Today's hearing aids: Using technology to its best potential

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Clear areas of agreement:
- Frequency specific stimuli for electrophysiologic hearing estimates are preferred to broadband stimuli
  - Frequency specific ABR and ASSR
- Normed corrections from nHL to eHL facilitate the transfer of these data to hearing aid prescription.
  - Missing this step may lead to overamplification.
- Measuring the RECD is an accepted method for estimating the child's ear canal acoustics and for tracking this as the child grows.
  - All pediatric prescriptions now include the RECD.

The bottom line:
- Pediatric audiologists work pretty hard to provide:
  - A physically comfortable hearing aid with acceptable, comfortably clear sound quality that allows a child access to as many sounds of speech possible, across as many input levels as possible.

Best practices in 2013

EHDI allows early identification

Many families choose early hearing aid fittings

Hearing aids with modern DSP follow up

A few favorite resources:
- Online:
- Textbook:
- Protocols online:
  - http://hearing.screening.nhs.uk/audiologyprotocols
  - http://www.phsa.ca/AgenciesAndServices/Services/BCEarlyHearing/ForProfessional/Resources/Resources/default.htm

How about these features?
- Feedback control
- Venting
- Digital noise reduction
- Frequency lowering

For each of these, we can review the evidence, consider developmental impacts and needs, and plan for fitting & verification.
**Topic One: Feedback control**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Clinical need</th>
<th>Evidence</th>
<th>Fitting &amp; verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>Maximum: the rapidly growing ear presents an ongoing challenge.</td>
<td>Devices vary in terms of the gain limitations imposed by the feedback control system.</td>
<td>Measuring the hearing aid's response before, during, and after ven-</td>
</tr>
<tr>
<td></td>
<td>Older children: High ear growth slows but ear mold shrinkage may be a factor.</td>
<td></td>
<td>sting is introduced.</td>
</tr>
<tr>
<td>Older children</td>
<td>Possible: Depending upon gain and venting. When should venting be introduced?</td>
<td></td>
<td>What are the benefits of</td>
</tr>
<tr>
<td>and adults</td>
<td></td>
<td></td>
<td>venting?</td>
</tr>
</tbody>
</table>

**Topic Two: Venting**

<table>
<thead>
<tr>
<th>Age group</th>
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<th>Evidence</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>Even when “needed”, it is very difficult to attain (ear size).</td>
<td></td>
<td>Real ear measurement</td>
</tr>
<tr>
<td></td>
<td>Older children: Large incidence of children with near-normal hearing in the low frequencies. When should venting be introduced?</td>
<td></td>
<td>techniques for venting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>evaluation.</td>
</tr>
</tbody>
</table>

Let’s merge those into one topic:

- The vent
- The aided response
- The feedback control
- The fitting!

Is the vent providing any vent-transmitted sound?

![](image)

Is the feedback controller effective?

- In the low frequencies:
  - Normal pitch cues, binaural cues for localization (interaural time differences) from the normal acoustic path.
- In the high frequencies:
  - Electroacoustic gain to provide access to consonants.

Combine vent transmitted sound with the hearing aid's electroacoustic response:

Evaluating Additional Hearing Aid Features

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**Evidence considerations:**

**Adults**

(Noble et al 1998)

**Kids**

(Johnstone et al 2010, 2011)

With closed versus open earmolds, people had more difficulty with accurate horizontal localization.

**Venting & feedback:**

- Not the challenge it used to be.
  - Feedback control systems have advanced, allowing more venting than ever before. But they also vary. Can you use your verification system to learn which ones are best?
- In pediatrics, have we lost sight of venting in the face of more complex DSP? Or perhaps in the face of such tiny ear canals? I know this is a back to basics message, but:
  - Does Johnstone raise an important point? Is early venting better than late venting?

**Topic Three: Noise reduction**

<table>
<thead>
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<th>Evidence</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Infants</td>
<td>Possible Less need at home, car noise? Shopping centers? Daycare?</td>
<td>Noise levels in schools and daycares.</td>
<td>Does the hearing aid preserve speech audibility in the noise setting?</td>
</tr>
<tr>
<td>Young children</td>
<td>Probable: Daycare, car, transitioning to school</td>
<td>Children’s variations in loudness, preference for environment-specific choices.</td>
<td>Who switches?</td>
</tr>
<tr>
<td>Older children &amp; adults</td>
<td>Probably: Noise levels in schools, importance of multi-environmental functionality.</td>
<td>New DNR studies on children provide helpful information.</td>
<td>How much noise reduction does the DNR provide?</td>
</tr>
</tbody>
</table>

**Noise levels at daycare & school:**

[Graph showing noise levels at different times of the day]

Crabley, Scollie, & Parsa 2011

**Options for noise management:**

- A noise program with less gain?
  - An older trial of NAL-NLI vs. DSL4 showed that many school aged kids liked having and used two programs. They often chose programs based on the sound levels and noisiness of the environment. (Scollie et al, 2010)
- Digital noise reduction?
  - Newer evidence reveals that DNR may ease the burden of listening in noise for children, with older children more able to derive this benefit. No harms noted. (Pitman, 2011, Stelnachowicz et al, 2010)
In a recent evaluation, this prescription maintained speech target with slightly less gain. (Scollie et al., 2005)

Crukley, & Scollie, 2012

Validation measures?
- Interested in knowing if young children are benefiting in quiet and noisy environments?
- A clinical monitoring protocol:

Noise programs:
- It’s not only about the DNR.
  - We may be able to have a systematic approach to fitting the gain in noise programs, if one goal is to maintain good speech audibility for mid to high level speech.
  - Should we couple this to DNR? To directionality?
- What about verification measures?
  - Can we use these techniques to compare strengths or products?
  - How much DNR is enough?

Crukley, & Scollie, 2012

Topic Three: Frequency lowering

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Pediatrics</td>
<td>Possible If the hearing aid bandwidth restricts access to some speech sounds.</td>
<td>Adult-child differences in the need/benefit associated with both bandwidth and frequency compression.</td>
<td>Systematic fitting approaches exist. Systematic relationships exist between strength of setting, sound quality, and benefit. New validation tools allow outcome assessment.</td>
</tr>
<tr>
<td>Adults</td>
<td>Possible If the hearing aid bandwidth restricts access to some speech sounds. Some wonder if adults are as able to become accustomed to it.</td>
<td>Adult-child differences in response to sound quality. Pediatric evidence for acclimatization, benefit.</td>
<td></td>
</tr>
</tbody>
</table>
**Frequency Lowering (FL): three types**

- Frequency Compression (FC)
  - Phonak SoundRecover®
  - Siemens FC
- Frequency Transposition (FT)
  - Widex
  - AudibilityExtender®
- Frequency translation
  - Starkey Spectral IQ®

**Fitting tips:**

- Start with the best possible fit without FL.
  - Why?
- Examine the fitting for mid-level speech at 65 dB SPL to determine what is missing.
  - Probe further using frequency-specific sounds
  - We’ll talk about clinical options for this.
- Important: if the frequency lowered signal is far below threshold, it will not help.
- Important: if the frequency compression is too strong, it may affect sound quality.

**Outcomes in adults and children:**

- 24 patients: 11 children and 13 adults
  - Phonak frequency compression (pre-commercial, ear level devices)
- Most of the children were followed for about 2 years. (2009a)

**Speech sound detection improved.**

- Glista et al (2009a), JA (2009b)
- Hearing Review
- Support: NSERC-CHRI, CFHR, Hearing Foundation of Canada, Phonak AG

- Below cutoff
- Above cutoff

- Frequency (Hz)
Consonant & word-final plural recognition improved.

Individual adults, sorted by HL:

Individual kids, sorted by HL:

Audiometric & age candidacy:

- Significant predictors of outcome:
  - Age group (adult versus child)
  - Better ear high frequency pure tone average
  - The lowest frequency at which the audiogram had a severe loss (drop off frequency)

Sound quality of female speech:

(Parsa et al, in press)

Time course of acclimatization:

- 6 participants (11-18 years)
  - DSL5 at baseline trial
  - Frequency compression trial
  - Withdrawal and testing
  - Four month trial, no training.
- Some participants had significant acclimatization trends. May relate to degree of hearing loss?

(Parsa, Scolie, and Sulkes 2012, JLHR)
**Time course of acclimatization**

(Glista et al, 2012, JSLHR, 55(6))

- **Fitting and baseline testing**
- **Testing with FC**
  - Every 2 to 4 weeks for several months
- **Testing after withdrawal of FC**

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**Aided cortical potentials:**

- Waveform showing neural activity in response to auditory stimuli.
- Case 3
- Age: 11 yrs
- NLRP
- NLR (11-14 yrs)

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**Acclimatization summary:**

- Some but not all listeners!
- Some show gradual improvement, others a sudden jump after 6-8 weeks.
- Improvement on the day of fitting is not always the case.
- Results of verification generally agree with behavioural outcomes.

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**Fitting & verification**

- A new test signal from the Verifit allows us to see if a high frequency band is lowered.
  - Run with & without SoundRecover.
  - Test at 3.1, 4k, 5k or 6.3kHz.
  - May offer a calibrated alternative to live voice /s/ and /sh/.

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**Is the frequency lowering tuned?**

- Graph showing frequency tuning with and without the Verifit test signal.
Real Example: Tuning

And the winner is...

<table>
<thead>
<tr>
<th>Test</th>
<th>Percent Correct Score Setting 1</th>
<th>Percent Correct Score Setting 2</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonsense syllables</td>
<td>50%</td>
<td>68%</td>
<td>Significant improvement with the revised setting</td>
</tr>
<tr>
<td>Discrimination of A/SH</td>
<td>77%</td>
<td>85%</td>
<td>Significant improvement with the revised setting</td>
</tr>
</tbody>
</table>

Interpret?

Frequency lowering off:

Frequency lowering A:

Frequency lowering B:
Fitting frequency lowering:
- The hearing aid's gain and FC interact:
  - If you have less high frequency gain, you will need to use a stronger FC setting to make S audible.
  - FC strength is correlated with sound quality changes… use the weakest setting you can that has positive effects.
  - Fine tuning is possible.
- Verification and real ear measurement is possible.

Fitting frequency lowering:
- Is the need for frequency lowering different in these scenarios?
  - An adult with a severe high frequency hearing loss versus a child with the same loss?
  - An older child with a moderately severe loss and a conventional fitting versus a power receiver in the ear with a custom concha mold.
- Verification measures can help us to assess the latter situation.
- Performance measures may help in either case.

Validation measures?
- Interested in knowing if people can hear new sounds with frequency lowering?
- Interested in knowing if your extended bandwidth fittings are providing access to /s/ without frequency lowering?
- New clinical test:

“For Monday Morning”
- Have a look at the verification article (Glista & Scollie, 2009, AudiologyOnline) and give it a try!
  - It shows speech bands and live s - sh.
  - Same principles as discussed today.

Colleagues and support
- Thanks to the Mayo Clinic for this opportunity!
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Selected References


