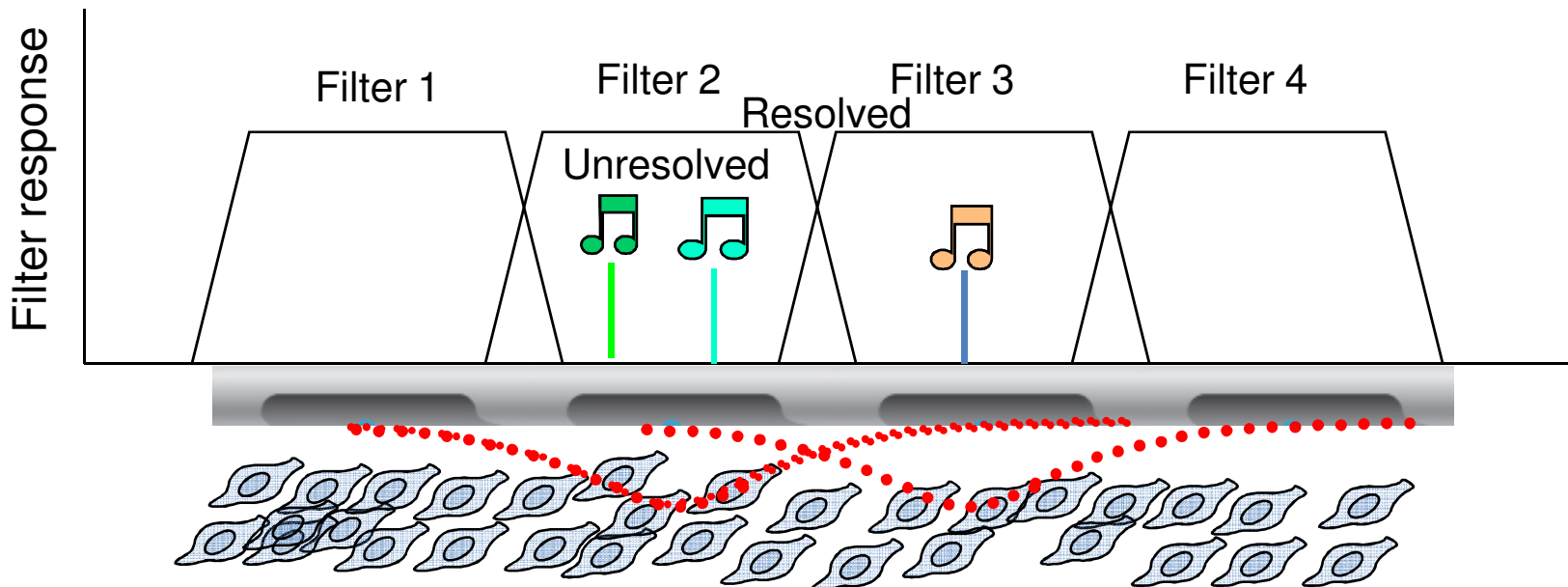
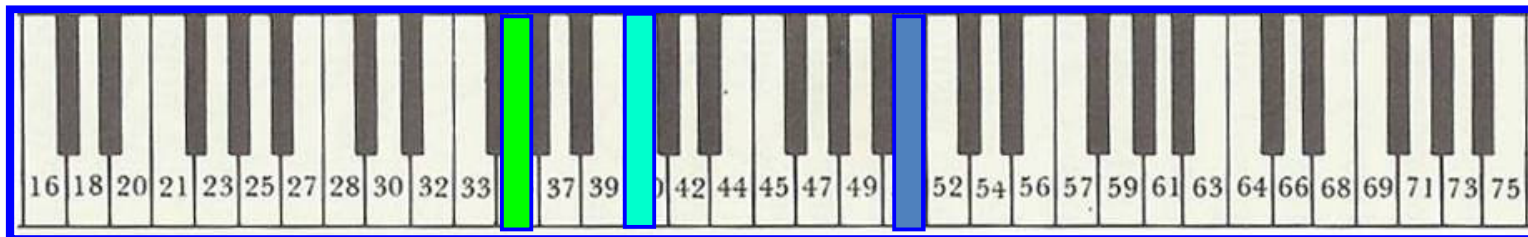
## Spectral Domain

- 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



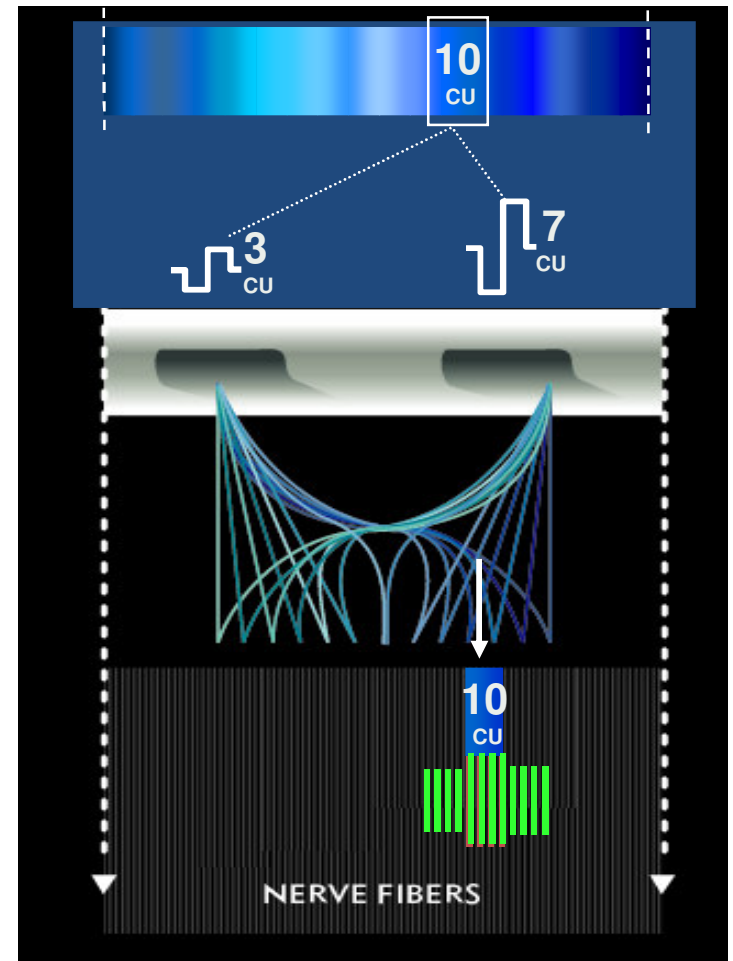


# Current Steering

## HiRes 120 via Current Steering

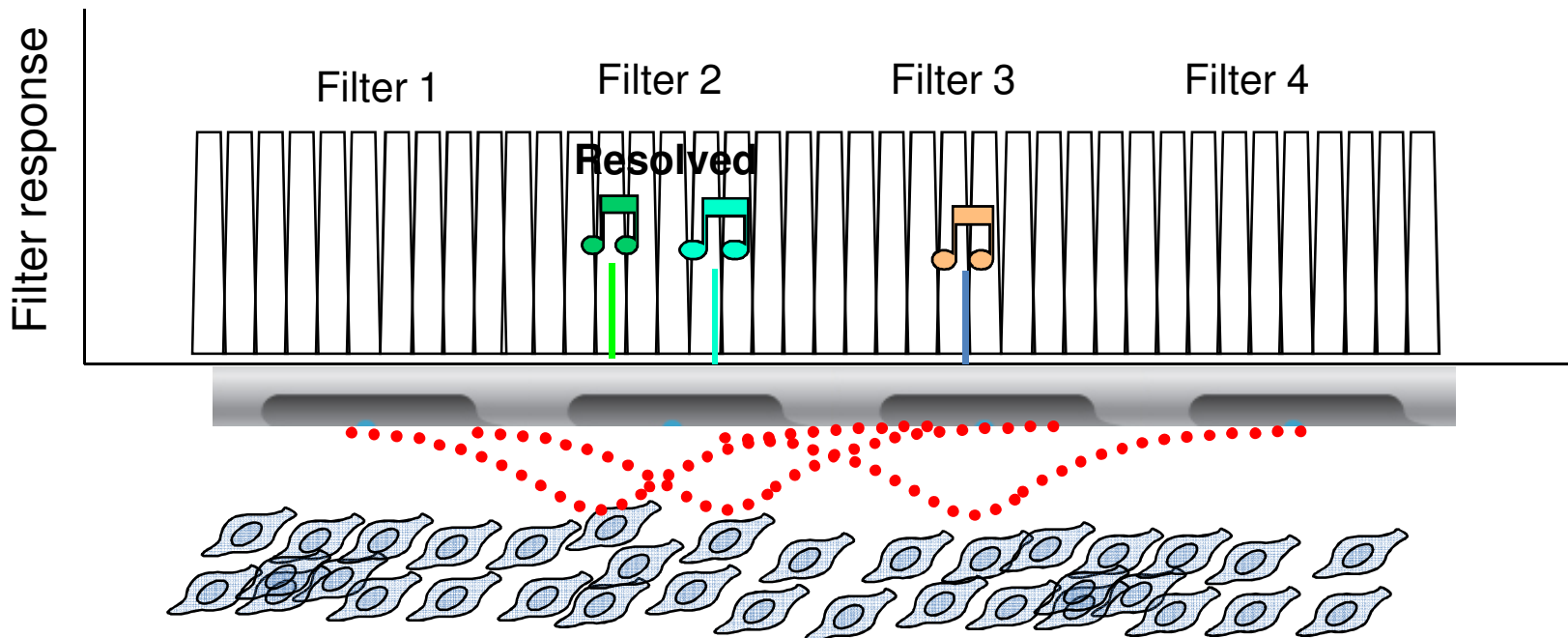
How do we do it?

- 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

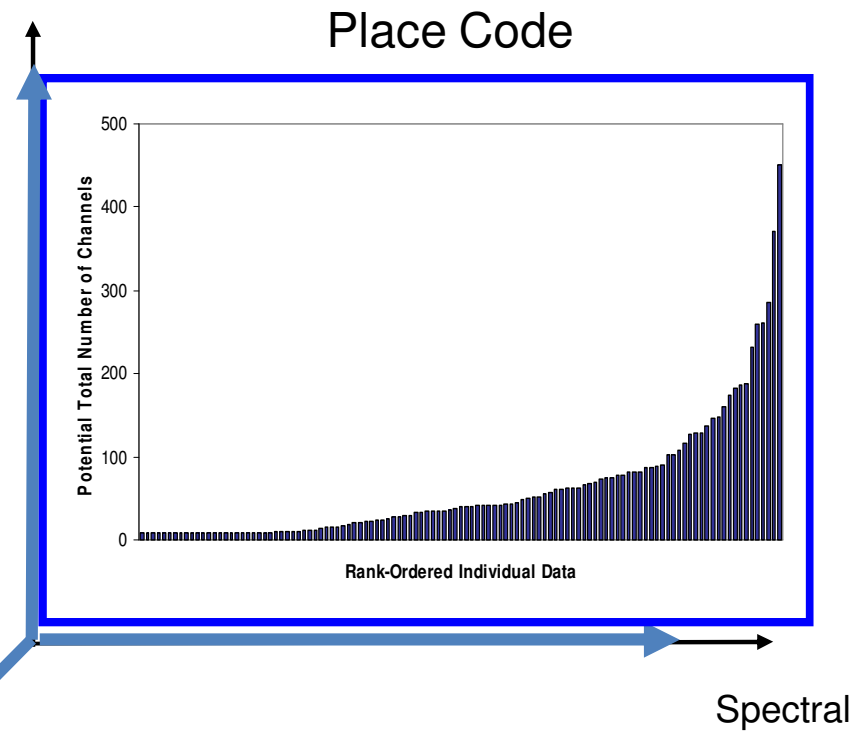






# Spectral

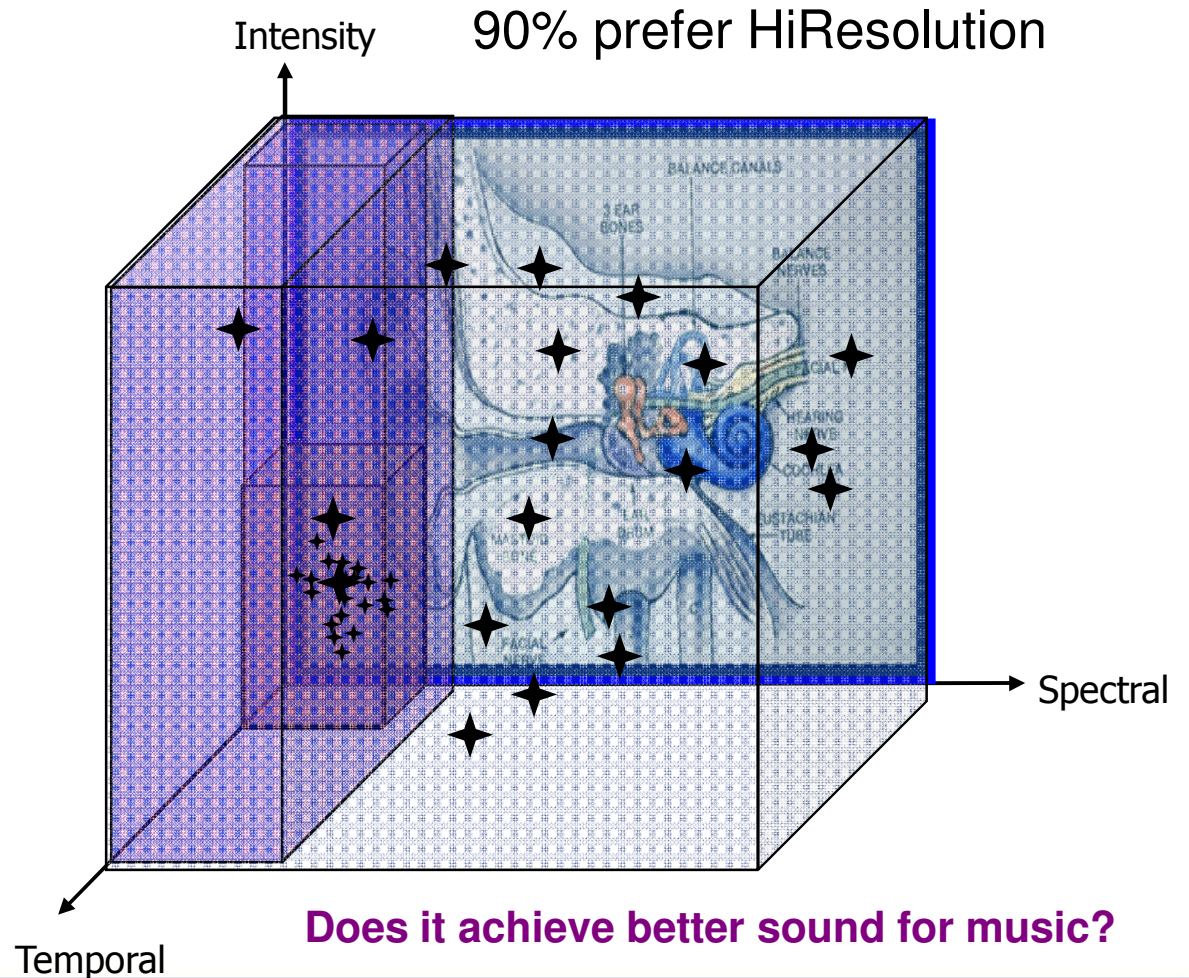
- Normal Hearing ear is tonotopically tuned to place of stimulation
- Conventional CIs are limited to # of electrodes
- HiRes 120 provides 120 spectral bands via current steering (place pitch)
- Intensity Addressed
- Temporal Addressed
- Spectral Addressed





# 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





# Better Hearing 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**





# Better Hearing for Music 🎵


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](http://www.BionicEar.com) today!



0 to 6 months



6 months to 1 year



1 year to 18 months



18 months and up