The Basics Of Hearing Aid Processing

Marc Brennan, PhD, CCC-A

Audiologist
Postdoctoral Fellow

The Basics Of Hearing Aid Processing
Questions?
For any questions during this broadcast, please send an email to: teresa.mcevoy@boystown.org
Questions will be answered at the end of the presentation.

Children With Hearing Loss

Children with hearing loss are navigating a world with limited access to sounds.

How Can The Caregiver Help?

Every caregiver/educator faces tough sailing in helping that child to navigate the hearing world.
**Limited Access To Sounds**

**Audibility**
- Portion of speech that child can hear

**Reduced Audibility Can Affect:**
- Spoken language development
- Social skills
- Academic performance
- Earning potential

**Success**

- Odds for success can be improved by following three steps:
  1. Appropriately fitting amplification
  2. Performing daily listening checks
  3. Optimizing the listening environment

**These Steps Will Ensure Access To Sounds**
Step 1: Appropriately Fit Amplification

- How hearing aids work
- Optimizing speech audibility
  - Verification methods

How Hearing Aids Work

- Program Button / Volume Control
- Microphone
- Amplifier / CPU
- Receiver
- Tonehook
- Earmold
- Battery Door

Hearing Aids Make Sounds Louder!

- But it gets complicated...
The Basics Of Hearing Aid Processing

Speech Varies In Intensity, Frequency

- Whisper: 30 dB SPL
- Soft speech: 40-50 dB SPL
- Conversation: 60 dB SPL
- Shout: 85 dB SPL
- 130 to 8000+ Hz

How do we make sure the child can hear all of speech?

Verification: Using Real Ear

Verification: Insert Probe Tube
Verification: Insert Earmold

Play Speech And Record Output

SPLoGram

Loud

Soft

Frequency
The Basics Of Hearing Aid Processing

SPLoGram

Audible

Inaudible

Speech

Banana

Frequency

Boys Town National Research Hospital

SPLoGram

Audible

Inaudible

Child’s Hearing Loss

Speech

Banana

Frequency

Boys Town National Research Hospital

SPLoGram

Audible

Inaudible

Speech

Banana

Frequency

Boys Town National Research Hospital
The Basics Of Hearing Aid Processing

Summary Of Real Ear

- **Benefits of real ear**
  - optimizes the audibility of speech
  - better outcomes
- **Behavioral methods**
  - functional gain, speech recognition
The Basics Of Hearing Aid Processing

**Functional Gain**

- Provides a measure of the child’s response to sounds
- Is the difference in level between that child’s unaided and aided threshold
- Does not measure audibility
The Basics Of Hearing Aid Processing

Functional Gain

Real Ear With Function Gain

Speech Recognition

- Child wears hearing aid(s)
- Play words
- Record Correct/Incorrect
**Binomial Distribution**

- Based on sampling theory
- Of the words tested, what is the true proportion correct for the entire test?
- Thornton & Raffin (1978) computed the binomial distribution for the W-22

Thornton & Raffin (1978)

---

**What Is A Significant Difference?**

Scores within the range are not significantly different

<table>
<thead>
<tr>
<th>Score</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>48-92</td>
</tr>
<tr>
<td>76</td>
<td>52-92</td>
</tr>
<tr>
<td>80</td>
<td>56-96</td>
</tr>
<tr>
<td>84</td>
<td>60-96</td>
</tr>
<tr>
<td>88</td>
<td>68-96</td>
</tr>
</tbody>
</table>

Example

<table>
<thead>
<tr>
<th>Score</th>
<th>Range</th>
<th>Hearing Aid Setting A</th>
<th>Hearing Aid Setting B</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>48-92</td>
<td>48-92%</td>
<td>68-96%</td>
</tr>
</tbody>
</table>

Thornton & Raffin (1978)

---

**Comparison Of Verification Methods**

- **Speech Recognition / Functional Gain**
  - Behavioral measures
  - Measures ability of child to repeat words or the softest tone they can hear
  - Octave frequency information?
  - Time-consuming
  - Data for low-input level
  - No assessment of advanced features
  - Easier for parents?

- **Real Ear**
  - Aided output with speech
  - Not a measure of behavioral response
  - ½ octave frequency information
  - Less time-consuming
  - Data for multiple-input levels including MPO
  - Assessment of advanced features
  - May be difficult for parents to understand?
Step 1: Summary

- Hearing aids amplify sounds
- Speech varies in frequency and intensity
- Ensure audiologist sets up hearing aids to hear speech
  - Done using real ear
  - Other measures are useful for describing functional ability of that child

Step 2: Perform Daily Listening Checks

- Assign someone to conduct daily listening checks
  - Common problems
  - How to conduct a listening check

Common Problems

- Distorted Speaker
- Dead Microphone
- Dead Battery
- Amplifier / CPU
- Plugged Earmold or Tonehook
Hearing Aids Need To Work Each Day!

Dead Hearing Aid  Working Hearing Aid

Inconsistent access  Consistent access
Poorer outcomes      Better outcomes

Assign Someone

How To Conduct A Listening Check
Connect Stethoscope To Hearing Aid

Speak Into The Microphone

da, da
sh, sh

Common Issues

- Common issues
  - Distortion
  - Weak
  - Dead
- Steps you can take
  - Clean Hearing Aids
  - Check Battery
  - Call your audiologist
Step 2 Summary

- Hearing aids break down
- Listening check
  - Ensures that child receives consistent access to sounds
  - Assign someone to conduct daily
  - Contact audiologist if device is malfunctioning

---

Step 3: Optimize The Environment

- Advocate to optimize that child’s listening environment
- Hearing aids are not perfect
  - Noise, distance, reverberation
- Hearing aids plus FM, strategic placement

---

Hearing Aids Are Not Enough

- Distance
- Room Noise
- Hearing Aid
- Damaged Cochlea
- Brain
Aided Audibility Index (AAI)

- **Boys Town National Research Hospital**
- Aided Audibility Index (AAI)

**Conversational Level**
- AAI = 59%

**Soft Level**
- AAI = 40%

Unable To Restore Audibility

**Conversational Level**
- **Soft Level**
- **Unable To Restore Audibility**

**AAI** = 59%

**Aided Audibility Index** = 40%

**Mild Hearing Loss**
- AAI = 87%

**Profound Hearing Loss**
- AAI = 29%
The Basics Of Hearing Aid Processing

Unable To Overcome Damage

- **Hair cells**
  - 1-2 micro meters
  - Do not regrow
- **Auditory nerve**
  - Nerves can degenerate

Acoustic Access In The Classroom

- **BACK Rows**: 55%
- **MIDDLE Rows**: 66%
- **FRONT Rows**: 83%

Crandell, 1994

Audibility In The Classroom
The Basics Of Hearing Aid Processing

Audibility In The Classroom

Why Audibility is Important

- Auditory development
- Speech and language development
- Academic performance
- Social development

Optimize the Auditory Environment

- Strategic seating
- Speaker face the listener
- FM system
The Basics Of Hearing Aid Processing

FM Systems

• Soundfield FM
  – Benefits everyone in the classroom
  – Works best in rooms with low noise level/ reverberation

• Personal FM
  – 55% with HA only
  – 75% with FM + HA

Wilson 2011; Pittman 1999

Reduce Distance

12 feet in quiet

12 feet in quiet with FM

Thibodeau, L. FM Sound Recordings.
The Basics Of Hearing Aid Processing

Classroom Noise

<table>
<thead>
<tr>
<th></th>
<th>Unoccupied Noise Level</th>
<th>Occupied Noise Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanders (1965)</td>
<td>42 – 58 dB</td>
<td>52-69 dB</td>
</tr>
<tr>
<td>Nober (1975)</td>
<td>NA</td>
<td>65 dB</td>
</tr>
<tr>
<td>Bess (1984)</td>
<td>58 dB</td>
<td>63 dB</td>
</tr>
</tbody>
</table>

Conversation = 60 dB

Adapted from Crandell 2000

Signal To Noise Ratio (SNR)

- SNR in classroom: -10 to 10 dB SNR
- McCreery et al. (2010)

<table>
<thead>
<tr>
<th>SNR</th>
<th>Words Identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>60%</td>
</tr>
<tr>
<td>0</td>
<td>80%</td>
</tr>
<tr>
<td>10</td>
<td>95%</td>
</tr>
</tbody>
</table>
The Basics Of Hearing Aid Processing

Optimize The Auditory Environment

- Strategic seating
- Speaker face the listener
- FM system

Optimize The Auditory Environment

Distance
Volume
Noise
Rate
Technology

Auditory Consultant Resource Network, 2011

Will This Child Be Able To Hear?
The Basics Of Hearing Aid Processing

Limited Access To Sounds

- Poor audibility
  - Distance
  - Noise
- Sounds are less clear

Success

- Odds for success can be improved by following three steps:
  1. Appropriately fitting amplification
  2. Performing daily listening checks
  3. Optimizing the listening environment

Advocate For Each Child With HL
The Basics Of Hearing Aid Processing

References


Marc Brennan
Boys Town National Research Hospital
555 North 30th Street
Omaha, Nebraska 68131
Marc.Brennan@boystown.org