Guidelines for determining hearing aid output, hearing aid features, and fitting parameters for children

Jace Wolfe, PhD
# The Hearts for Hearing Team

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**Knitknot**
From Good to Great!

All too often, good is the enemy of great. – Jim Collins
Oklahoma!

- 48th out of 50 states in teacher pay
- 50th recent visit to the dentist
- 48th in physical activity
- 50th in % of people who eat at least one vegetable per day
- #1 in fast food restaurants per capita
- 49th in heart health
Road Map

• Ensuring appropriate output for infants and children using hearing aids.

• Technologies for Children
  – Digital Noise Reduction
  – Directional Microphones
  – Technology for the Telephone
  – Frequency Lowering

Audibility is king!

• Do they “work” for children?

• Should we use them with our youngest patients?
Fitting Hearing Aids for Children

• How do I know when I have gotten it right?
Fitting Hearing Aids for Children

Search “American Academy of Audiology Pediatric Amplification Guideline”

http://www.audiology.org/resources/documentlibrary/Documents/PediatricAmplificationGuidelines.pdf
Fitting Hearing Aids for Children

Recommendations for Fitting/Verification

1. **Prescription methods**: Independent pediatric-focused and pediatric-tested prescriptive targets, normative data, and fitting methods that take into account the unique developmental and auditory needs of children should be used for pediatric hearing aid verification instead of manufacturer’s proprietary prescriptive approaches. Pediatric and adult populations differ significantly in areas that directly affect the prescription of appropriate hearing aid gain, output, and signal processing. Hearing aid manufacturers typically offer custom hearing aid prescriptions that have been developed for proprietary use with their hearing aids. Such prescriptions are not standardized or subjected to external scrutiny and are typically developed for use in the adult population. As such, their incorporation of important pediatric considerations is both unknown and unverified. Significant variance in gain and output among manufacturer designed fittings has been demonstrated, even for the same audiogram. Validation studies indicate high levels of speech recognition in controlled and real-world environments when hearing aids are fit using prescriptive targets generated by independently developed formulae such as the Desired Sensation Level (DSL) or National Acoustics Laboratories (NAL) prescription and when the individualized fitting is verified through real-ear, probe microphone measurements.

2. **Verification method**: The response of the hearing aid should be measured for a variety of input levels to estimate the audibility of speech and ensure that the maximum output does not exceed prescribed levels.

For children, there are two options for hearing aid verification:

1. **Real-ear aided response (REAR) probe microphone measurements**. The output of the hearing aid is measured in the child’s ear (in situ) using a probe microphone. This option is a better choice for highly vented fittings and for children with earmold tubing that is longer than 30 mm than simulated real-ear aided response measurements. The response of the hearing aid should be measured for a variety of input levels, minimally for average-level speech input and maximum power output of the hearing aid.

2. **Simulated real-ear aided response measurements** in the coupler using measured or age-appropriate real-ear to coupler difference (RECD). The output of the hearing aid is measured in a 2cc coupler. The RECD is used to convert coupler measurements to estimates of SPA in the child’s ear and to accurately display target fitting data against which to compare the estimated output in the ear canal. This option is a better choice for unventured fittings, fittings that cannot be verified on the ear without feedback, and for infants and young children who cannot sit for real-ear measurements.

Clinicians should consider multiple factors when determining which method will be used for verification. Simulated real-ear aided measurements using a previously measured RECD to estimate the output in the individual child’s ear canal may be more practical than direct real-ear aided response measurements with children because (a) a single measurement, requires less cooperation time from the child, and (b) is not affected by head movement. Because the signals used to verify maximum output are loud and may startle young children, simulated, coupler measurements of maximum output using RECD may be preferable over real-ear maximum output measurements. Correct use of the RECD in clinical practice relies upon appropriate clinical decision-making, and consideration of five evidence-based points:

1. The RECD is measurable in most cases, as long as it is attempted routinely. One common practice is to measure the RECD for at least one ear, and apply it to the fitting of both ears when exact values are obtained. An RECD from one ear may be a good predictor of the RECD in the other ear if this is not possible on a case-by-case basis, age-appropriate predicted RECDs or recently measured RECDs from the same child might be used to fit in lieu of newly measured RECDs. These substitute RECDs are likely less accurate
Fitting Hearing Aids for Children

Recommendations for Fitting/Verification

1. Prescription methods: Independent pediatric-focused and pediatric-validated prescriptive targets, normative data, and fitting methods that take into account the unique developmental and auditory needs of children should be used for pediatric hearing aid verification instead of manufacturer’s proprietary prescriptive approaches. Pediatric and adult populations differ significantly in areas that directly affect the prescription of appropriate hearing aid gain, output, and signal processing. Hearing aid manufacturers typically offer custom hearing aid prescriptions that have been developed for proctorary use with their hearing aids. Such prescriptive methods are not standardized or subjected to external scrutiny and are typically developed for use in the adult population. As such, their incorporation of important pediatric considerations is both unknown and unlikely. Significant variance in gain and output among manufacturer-driven fittings has been demonstrated, even for the same audogram. Validation studies indicate high levels of speech recognition in controlled and real-world environments when hearing aids are fit using prescriptive targets generated by independently developed formulae such as the Desired Sensation Level (DSL) or National Acoustical Laboratories (NAL) prescriptions and when the individualized fitting is verified through real-ear, probe microphone measurements.

2. Verification methods: The response of the hearing aid should be measured for a variety of input levels to ensure the quality of speech and ensure that the maximum output does not exceed prescribed levels.

   - Real-ear aided response measurement (PERA): probe microphone measurements - The output of the hearing aid is measured in the child’s ear (in situ) using a probe microphone. This option is a better choice for highly vented fittings and for children with earmold tubing that is longer than 30 mm than simulated real-ear aided response measurements. The response of the hearing aid should be measured for a variety of input levels, minimally for average level speech input and maximum power output of the hearing aid.

   - Simulated real-ear aided response measurements in the coupler using measured or age-appropriate real-ear to coupler difference (RECD): The output of the hearing aid is measured in a 2cc coupler. The RECD is used to convert coupler measurements to estimates of SNR in the child’s ear and to accurately display target fitting data against which to compare the estimated output in the ear canal. This option is a better choice for unvented fittings, fittings that cannot be verified on the ear without feedback, and for infants and young children who cannot sit for real-ear measurements.

   - Clinicians should consider multiple factors when determining which method will be used for verification.

Simulated real-ear aided measurements using a previously measured RECD to estimate the output in the individual child’s ear canal may be more practical than direct real-ear aided response measurements with children because it is a simple measurement, requires less cooperative time from the child, and is not affected by head movement. Because the signals used to verify maximum output are loud and may startle young children, simulated, coupled measurements of maximum output using RECD may be preferable over real-ear maximum output measurements. Correct use of the RECD in clinical practice relies upon appropriate clinical decision-making and consideration of five evidence-based points:

1. The RECD is measurable in most cases, as long as it is attempted routinely. One common practice is to measure the RECD for at least one ear, and apply it to the fitting of both ears each time new earmolds are obtained. An RECD from one ear may be a good predictor of the RECD in the other ear. If this is not possible on a case-by-case basis, age-appropriate predicted RECDs or recently measured RECDs from the same child may be used in lieu of newly measured RECDs. These substitute RECDs are likely less accurate.
Fitting Hearing Aids for Children

The clinician should use independent pediatric-focused and pediatric-validated prescriptive targets, normative data, and fitting methods that take into account the unique developmental and auditory needs of children.

DSL v5.0 for Children

NAL-NL2
Want to learn more about DSL v5.0 and NAL-NL2?

DSL v5.0

The Desired Sensation Level Multistage Input/Output Algorithm

Clinical Protocols for Hearing Instrument Fitting in the Desired Sensation Level Method

NAL-NL2

The NAL-NL2 Prescription Procedure
Fitting Hearing Aids for Children

The clinician should use independent pediatric-focused and pediatric-validated prescriptive targets, normative data, and fitting methods that take into account the unique developmental and auditory needs of children.

The response of the hearing aid should be measured for a variety of input levels to estimate the audibility of speech and to ensure that the maximum output does not exceed prescribed levels.
The clinician should use independent pediatric-focused and pediatric-validated prescriptive targets, normative data, and fitting methods that take into account the unique developmental and auditory needs of children.

The response of the hearing aid should be measured for a variety of input levels to estimate the audibility of speech and to ensure that the maximum output does not exceed prescribed levels.

1) In situ probe microphone measurement

2) Simulated probe microphone measurement
Real Ear Probe Microphone Measurement (In Situ)

Gold Standard: Measure RECD and conduct in situ probe microphone measure
Ensure Goals Are Met Through Real Ear Measures

Ensure Audibility
- Speech Signal at Multiple Levels
  - 55 dB SPL
  - 65 dB SPL
  - 75 dB SPL

Ensure Comfort & Safety
- High-Level Swept Pure Tone
What do I do with wiggly babies?
Simulated Real Ear Probe Microphone Measures (Coupler)
Coupler Measurements in Infant Fittings
Real-Ear-to-Coupler Difference
Real-Ear-to-Coupler Difference

Measure RECD

Real Ear Response

Coupler Response

Max TMI SPL: 100

Scale (dB) SPL

Real ear

Coupler

Coupler Response

Real Ear Response

NA-2 RECD

Avg NA-2 RECD

Cancel Continue Help

Max TMI SPL: 100

Scale (dB) SPL

Real ear

Coupler

Coupler Response

Real Ear Response

NA-2 RECD

Avg NA-2 RECD

Cancel Continue Help
Real-Ear-to-Coupler Difference

Figure 10: An illustration of a real-ear-to-coupler difference response (RECD) measured from an adult hearing aid wearer. This RECD is higher than the average value (dotted line).
Simulated Real Ear Probe Microphone Assessment
• Hearing Aid Features for Children
DIGITAL NOISE REDUCTION IN CONTEMPORARY HEARING AIDS
Digital Noise Reduction

• Classifies the input as either speech or noise

• Reduces gain when the input to the aid is primarily noise

• Wide variety in implementation of DNR across manufacturers

• Studies with adults
  – no change in speech recognition
  – Improvement in noise tolerance, listening ease, comfort, and cognitive load
Stelmachowicz et al., (2010) Ear and Hearing

Overall, DNR use resulted in no change in speech recognition in noise

• 16 children with mild to moderately severe HL
  – 8: 5-7 years old
  – 8: 8-10 years old

• Evaluated speech recognition in noise with and without DNR (-6 dB)
Overall, DNR use resulted in no change in speech recognition in noise

- Other studies examining auditory performance for school-aged children have also shown no degradation in speech recognition in noise with the use of DNR.

-- Auriemma et al., (2009), J American Acad Audiology
-- Pittman (2011a), J Speech Language Hearing Research
DNR may improve novel word learning as well as tolerance of noise

- NH children outperformed children with HL
- Older children outperformed younger children
- Older children performed better with DNR
Does DNR “work” for children?"

• Yes!

• At the very least, **when implemented correctly**, it seems to result in no degradation in speech recognition.

• It may improve listening ease, comfort, cognitive load, and novel word learning.
Should we use DNR with our youngest children?

• Maybe

• We must verify that gain will not be reduced when audible speech is present.
Ensuring DNR does not sacrifice audibility

• Inspired by
  – McCreery (2011) – AudiologyOnline.com
Directional Technology for Children

• Experts are divided as to whether directional technology should be used with young children

• Many experts do not explicitly recommend directional amplification for infants and young children
  
  – Ontario Guideline for Pediatric Amplification
  – American Academy of Audiology Pediatric Amplification Guideline (2013)
However, some experts do condone directional mics for infants.
...infants and young children should routinely be fit with advanced directional microphones.
• What about the evidence?
• There’s very little in the way of direct evidence supporting the benefits of directional use with infants and young children!
Ricketts & Galster (2007) American J of Audiology

- Evaluated speech recognition in 26 children with mild to moderate HL
- Simulated classroom environment
- Directional vs. Omnidirectional
- Signal from front and signal from behind

Directional amplification reduced performance when signal arrived from behind
Additional Considerations

• **Cons**
  
  – Little to no evidence suggesting infants can orient toward signal of interest
  – Children 11 to 78 months orient to the signal of interest about 40% of the time, and majority of the speech young children are exposed to arrives incidentally (Ching et al, 2009)
  – Incidental listening responsible for 90% of what a child learns about the world (Cole and Flexer, 2009)
  – No evidence showing benefits and lack of detriment with adaptive directional use in young children

• **Pros**
  
  – Directional aids can improve speech recognition in noise
  – Directional mics are not that directional in real world environments
  – Children may learn to orient toward sound of interest (Ricketts & Galster, 2008)
  – Automatic/adaptive directional aids may limit directional detriment
Do directional mics “work” for children?”

• Yes!
  
  • Research conclusively shows that they can improve speech recognition in noise when the signal arrives from the front
  
  • However, they may degrade speech recognition for signals arriving from behind (Ching et al., 2009; Ricketts & Galster, 2007)
  
  • There is no evidence supporting their efficacy for infants and young children
Should we use directional amplification with children?

- Possibly

- Unlikely to be appropriate for infants birth through 9-12 months
  
  - Likely okay for school-aged children
    - Can they report on experiences?
    - Do they understand rationale behind directional use?
    - Can they (or the aid) reliably switch programs?

- More research is needed to develop and determine whether adaptive directional microphones limit access to speech for pre-school aged children
What about the telephone?
DuoPhone

• DuoPhone uses wireless streaming to deliver telephone signal from one ear to the other.

• It allows for binaural listening on the telephone.
• DuoPhone Telephone Study with Children
Subjects

• Tested word recognition on the telephone with and without DuoPhone in quiet and in noise for children with hearing loss

  – 14 children (6-14 years-old)
    • Recorded CNC words

  – 10 children (2-5 years-old)
    • NU-CHIPs words via live voice (open-set)
Mean CNC word recognition scores for older children (6-14 years-old)
Mean NU-CHIP word recognition scores for younger children (2-5 years-old)

![Graph showing mean NU-CHIP word recognition scores for younger children in quiet and noise (55 dBA) conditions for monaural and duoPhone listening.]
Hailey with Monaural Telephone Use
Hailey with the DuoPhone
• What about frequency-lowering technology?
NLFC improves speech recognition on UWO Plural Test by 16% points.

* Wolfe et al. (2010), J Am Acad of Audiol

* P < .001
• Yes, it works.

• More from Andrea Bohnert!
Thank you for your attention!!!