Music for Cochlear Implant Recipients: C / Can!

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Let’s Put It In Context
Outcomes

• Speech perception in quiet is excellent for CI recipients – both adults & children

• However, performance is poorer for more complex stimuli and listening environments such as:

  • **Pitch perception** (Gfeller et al., 2000; Kong et al., 2004; Leal et al., 2003; Looi et al, 2008am 2012; McDermott, 2004; McDermott & McKay, 1997; Shannon et al., 2004; Smith et al., 2002)

  • **Music perception** (Fujita & Ito, 1999; Gfeller et al., 1998, 2000, 2002; Looi et al., 2012; McDermott, 2004)
Music vs. Speech signals

• Both speech & music have spectral and temporal envelopes that vary in time.

• Speech & music share similarities, but also differ:
  – F0 range and loudness for music > speech.
  – Accurate F0 perception is not imperative to speech recognition for non-tonal languages.
  – For accurate melody recognition, information related to pitch, F0, duration, and timing of the pitches are critical.

(Chasin & Russo, 2004; Wolfe, 2002)
Perceptual Consequences Of A S/NHL

- A significant S/N HL assoc. with:
  - ↓ pitch discrim. & perceptual anomalies (e.g. non-monotonic pitch-scaling). Degree is unpredictable & not strongly correlated with hearing thresholds (Moore & Carlyon, 2005; Moore, 1995)
  - Affects BOTH pitch AND timbre perception - spectral shape perceived would be altered (Moore, 1995).
Technical limitations of CIs

- CI - sound percepts different from acoustic hearing.
- Existing research: Temporal resolution skills = to NH. But CI poorer on pitch and spectral-based tasks. (McDermott, 2004; Looi et al., 2012; Limb & Rubinstein, 2014)
- Impacts on music - western music requires discriminating frequency modulations of 6% (1 semitone).
- Pitch perception - extract F0 info. via 2 different mechanisms:
  1. Resolve individual frequency components (place pitch).
  2. Extract temporal pitch information from the signal.
- For CI recipient, both mechanisms affected by numerous factors.
What do we know?
General Music Listening (Adults)

- Time spent listening post-CI is significantly < pre-CI (Gfeller et al., 2000; Looi & She, 2010).

- Many CI recipients report music to sound strange, noisy, tinny, mechanical, unnatural.

- Some deliberately avoid it.

(Gfeller et al., 2000; Leal et al., 2003; Looi & She, 2010; Looi et al., 2007, 2012).
Music Overall

• No indication that one type of CI and/or manufacturer is better or worse (Gfeller et al., 2000, 2008, 2010).

• No strategy is any better or worse (Gfeller et al., 2008, 2010; Lassaletta et al., 2008; Looi et al., 2008).

• No indication that electrode insertion depth of standard arrays, including ‘deep insertion’ have any benefit for music (Gfeller et al., 2008, 2010; Lassaletta et al., 2008).
Rhythm & Pitch

• Adults with CIs similar to NH or HA for rhythm or temporal discrimination (Gfeller & Lansing, 1991, 1992; Leal et al., 2003; Looi et al., 2008a).

• However CI users score significantly < NH on pitch-based tasks.

HOWEVER – are NH results a fair comparison or realistic expectation as CI recipients have a significant S/NHL?
Looi et al. (2008a,b; 2012) – CI users significantly poorer than HA users in pitch-ranking 1, ½ & ¼ oct. intervals.

- CI: chance performance for ¼ oct. interval (51.75%).
- HA: performance for all 3 intervals was significantly above chance.

NB* - HA pitch results in all of these studies were NOT as good as NH listeners.
Timbre

- Multi-dimensional; related to differences in sound spectra.
- Assessed using music instrument tests.
- Sound Quality is related to timbre & contributes more to satisfaction & appreciation than identification skills.

  — **Music Appreciation & Identification are DIFFERENT!**
Timbre Research

• Gfeller et al. (2002) compared CI & NH - recognition & appraisal of 8 instruments:
  – NH: 91%; CI: 47% & lower appraisal scores.
  – No correlation to speech perception.
  – Weak correlation between recognition and music experience or length of HL.
  – No significant correlation accuracy & appraisal scores.
Timbre Research

• Looi et al. (2008a) - CI vs. HA - identification of 12 instruments & 12 ensembles.
  – CI: 61% (inst); 43% (ensembles).
  – HA: 69% (inst); 47% (ensembles).
  – No significant difference CI & HA.

• Looi et al. (2008b): no significant difference pre → post CI surgery in identification scores.

• Looi et al. (2007): compared CI & HA quality ratings:
  – For newly implanted, ratings significantly higher post- than pre-implant (with HAs) (p = 0.026).
  – For experienced CI and HA groups, CI group higher ratings than HA group (but not statistically significant).
Recent CI vs. HA results

<table>
<thead>
<tr>
<th>Test</th>
<th>CI (n=17)</th>
<th>HA (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument Identification</td>
<td>76%</td>
<td>83%</td>
</tr>
<tr>
<td>Ensemble Identification</td>
<td>54%</td>
<td>72%</td>
</tr>
<tr>
<td>Style Identification</td>
<td>55%</td>
<td>72%</td>
</tr>
<tr>
<td>Pitch – ½ Oct.</td>
<td>71%</td>
<td>91%</td>
</tr>
<tr>
<td>Pitch – ¼ Oct.</td>
<td>54%*</td>
<td>83%</td>
</tr>
<tr>
<td>Instrument Rating</td>
<td>6.7/10#</td>
<td>7.4/10#</td>
</tr>
<tr>
<td>Ensemble Rating</td>
<td>5.9/10#</td>
<td>7.4/10#</td>
</tr>
</tbody>
</table>

Looi, King et al. (2012)

Things to note:
- *CI – ¼ oct. pitch ranking at chance level.
- CI – ensemble & style identification & rating scores lower than single inst.
- Scores not much better than results 5-10 years ago.
- HA, although better than CI, are not close to ‘perfect’ – AND HA users had much better hearing levels (mild – mod-severe losses)
- #Ratings of CI & HA not close to 10.
Melody Recognition Research

- Gfeller et al. (2002): closed-set recognition 12 melodies:
  - CI: 19% correct. 66% of correct items ‘rhythmic’.

- Looi et al. (2008a): compared CI vs. HA - closed set recognition 10 melodies:
  - CI (M=52%) significantly poorer than HA (M=91%) (p<0.001).
Correlations

• The only consistent correlations between music perception and various patient characteristics:
  
  – **Age** (Gfeller et al., 1997, 2002, 2005; Looi et al., 2008a).
  
  – **Post-implant (or ‘current’) music listening habits** (Gfeller et al., 1998, 2000, 2005; Looi & She, 2010; Looi et al., 2007).
  
  – **Use of a hearing aid** (Gfeller et al., 2008).
Example Simulation

Normal Hearing

CI-only

ACE OF BASE

ALL THAT SHE WANTS

Radford - http://thelisteningtree.wordpress.com/
Summary

- CI & HA users = NH rhythm; poorer pitch, timbre & melody.
- Reflected in appraisal ratings - music reported to sound empty, rough, tinny, unpleasant, & disappointing.
- BUT…large variability; no single variable or explanation.
- Only consistent correlations: ↓ age, ↑ listening post-CI, & simultaneous HA.
- Time with CI doesn’t improve music perception – incidental exposure is NOT enough.
So What Can We Do About it?
Music Training

- **MUSIC TRAINING**, and focused listening practice helps both identification & appreciation. (Gfeller et al., 2000; Galvin & Fu, 2007, 2008; Looi et al., 2014).

- Some recipients love music, and are successful with it.

- Children can learn to perceive music accurately, & enjoy music.

- In lieu of a formal music training program, recipients can still ‘self train’ or work at their music listening skills.
Music Training

• Although sound processors may limit pitch and timbre perception, studies have shown that music listening can be improved with training. (Gfeller et al., 2000; Galvin & Fu, 2007, 2008; Looi et al., 2012).

• Maximise potential from current device, with current technology.
Example of Music Training Research

- Looi et al. (2012) developed a music appreciation training program.
- Aim: to improve enjoyment (rather than recognition) of instruments, ensembles and styles.
- After training (10wks, 4x wk, 30mins), in training group’s enjoyment ratings significantly > control group’s (p = 0.043).
- Suggests music enjoyment can be improved with training.
Reintroducing Music to Adults
Tips for reintroducing music to adults

- **Tips for new recipients or reintroducing music**
  - Start simple – i.e. 1 instrument/singer, or small # inst
  - Start with music you know or remember
  - Start with music with words
  - Try to have visual cues available (e.g. Score, song lyrics, DVD or video)
  - Start with music with a strong rhythm/beat
  - Use good quality equipment if possible
  - Optimise the listening environment
  - Don’t be afraid to experiment
  - **DON’T GIVE UP!!!**
Considerations for adults for ‘Self training’

- **Frequency**: ‘spaced’ sessions better than ‘massed’ practise (Moore & Amitay, 2007). Aim for 30min sessions, 2-3 times a wk (Looi & She, 2010):
- **Duration**: Longer time frame better (Moore & Amitay, 2007).
- **Difficulty**: Too easy does NOT enable optimal learning; difficult tasks result in more robust learning (Moore & Amitay, 2007).
Do-at-home tasks to try

Listen to:

🎵 The same piece with different listening modes. E.g. stereo, computer, MP3, DAI. Which prefer? Why? What’s the difference?

🎵 2 CDs of styles have never listened to, or wouldn’t normally listen to. Compare. What’s similar? What’s different? Which sounds better? Why? What elements of the new styles do you like/dislike?

🎵 2 pieces from a different culture – e.g. Chinese, African. What features are distinctive? What sounds different? How does it compare to the music you normally listen to?

🎵 2 radio music stations you've never listened to for 30 mins each. Describe the music played on each station.

🎵 2 contrasting CDs in your preferred style (e.g. different singers, groups, or types of music). e.g. Classical: orchestra vs. string quartet. Pop/Rock: ‘heavy metal’ vs. ‘soft rock’.
Do-at-home tasks for recipients to try cont.

🎶 Compare your everyday listening program to the ‘music’ program whilst listening to music. Differences? Similarities?

🎶 Experiment on a keyboard or piano. Start with the lowest note and go up 1-by-1. Is there an ↑ in pitch? Or do a series of notes sound the same? Or do some notes sound 'out' or ‘wrong’?

🎶 Try to find the same song recorded with different instrumentations – e.g. i) solo instrument (melody, no lyrics); ii) singer (lyrics) + simple accompaniment; iii) a karaoke version with subtitled lyrics; iv) a larger group version (e.g. band) with lyrics; and v) instrumental-only larger group version (no lyrics).
Introducing music to children
Pediatric Results

• Direct comparisons of adults vs. children are not valid:
  – Congenital or pre-lingual HL.
  – No internal representation of NH sound; learnt to hear with CI.
  – Concepts such as ‘pitch’ & ‘timbre’?
  – Brain plasticity & sensitive period for learning.

• ? cues to recognise music – may not be same cues we use.

• If they don’t like music or low music test scores, may not only be due to limitations of CI:
  – Little exposure to music?
  – No understanding of musical concepts?
  – Maturation of auditory system and/or musical skills?
Music Training

- Research NH adults: music training primes brain for music sounds.
- Training → functional & structural changes in auditory system. E.g:
  - ↑ neural activity in fMRI studies
  - Music training benefits non-music domains (e.g. speech, language, emotion & auditory processing) (Kraus & Chandrasekaran, 2010).
- Hyde et al. (2009) – NH children after 15mths music training:
  - Structural changes in their auditory & motor cortex areas, relative to no training group.
- Music training promotes neuroplasticity. (Chermak, 2010; Galvin et al., 2007)
Music Training for children with CI

- Based on NH findings, professionals recommend music-based training for children with CIs. (Limb & Roy, 2014; Looi et al., 2012)

- Children with CIs benefit from being involved in music; evidence of skill transference to non-musical tasks.
  - Consider age-appropriate music development, speech & language abilities, and limitations of CI.
  - Make it a positive, fun experience.
  - Focus on what they CAN do, rather than what they can’t do, and build on this.
Ideas for children

• First emphasise exploration & enjoyment, not accuracy.

• Gradually introduce auditory concepts – e.g. pitch, treble/bass, low/high etc.

• Introduce simple auditory segregation tasks – e.g. separating melody/words from accompaniment.

• Start with single instrument accompaniment (e.g. guitar, piano). Harmony: 2-3 simple chords only.

• Gradually ↑ complexity – e.g. ↑ # instruments, harmonic complexity, speed of melody. Also consider the contrast between timbral qualities (e.g. same vs. different inst. families), or singers (e.g. gender).

(Rocca, 2012)
Ideas for children

- Singing in tune is complex – requires BOTH pitch perception and control of vocal expression.
- NH child – later developed skill.
- Singing/vocal exercises that can help:
  - Vocal and pitch exploration, pitch glissandos, melodic contour matching, imitation, singing simple, known melodies.
- Playing instruments can help CI children develop listening skills, from initial sound awareness to discriminating between instruments, and then identifying and naming instruments.

(Rocca, 2012)
In summary

• Adults with CI can improve their music listening skills.
• Children with CIs DO enjoy music. They CAN learn music, musical instruments & singing.
• Music Training and Focused Listening Practise DOES help.
• Consider limitations of CI, but don’t let this stop participation.

A CI is NOT a contraindication to music involvement.
References

Chermak G. Music and auditory training. Hear J 2010;63:57-58
References


Rocca CA. Different Musical Perspective: Improving Outcomes in Music through Habilitation, Education and Training for Children with CIs. Semin Hear. 2012;33(4),

THANK YOU!
Questions???
<table>
<thead>
<tr>
<th>Age</th>
<th>Milestone</th>
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<tbody>
<tr>
<td>9-12 m</td>
<td>Spontaneous singing</td>
</tr>
<tr>
<td>12-18 m</td>
<td>Attends to lyrics, sings extracts of songs, rough pitch matching</td>
</tr>
<tr>
<td>18-24 m</td>
<td>Coarsely imitate songs – lyrics more accurate than pitch</td>
</tr>
<tr>
<td>Infant</td>
<td>Detect change of direction in melody contour, but difficulty ‘higher’/ ‘lower’ concept</td>
</tr>
<tr>
<td>2-3 yr</td>
<td>Some instrument discrimination</td>
</tr>
<tr>
<td>3-4 yr</td>
<td>Pitch match consistently &amp; reproduce intervals</td>
</tr>
<tr>
<td>4-5 yr</td>
<td>Start to recognise familiar melodies without lyrics</td>
</tr>
<tr>
<td>5-6 yr</td>
<td>Better pitch accuracy in singing; can remember songs in head</td>
</tr>
<tr>
<td>6-7 yr</td>
<td>Develop ‘tonal centre’ (can sing a song in 1 key)</td>
</tr>
<tr>
<td></td>
<td>Singing range focuses around 5-6 notes</td>
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<tr>
<td>7-9 yr</td>
<td>Vocal range expands. Pitch ranking ability matures.</td>
</tr>
<tr>
<td></td>
<td>~9yrs – develop preference for a music style.</td>
</tr>
<tr>
<td>11 yr</td>
<td>Consistent singing in tune</td>
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(Andrews & Madeira, 1997; Barton, 2010; Dowling, 1999; Rocca, in press; Stalinski et al., 2008)