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Individualizing Pediatric Hearing Aid Fittings Part 2: Hearing Aid Verification

Presenter: Marlene Bagatto, Au.D., Ph.D.

Moderator: Carolyn Smaka, AuD, Editor in Chief, AudiologyOnline

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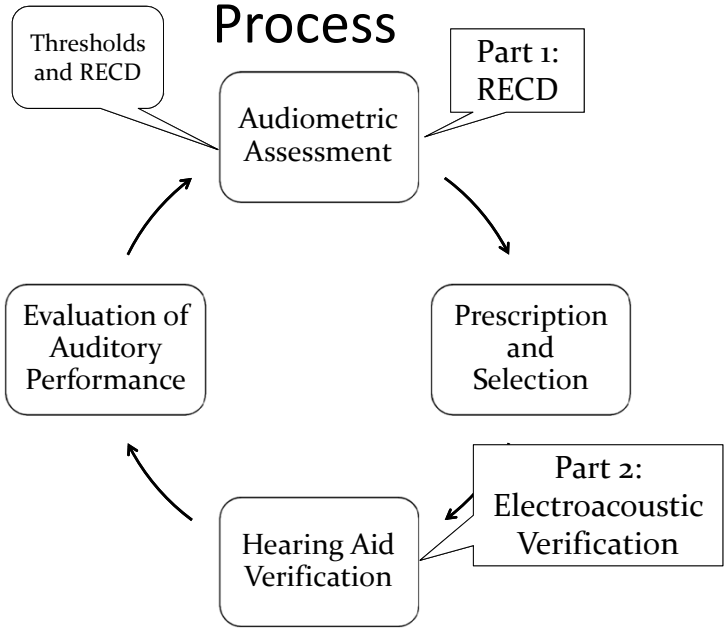
Individualizing Pediatric Hearing Aid Fittings Part 2: Hearing Aid Verification

Marlene Bagatto, Au.D., Ph.D.
Child Amplification Laboratory, Western University

March 30, 2016
Audiology Online

Western
National Centre
for Audiology

Pediatric Hearing Aid Fitting Process



Two Essential Components

1) Use of well-defined, evidence-based procedures

2) Detailed monitoring of the performance

.....in all aspects of the EHDI Program.

Guideline vs Protocol

Guideline

- **Systematically developed statements** to assist clinicians in fitting hearing aids to the pediatric population
- **Summary and appraisal** of the best available research evidence or expert consensus
- Does not provide information about the **exact clinical processes** that would fulfill the guideline

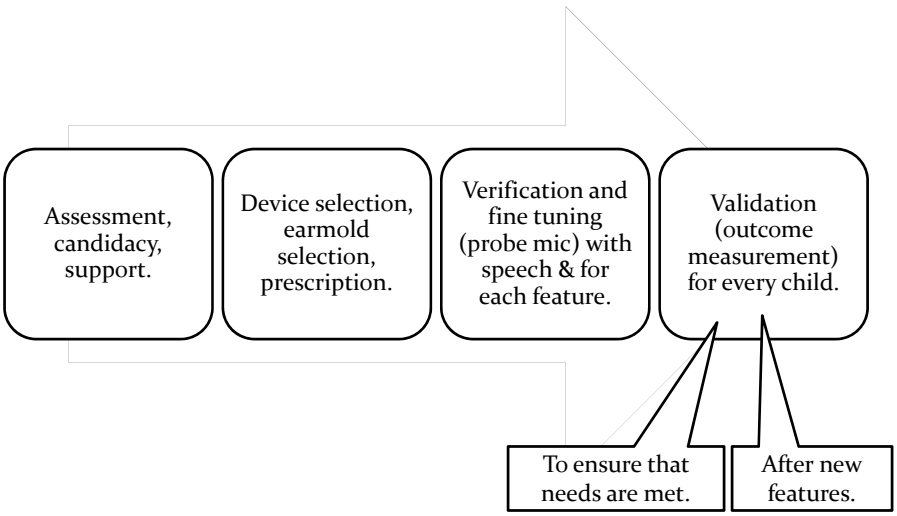
Protocol

- **Specifics** about how to execute a guideline
- **Tailored** for use with specific equipment or test signals
- **Details** that allow a **step-by-step operationalization** to fulfill a guideline
  - Morris, 2003

Provision of Hearing Aids

- Suitable technology and evidence-based hearing aid fitting guidelines and protocols support accurate and safe hearing aid fittings for the pediatric population
  - American Academy of Audiology, 2013
  - Australian Protocol; King, 2010
  - British Columbia Early Hearing Program, 2006
  - Modernizing Children's Hearing Aid Services, 2005
  - Ontario Protocol; Bagatto, Scollie, Hyde & Seewald, 2010; **Updated in 2014: www.dslio.com**

AAA Pediatric Amplification Guideline (2013)



From Guideline to Protocol

Several topics in the AAA (2013) Guideline introduced new concepts from evidence review that prompted specific updates to Ontario's Amplification protocol.

Presentation Outline

- Importance of hearing aid verification
- Specific procedures for the pediatric population
- Candidacy considerations for special management needs
- Verifying additional hearing aid technologies

Learning Outcomes

1) Describe how to verify a hearing aid using simulated real-ear measurements.

2) Discuss candidacy considerations for additional hearing aid technologies for children.

3) Clarify the verification protocols for noise management and frequency lowering technologies.

Ontario Infant Hearing Program Protocol

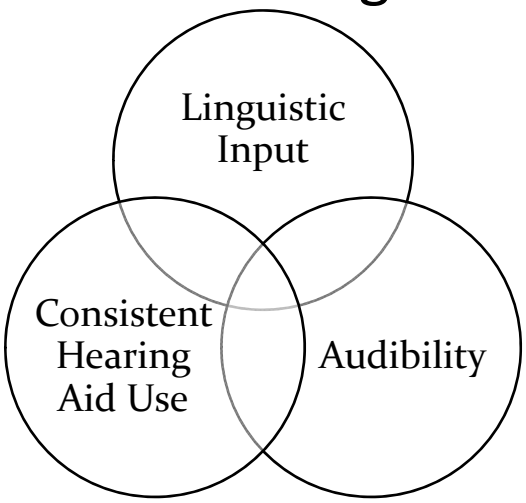
- Version 2014.01
- Editors: Marlene Bagatto & Susan Scollie
  www.dslio.com

- Contributors:
  - Susan Scollie, Marlene Bagatto, Sheila Moodie, Richard Seewald, Martyn Hyde, Stacey Weber, Vanessa Martyn
  - Danielle Glista, Anne Marie Tharpe, Jeff Crukley, Viji Easwar, Marianne Hawkins, Charla Levy, Sahar Zimmo, Andrea Dunn
  - Shane Moodie, Frances Richert, Christine Brown, Vijay Parsa

Ontario Infant Hearing Program Protocol

- Document addresses provision of Amplification to infants and pre-school children registered in the Ontario Infant Hearing Program (IHP)
- Specific context and procedures including specification of key procedures and equipment requirements
- Updates to evidence are intended to support current clinical practice within the IHP
- Aligns with AAA Pediatric Amplification Guidelines (2013)

Factors Influencing Outcome



Outcomes of Children with Hearing Loss
Ear & Hearing, 2015

Infants are not small adults

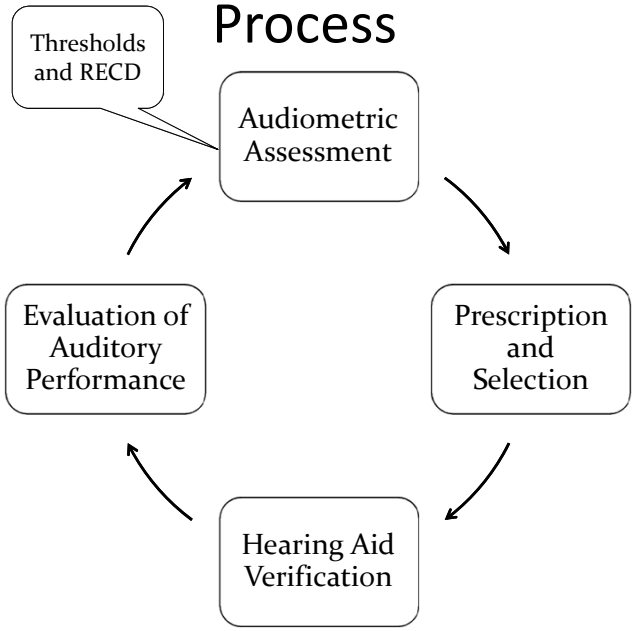
- Different listening needs
  - Pre-lingually hearing impaired
  - Critical period for language learning is birth to 2 years of age
- Significantly smaller ears
  - Ear canals grow and change
- Unable to provide verbal feedback about hearing aid fitting
  - Depend on caregiver for hearing aid use, monitoring and maintenance

Early Hearing Detection & Communication Development Programs

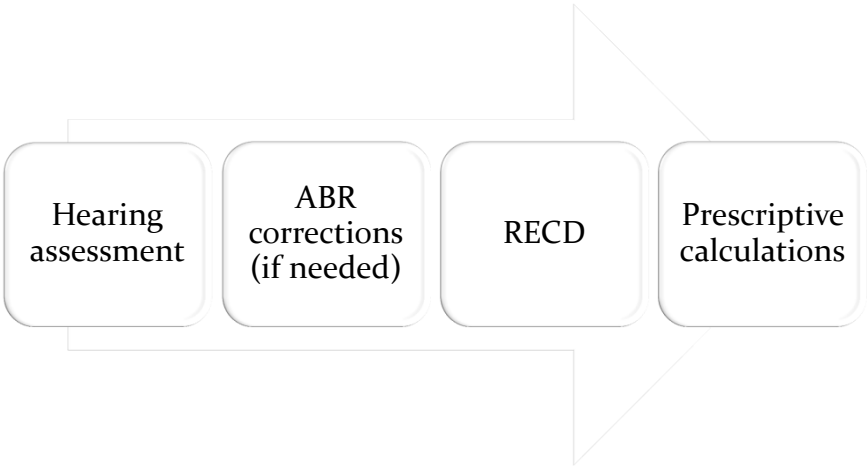
Goals:

- Identify infants with hearing loss and define the impairment by 3 months corrected age
- Initiate intervention by 6 months corrected age

Pediatric Hearing Aid Fitting Process

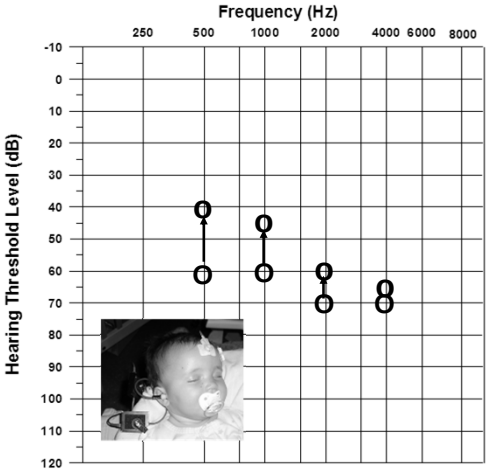


Assessment for Amplification



Best Practice: ABR Corrections

- Ensure a smooth transition from electrophysiologic hearing assessment to early hearing aid fitting: *standardized nHL to eHL corrections.*



Best Practice for Infant Assessment

- Use insert earphones for infant hearing assessment whenever possible
- It is more accurate and compatible with the target population

Assessments for Hearing Aid Fitting

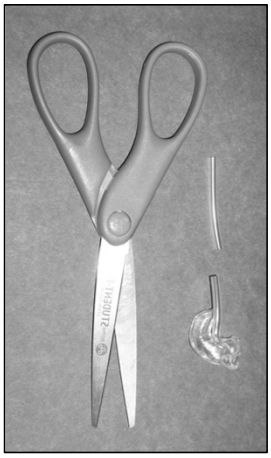
- Connect inserts to personal earmolds for follow-up audiograms
  - Better retention and acceptance
  - Sets you up for a more accurate hearing aid fitting
    - Earmold Audiogram
    - Earmold RECD

Best Practice: Measure the RECD

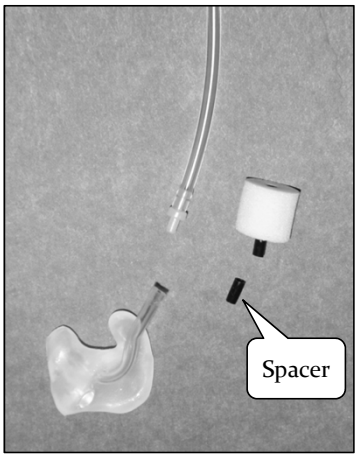
- Account for the child's unique ear canal: *measure the Real Ear to Coupler Difference (RECD), routinely.*

Do Audiometry & RECD with Earmolds

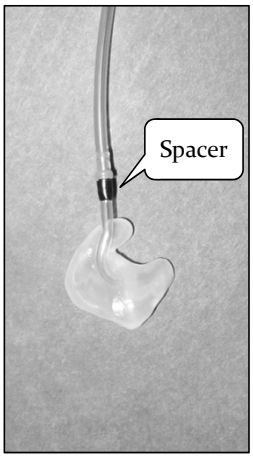
Trim Earmold Tubing



Trim Tube from Foam Tip



Connect Earmold to Insert Earphone



The RECD is used in <u>two</u> places:

HL Threshold **+ RECD** + RETSPL
= Real Ear SPL Threshold

HL to SPL transform

SPLogram

Coupler SPL or gain **+ RECD** + MLE
= predicted Real Ear SPL or gain

Coupler Verification

For BTEs, this needs to account for earmold!

If you do real-ear verification, you may still be using the first one behind the scenes:

HL to SPL transform

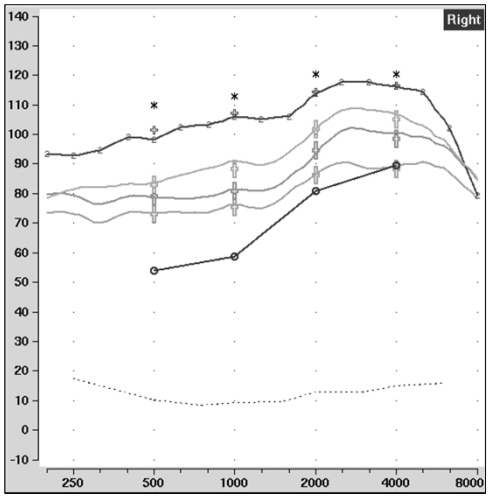
HL Threshold **+ RECD** + RETSPL
= Real Ear SPL Threshold

SPLogram

Direct verification of the REAR does not use the RECD at all.

Best Practice: Real-ear Verification

- Set the hearing aid for the infant or child, focusing on the long term levels of conversational speech: *verify every hearing aid, and fine tune to target. Use speech-based equipment.*



Why verify?

- To provide the best possible fittings.

"The responsible audiologist wants to know as much as possible about the levels of amplified sound that hearing instruments deliver into the ears of infants and young children. To this end, the audiologist must apply comprehensive and evidence-based verification strategies that are compatible with the characteristics and capabilities of this unique population. This is because the long-term implications of the fitting decisions we make are simply too important."

~ Richard Seewald

What we want..

- Accuracy, reliability
  - Electroacoustic verification is best
- Speech-like levels and MPO
  - Electroacoustic, some signals are best
- Infant-friendly procedures
  - There should be no requirement to sit up or respond behaviorally
- Meaningful displays for all patients
  - Should include dB for dB comparison to thresholds and upper limits of comfort

Characteristics of the Aided Audiogram

No • Does it tell us how the hearing aid processes *speech?*

No • Does it tell us the levels at which *output is limited?*

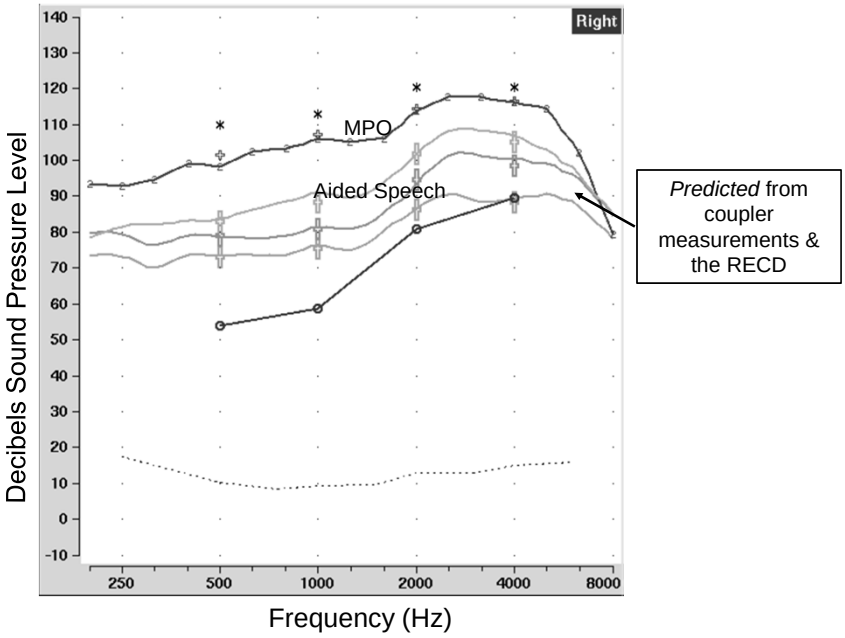
No • Is it an *efficient, reliable, and valid* procedure?

No • Can it be used with *infants?*

Yes • It is *meaningful?*

Characteristics of the Aided Audiogram

In less time, a very accurate and more detailed set of electroacoustic measurements could have been made.



How well does it work???

Predictive Validity of RECD Measures: 95% Confidence Intervals

250	500	1000	2000	4000
+/- 2.9	2.4	2.4	1.7	2.2 dB

+/- 2.3 dB for 95% of subjects across frequencies

From Seewald et al. (1999)

Clinical Implications

- Coupler measures & RECDs allow accurate and reliable prediction of real-ear hearing aid performance
  - Across ages
  - Across frequencies
- Reduces time/cooperation needed
  - Your patient must sit for ONE measurement
  - Maybe you already measures it for Assessment!

Clinical Implications

- Precise control over acoustic environment
  - Head movement is NOT a concern
  - Avoid effects of environmental noise
- Ideal for kids, also handy for adults

Verification

- 'Auto fit' not valid
  - First fit will be a good starting place, but fine-tuning is usually needed
- Speech-like signals are preferred
  - Soft, average, loud
  - MPO (narrowband)
- Target of choice is REAR(G) not REIG

How to view verification

- On an SPLogram
  - For comparison to threshold & upper limit
  - For comparison to unaided
- These allow you to inject meaning into the fit to targets
  - A 5 dB deviation from target for a mild loss is different than for a profound loss

Where to verify?

- **Coupler verification** is a better choice when:
  - The RECD has been measured
  - The ear/earmold is very small
  - Venting plays a small role in the fitting
  - Patient compliance for "real real-ear" is low
- **Real-ear verification** is more accurate when:
  - The RECD has been measured (!!)
  - The ear/earmold is larger
  - Venting plays a large role in the fitting (e.g., open fits)
  - Patient compliance for "real real-ear" is high and room noise is low

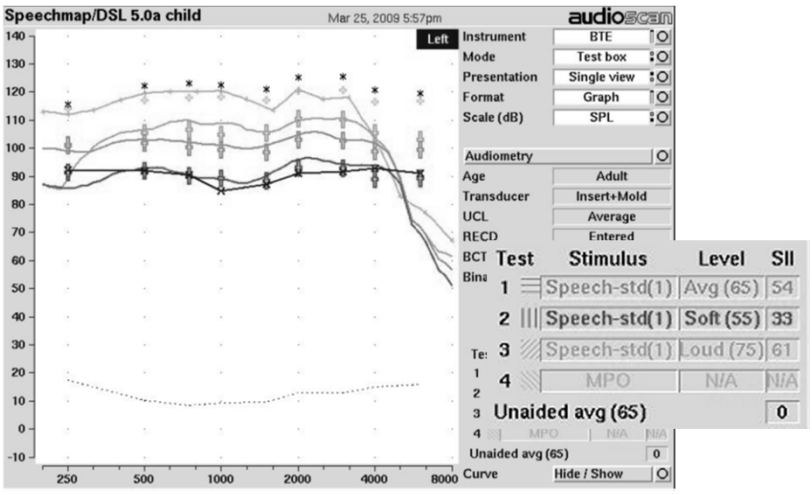
Speech test levels

- Prescriptions can calculate targets for any level or shape of speech
- Using multiple levels can represent functional conversational situations
  - In the range of 52 dB SPL for soft speech (48 for distant)
  - In the range of 60 dB SPL for conversation
  - In the range of 74 dB SPL for loud (with shaping)
  - You could use 82 dB for shout, but it will be too loud even for normal hearing listeners, so we don't
  - Any reasonable range of levels will likely do the job!

Other Analyses

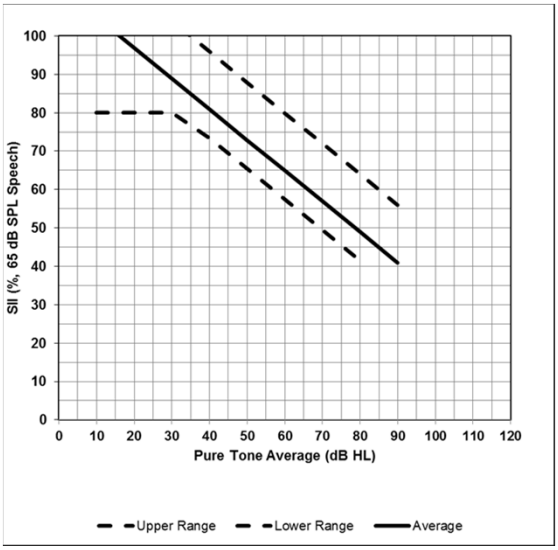
- The Speech Intelligibility Index (SII)
  - An updated version of the Articulation Index (AI), standardized in 1997
- How to interpret:
  - 0 means no speech is audible
  - 1 means 100% is audible
  - *This doesn't mean that 100% will be heard correctly.*

Example:



Pediatric Norms

(Bagatto et al, 2011: Trends; 2016: JAAA)



Protocol For Infants

- Estimate thresholds with evoked potentials
  - Convert to eHL if necessary, use insert phones
  - Measure the RECD
- Calculate targets & select device
  - BTE with filtered earhook
  - Must be able to lock VC & battery door
  - Typically deactivate directionality & automatics
- Verify for speech and maximum output
  - Coupler-based verification
- Follow up every 2-4 months
  - Outcome measures & reports from caregivers
  - Re-assess thresholds & RECDs (earmolds!) and re-adjust

Protocol For Children

- Measure thresholds with behavioral procedures
  - Use insert phones
  - Measure the RECD
- Calculate targets & select device
  - BTE with filtered earhook
  - Must be able to lock VC & battery door
  - Noise program may be a good option, in addition to FM
- Verify for speech and maximum output
  - Coupler-based verification is usually best
- Follow up every 3-6 months
  - Outcome measures & reports from caregivers/educators
  - Re-assess thresholds & RECDs (earmolds!) and re-adjust

Additional Hearing Aid Technologies for Children

Topics Discussed

- Noise Management
- Frequency Lowering

- Candidacy themes:
  - Case-by-case
  - Factors to consider

Noise Management in Pediatric Hearing Aid Fitting

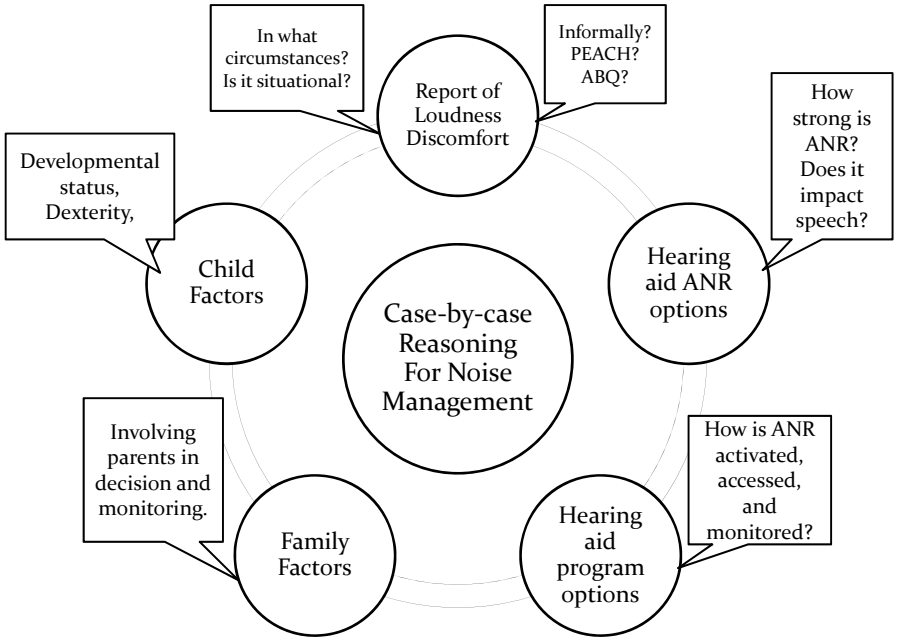
Rationale for Noise Management

- Infants and children may experience environments with high levels of speech, background noise or reverberation (Crukley et al, 2011)
- Excessive loudness may be associated with fewer hours of daily hearing aid use which may limit benefit through inconsistent access to amplified sound (Humes et al, 2010)
- Information about loudness perception and hearing aid use are available from items within the UWO PedAMP (Bagatto et al, 2011)
- Older children can indicate preference & tend to prefer the setting that maximized their benefit, following a period of acclimatization (Pittman & Hiipakka, 2013, JAAA)

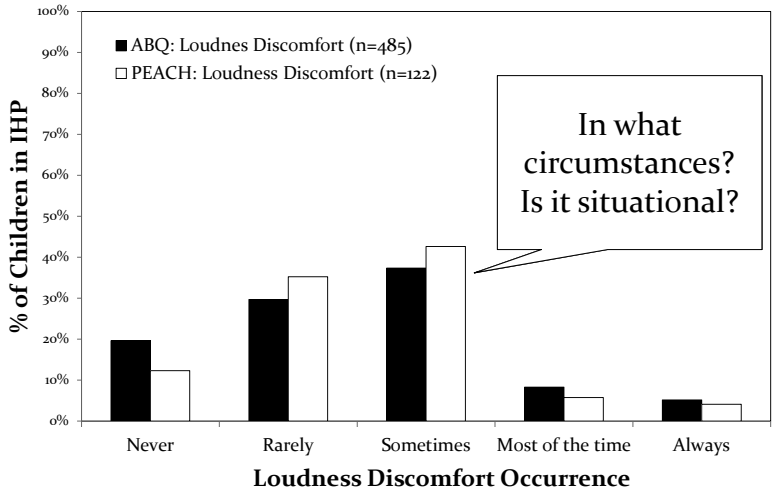
Determining Candidacy

- Evidence-based rationales aim to:
  - Provide aided listening levels that are comfortable across environments
  - Prevent excessive loudness percepts from limiting daily hearing aid use
- **Trials with noise management are warranted on a case-by-base basis and at the clinician's discretion**
- Indicators to consider:
  - Child is regularly in noisy situations
  - Child or caregiver reports limited hearing aid use due to loud situations
  - Child or caregiver reports loudness discomfort in any situation

Factors Considered



Candidacy info from outcome measures:



Noise Management Features

- Directional microphones
  - More than one microphone used to reduce amplification of sounds coming from non-frontal locations
- Adaptive noise reduction (ANR)
  - Digital signal processing to identify and minimize unwanted noise in hearing aid output
- Frequency-gain shaping
  - Adjustment of hearing aid gain
- Automatic switching between programs
- Data logging to monitor impact on use, and the child's exposure to situations.

Directional Microphones for Kids is trickier than for Adults

- Beneficial if listener's head is pointed toward the talker and competing sounds are from other directions
- Children have low rate of accurate head orientation toward talker
  - Orientation away can have deleterious affects on speech recognition when directionality is used
    - Ching et al, 2009; Ricketts & Galster, 2007
- Children rely on non-frontal listening and over-hearing for incidental language learning
  - Akhtar, 2005; Akhtar et al, 2001

AAA Recommendations for Directional Microphones

- Full time use not recommended for infants and young children (AAA, 2013)
  - Unlikely to orient to talker
  - Reduction of sounds from side and back may impair learning
- Consider part time use if SNR is an aim
  - Monitor for benefit and appropriate use

Evidence Review: Noise Reduction

- Adults do not show improvement in speech recognition with use of ANR (Bentler & Chiou, 2006; Bentler et al, 2008)
- Use of ANR does not affect speech recognition in children
  - Crukley & Scollie, 2014; McCreery et al, 2012; Pittman, 2011; Stelmachowicz et al, 2010
- Fitting practices that preserve speech audibility may help avoid any negative impacts of ANR (Stelmachowicz et al, 2010)
- Increased rate of novel word learning in older children but not younger children due to improved ease of listening (Pittman, 2011)

Some Cautions & Suggestions

- ANR systems differ in the amount of noise reduction they provide
- As long as the aid's ANR does not reduce audibility for speech in quiet, may be activated in hearing aids for children when factors considered
- Make sure you routinely verify so you know what the ANR is doing

Frequency-Gain Shaping

- Less gain and output in hearing aid's main program or a second program
- DSL v5.0 has targets for noisy situations designed to maintain audibility of most important cues for speech intelligibility
  - Manage loudness comfort in noisy situations without degrading speech recognition abilities (Scollie et al, 2005)
- Using either NAL-NL1 or DSL v5.0 Noise Targets can alleviate excessive loudness for noisy environments

The use of automatic Program Switching in kids hasn't been studied very much.

- Some hearing aids allow automatic switching between programs.
- These hearing aids monitor the acoustic environment, classify it by acoustic features, and switch to the program that is associated with that environment.
- Little research available on the use of these features in infants and young children.
- Trials on a case by case basis with monitoring are recommended.

AAA Guideline (2013)

We operationalized the recommendations so they could be applied in clinical practice:

A Protocol

Embed within a Program

Embedding a noise management strategy.

- Embed in program 1 *(preferred)*
- Embed in automatically activated program 2 *(preferred)*
- Embed in a manually accessed program 2 *(not preferred unless the child can manage)*

Add Signal Processing

Building a noise management strategy.

- Routine use of the following processors is suggested: *ANR, speech enhancement, transient sound reduction*
- Microphone strategies: *More caution for younger children and less caution for pinna-matched mics.*
- Data logging / use monitoring strategies: *Routine use is suggested.*

Verify

Get acquainted with your NR system.

Does it affect speech in quiet?

Does it reduce noise?

Recommended Protocol

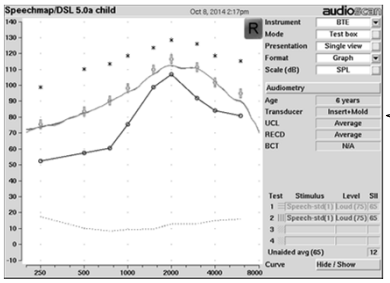
1) Consider candidacy factors
2) Consider practical factors
3) Verify the hearing aid without ANR
4) Decide what program will house the strategy
5) Program the noise management strategy
6) Verify by running 75 dB SPL speech into the hearing aid with and without noise management enabled
   a) Both curves should be similar
7) Measure noise signal at 85 dB for 30 seconds
   a) Consider strengthening processor if <3 dB attenuation
8) Counsel on appropriate use and monitor outcomes

Recommended Protocol

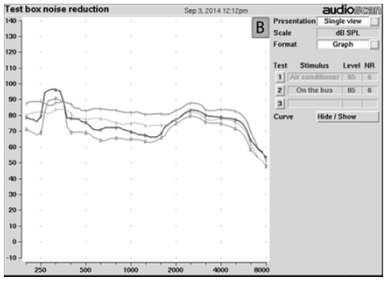
Our interpretation of AAA (2013):
Because this step rarely produces any concern, it is sufficient to run this when learning a new make/model/processing scheme, and does not need to be performed on a case by case basis unless there are concerns.

1) Consider candidacy factors
2) Consider practical factors
3) Verify the hearing aid without ANR
4) Enable noise management program
5) Program noise management strategy
6) **Verify by running 75 dB SPL speech into the hearing aid with and without noise management enabled**
   a) **Both curves should be similar**
7) Measure noise signal at 85 dB for 30 seconds
   a) Consider strengthening processor if <3 dB attenuation
8) Counsel on appropriate use and monitor outcomes

Case Example A (Medium Strength ANR)



Output of hearing aid does not change with loud speech input when ANR on versus off.



Average of 6 dB noise reduction is noted for 'Air Conditioner' and 'On the bus'

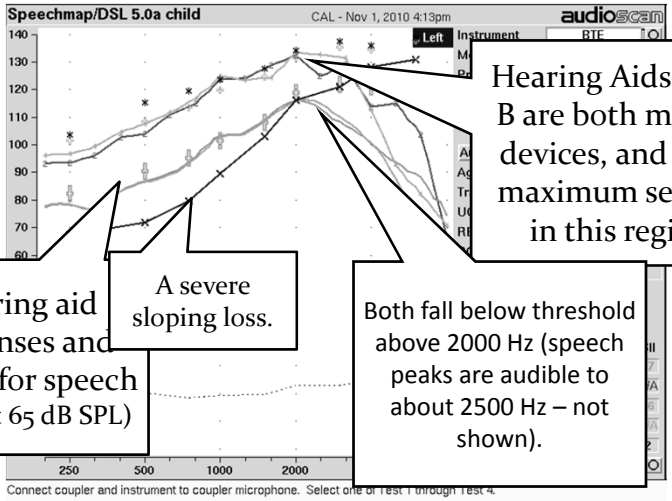
Frequency Lowering

Bandwidth matters

- Children and adults need access to the high frequency sounds of speech, to understand and monitor speech production:
  - See: Moeller et al, 2007, a review article by Stelmachowicz et al (2004), Pittman 2008, and various other studies … only mentioned a few here.
- But:

  If audibility cannot be provided via the available bandwidth and gain/output, consider applying a frequency lowering technology to lower the cues to an audible frequency range.

Bandwidth limitations for severe losses:



Hearing Aids A and B are both modern devices, and are at maximum settings in this region.

Hearing aid responses and targets for speech (input at 65 dB SPL)

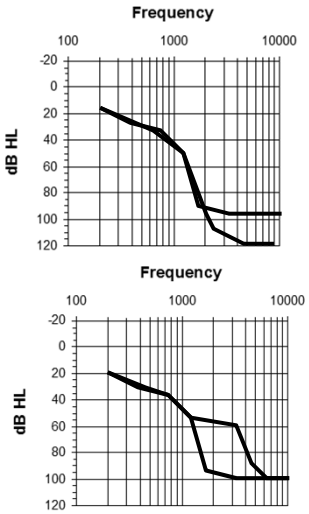
A severe sloping loss.

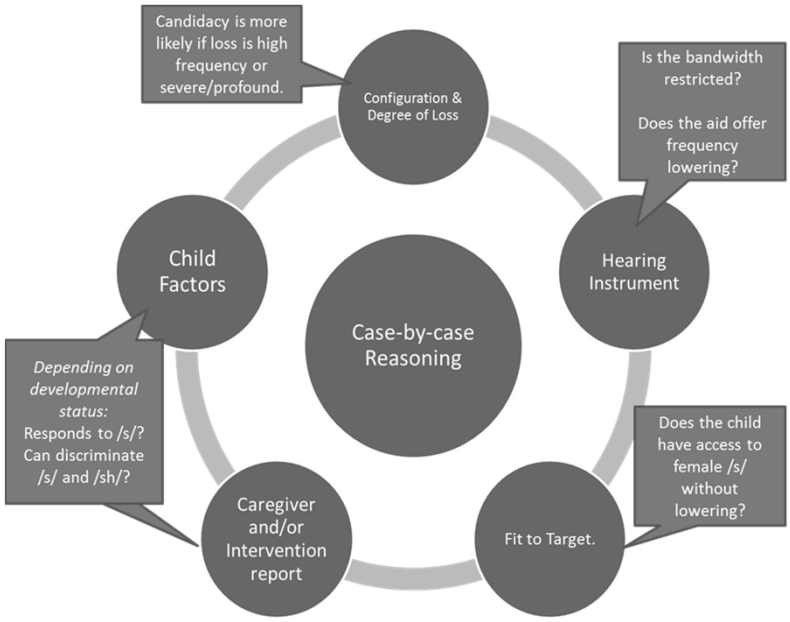
Both fall below threshold above 2000 Hz (speech peaks are audible to about 2500 Hz – not shown).

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)

Glista et al., 2009



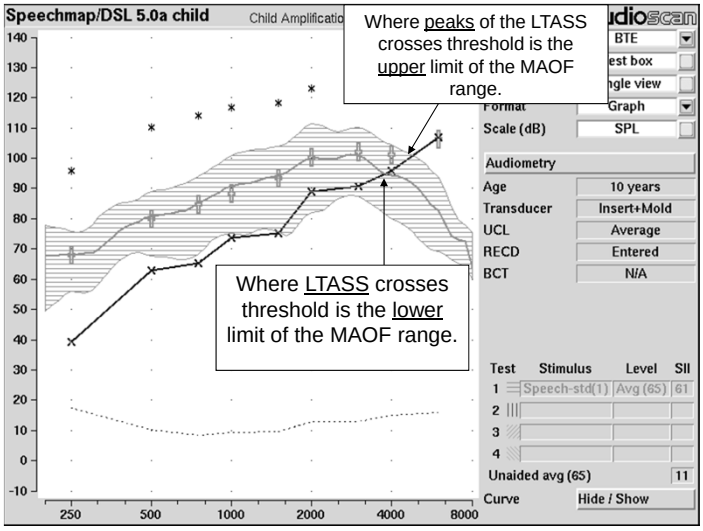


Overview

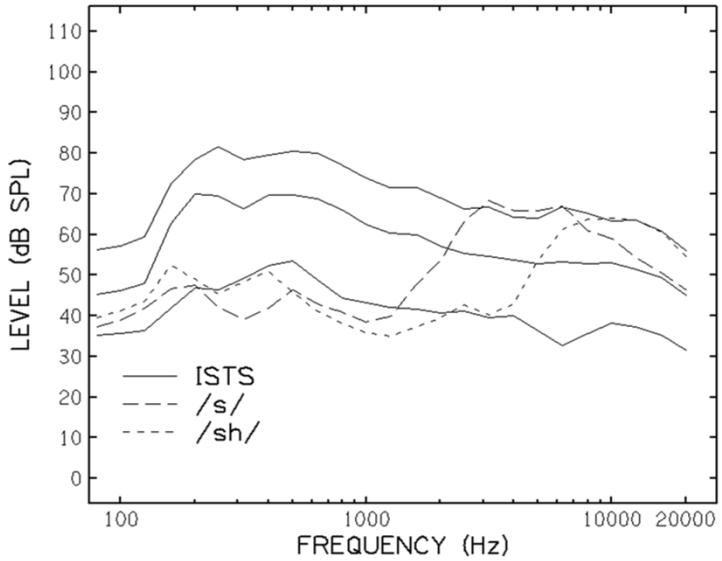
1) Provide more audibility of high-frequency cues than is possible with a well-fitted device. The frequency response is based on DSL5 formula to maximize the bandwidth of the fitting without frequency lowering.

2) We verify using measures that show us audibility of specific high frequency speech bands.

Major concept 1: MAOF range



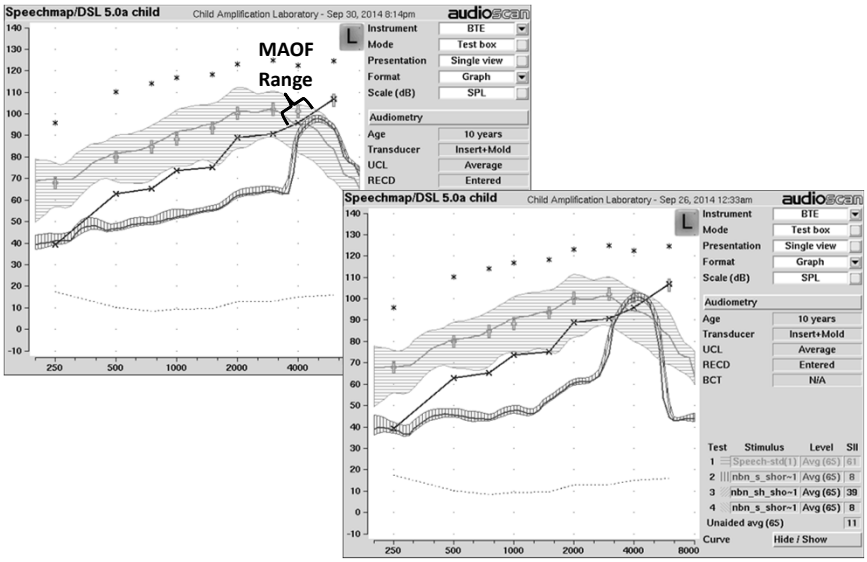
Major concept 2: Calibrated /s/



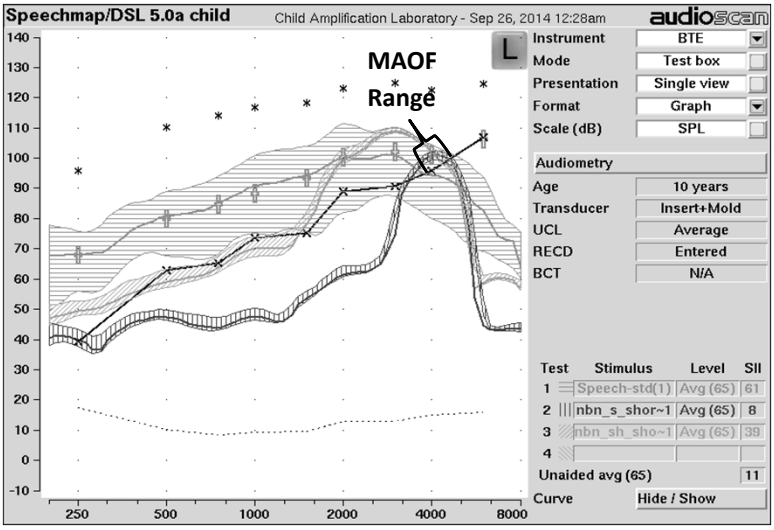
Steps (updated from 2009 → 2016)

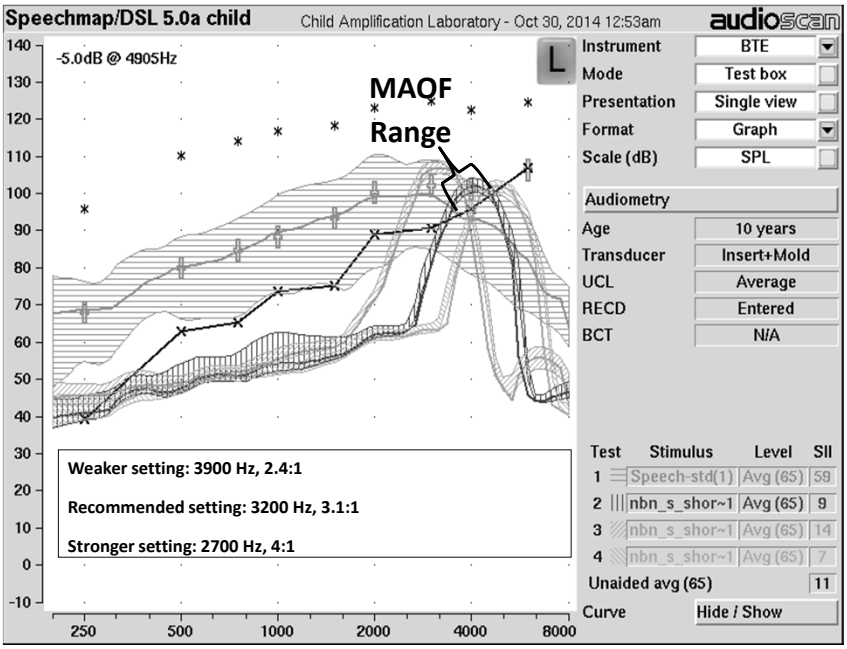
- Verify and tune the hearing aid to DSL (FL off):
  - Mark the lower & upper limits of the Maximum Audible Output Frequency (MAOF) range.
- Assess candidacy:
  - Measure aided /s/ at 65 dB SPL. Does the upper corner fall within the MAOF and/or passband? If not, frequency lowering candidacy may be a factor.
- Fit frequency lowering if indicated:
  - Tune to the weakest possible setting that moves the upper corner of /s/ into the audible passband of the device.

Example:



Example:


Speechmap/DSL 5.0a child
Child Amplification Laboratory - Sep 26, 2014 12:28am
audioscan
MAOF
Range
Instrument BTE
Mode Test box
Presentation Single view
Format Graph
Scale (dB) SPL
Audiometry
Age 10 years
Transducer Insert+Mold
UCL Average
RECD Entered
BCT N/A
Test Stimulus Level SII
1 Speech-std(1) Avg (65) 61
2 nbn_s_shor~1 Avg (65) 8
3 nbn_sh_sho~1 Avg (65) 39
4
Unaided avg (65) 11
Curve Hide / Show


Speechmap/DSL 5.0a child
Child Amplification Laboratory - Oct 30, 2014 12:53am
audioscan
-5.0dB @ 4905Hz
MAOF
Range
Weaker setting: 3900 Hz, 2.4:1
Recommended setting: 3200 Hz, 3.1:1
Stronger setting: 2700 Hz, 4:1
Instrument BTE
Mode Test box
Presentation Single view
Format Graph
Scale (dB) SPL
Audiometry
Age 10 years
Transducer Insert+Mold
UCL Average
RECD Entered
BCT N/A
Test Stimulus Level SII
1 Speech-std(1) Avg (65) 59
2 nbn_s_shor~1 Avg (65) 9
3 nbn_s_shor~1 Avg (65) 14
4 nbn_s_shor~1 Avg (65) 7
Unaided avg (65) 11
Curve Hide / Show

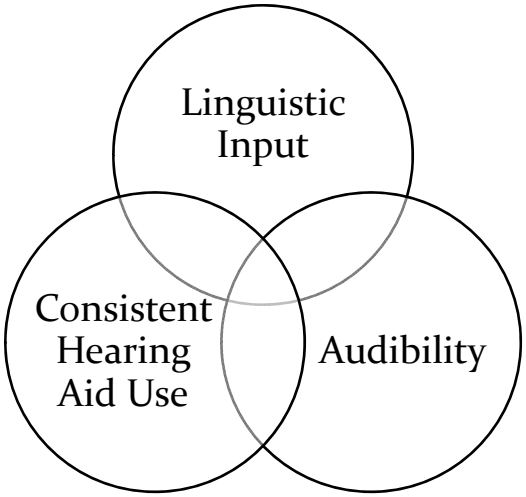
Optional for more information:

- Should /s/ be audible at 55 dB SPL?
  - Most studies have aimed at 65 dB SPL, but none have ruled out 55 dB SPL as a further consideration. Verify at your discretion.
- Should /s/ and /sh/ be separated in frequency?
  - Providing the best possible separation between these two sounds is a good way to support the listener in perceiving them as different. However, the MAOF protocol asks you to search for the weakest possible setting that provides /s/ audibility. By definition, this also maximizes s-sh separation. Therefore, fine tuning with /sh/ is not necessary, but the stimulus is provided for you use if you wish. For example, a description of s-sh audibility and separation may be informative for SLPs or AVTs, or for follow up.

Take Home Messages

- A *measured* RECD is necessary for an accurate description of your patient's ear canal which individualizes the hearing aid fitting
- RECDs are used to convert HL to SPL AND to allow for coupler-based verification
- Simulated REAR(in the coupler) is a valid way to assess hearing aid performance for kids
- Consider other hearing aid technologies (noise reduction, frequency lowering) on a case-by-case basis
- If activated, verify the characteristics, impact on audibility and benefit

Good Fittings Contribute to Good Outcomes



Outcomes of Children with Hearing Loss
Ear & Hearing, 2015