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

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Darlene Hale	Kelsey Kuehn	Verneda Osborne
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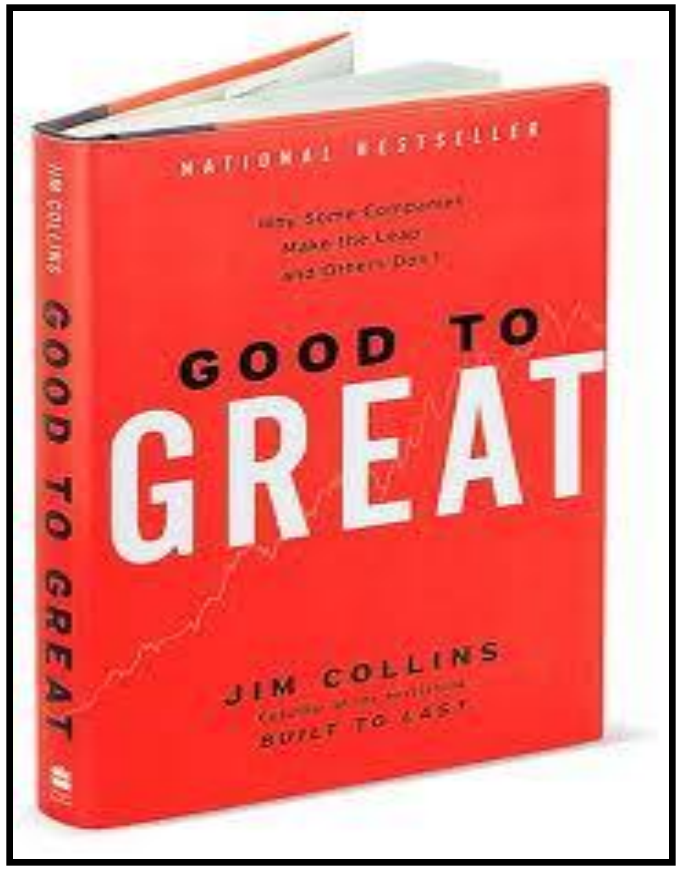
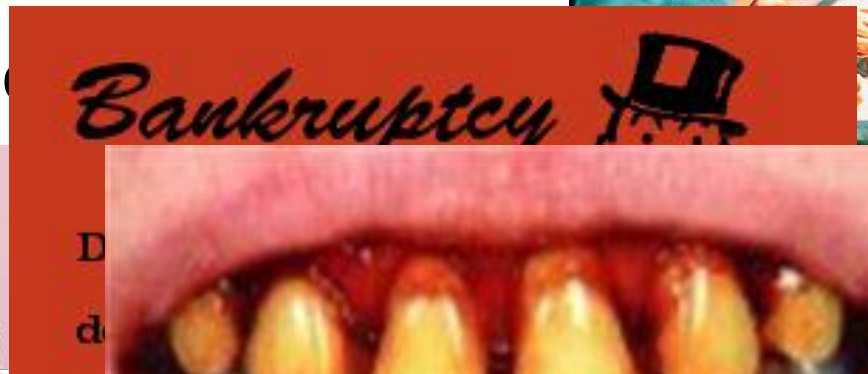
From Good to Great!



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

Oklahoma!

- 48th out of 50 states in teacher
- 50th recent visit to the dentist
- 48th in physi
- 50th i ble per day



Road Map

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

Audibility is king!

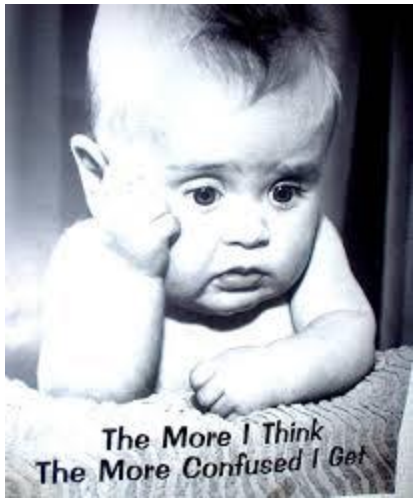
- Technologies for Children
  - Digital Noise Reduction
  - Directional Microphones
  - Technology for the Telephone
  - Frequency Lowering

- Do they “work” for children?

- Should we use them with our youngest patients?

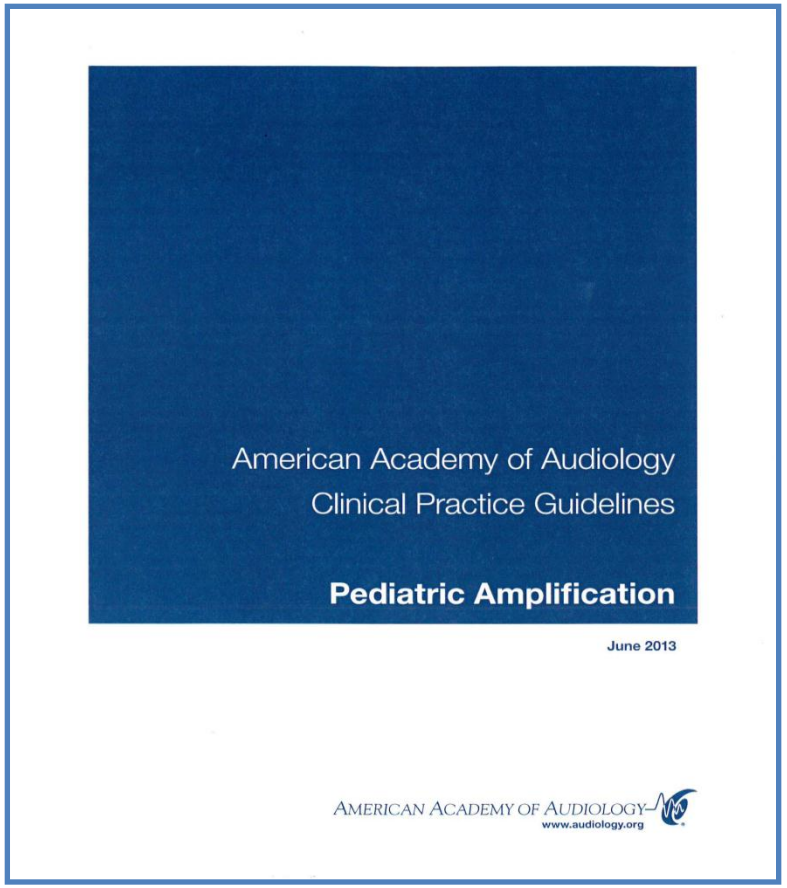
Fitting Hearing Aids for Children

- *How do I know when I have gotten it right?*



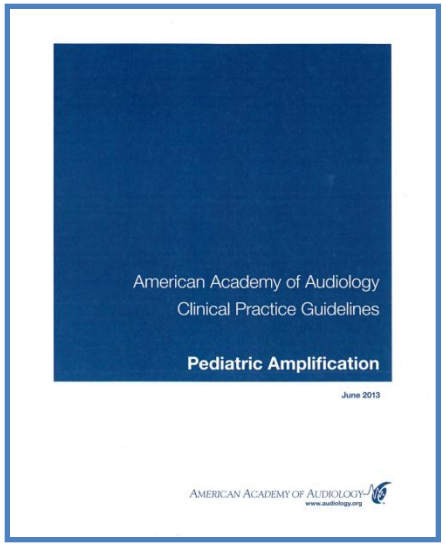
Fitting Hearing Aids for Children

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-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 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 unlikely. Significant variance in gain and output among manufacturer-driven 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) 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 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:

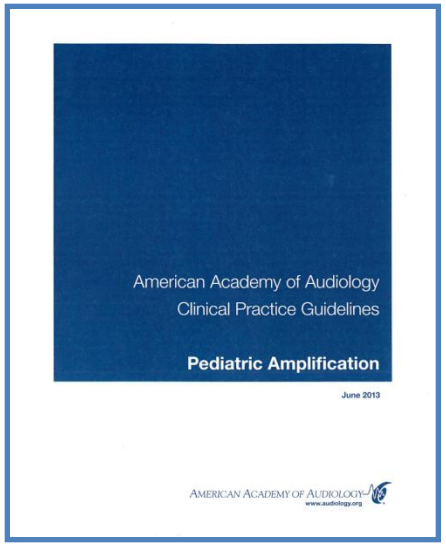
   1. Real-ear aided response (REAR) probe microphone measurements – The output of the hearing aid is measured in the child's ear (in situ) using a probe microphone. This option is a better choice for highly vented fittings and for children with earmold tubing that is longer than 35 mm than simulated real-ear 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 measures to estimates of SPL 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 single 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, 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 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



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Fitting Hearing Aids for Children

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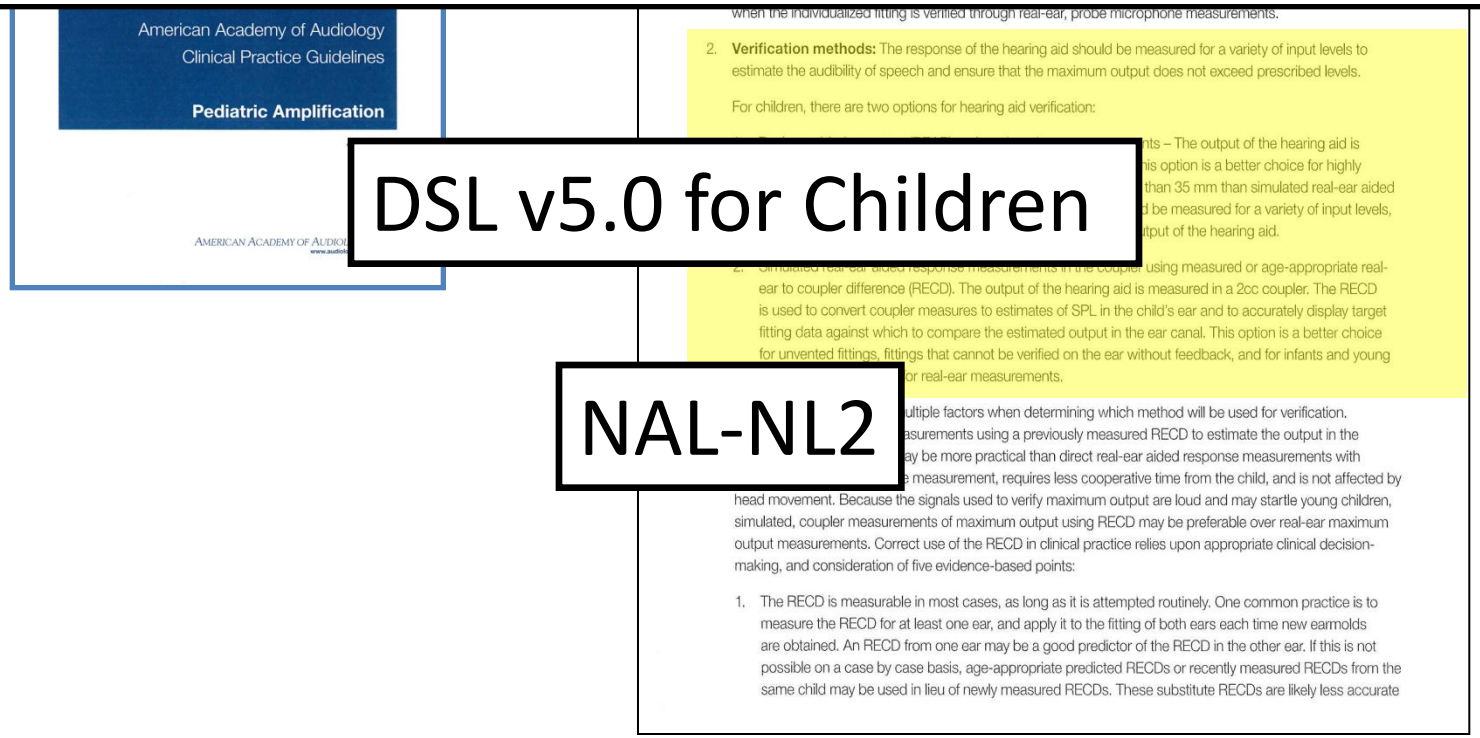


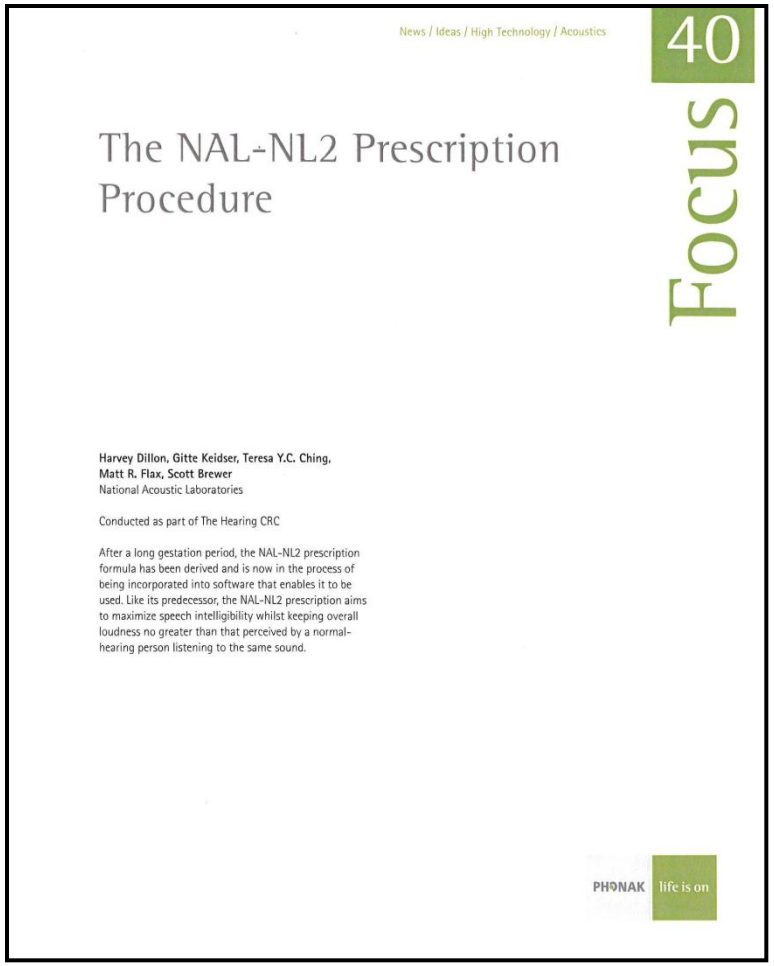
DSL v5.0 for Children

NAL-NL2

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

DSL v5.0

NAL-NL2



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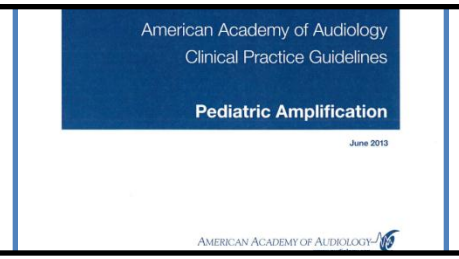

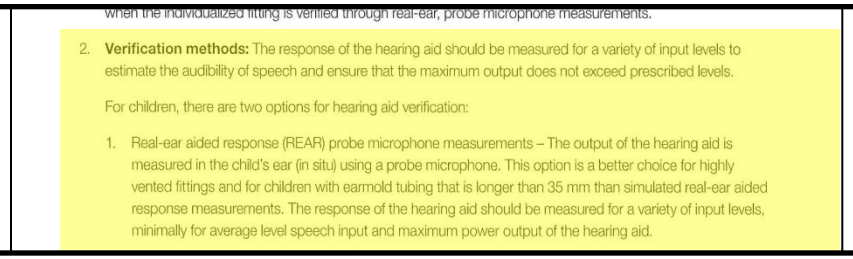

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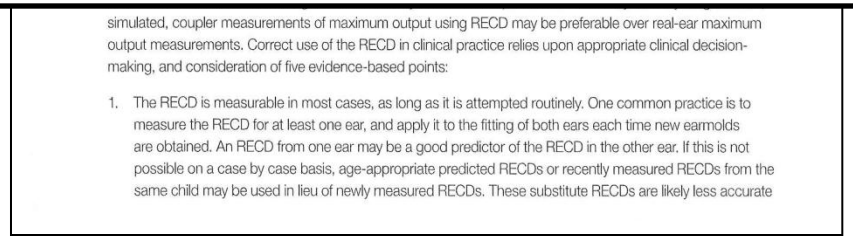

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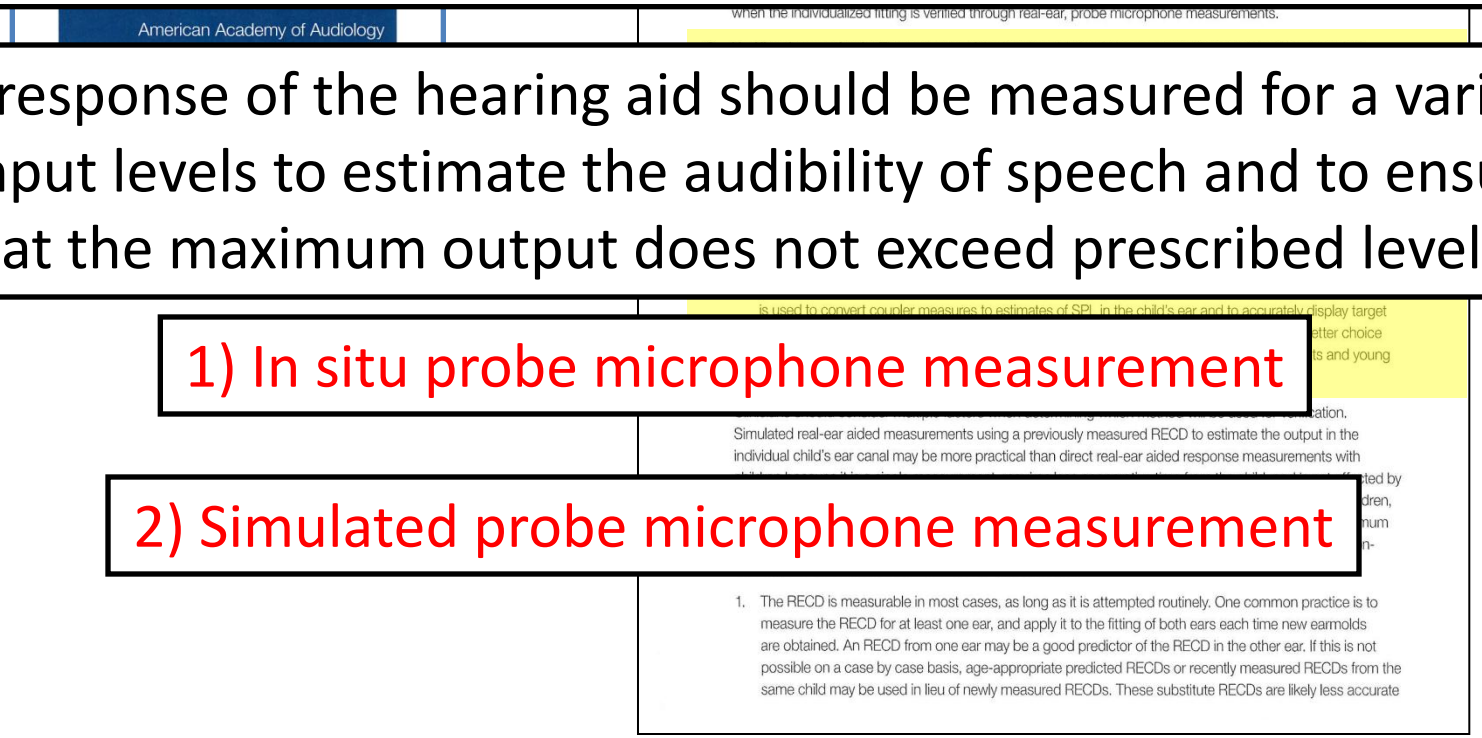
1) In situ probe microphone measurement

2) Simulated probe microphone measurement


American Academy of Audiology

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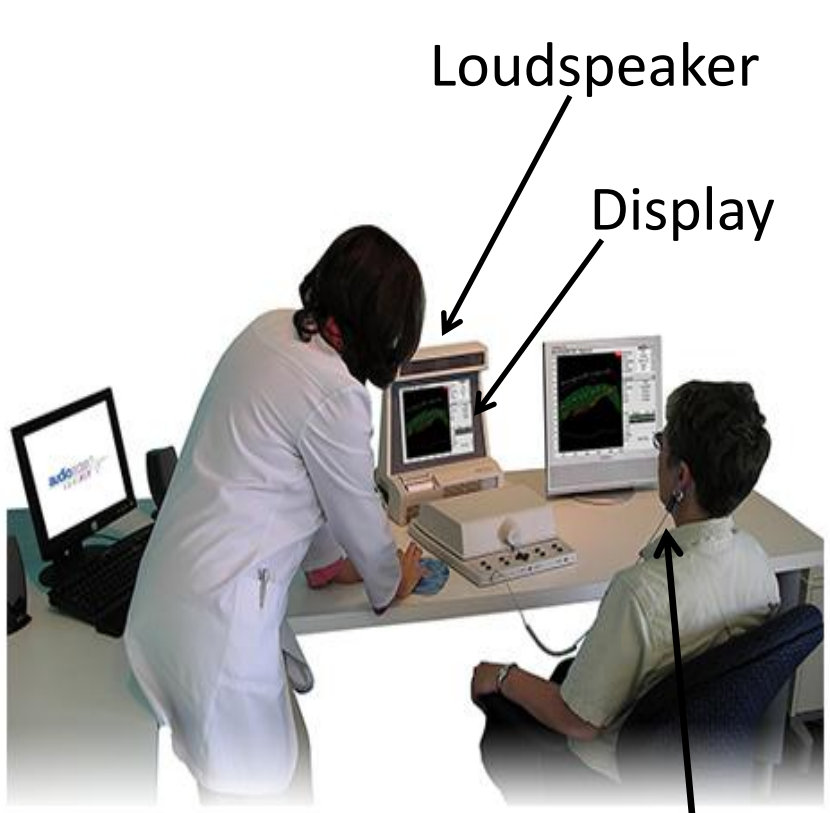
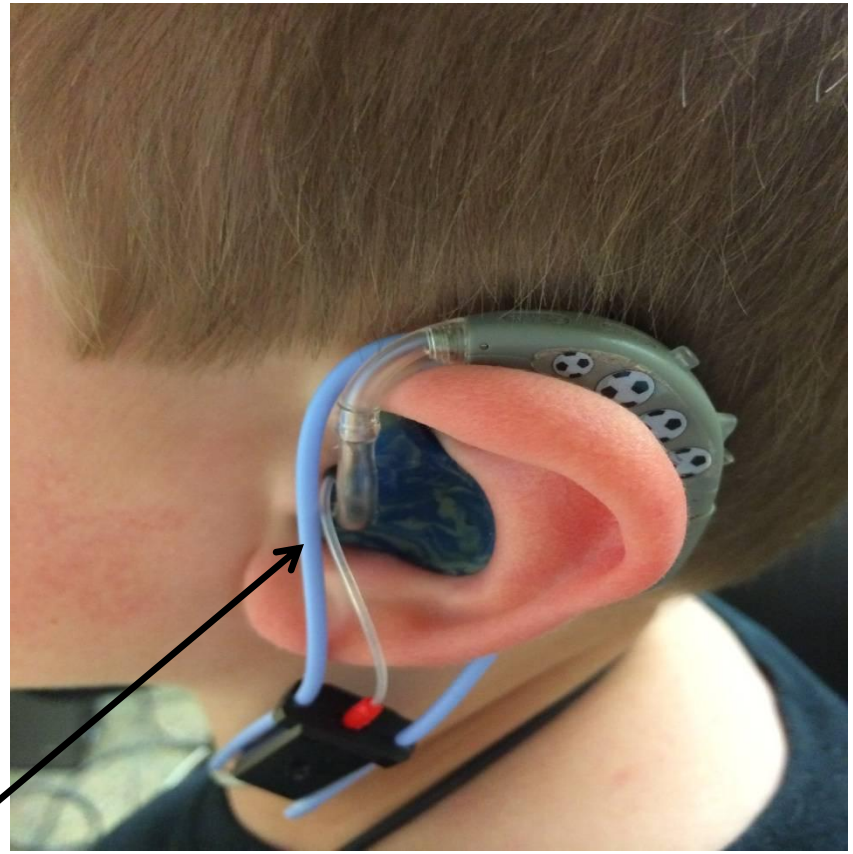
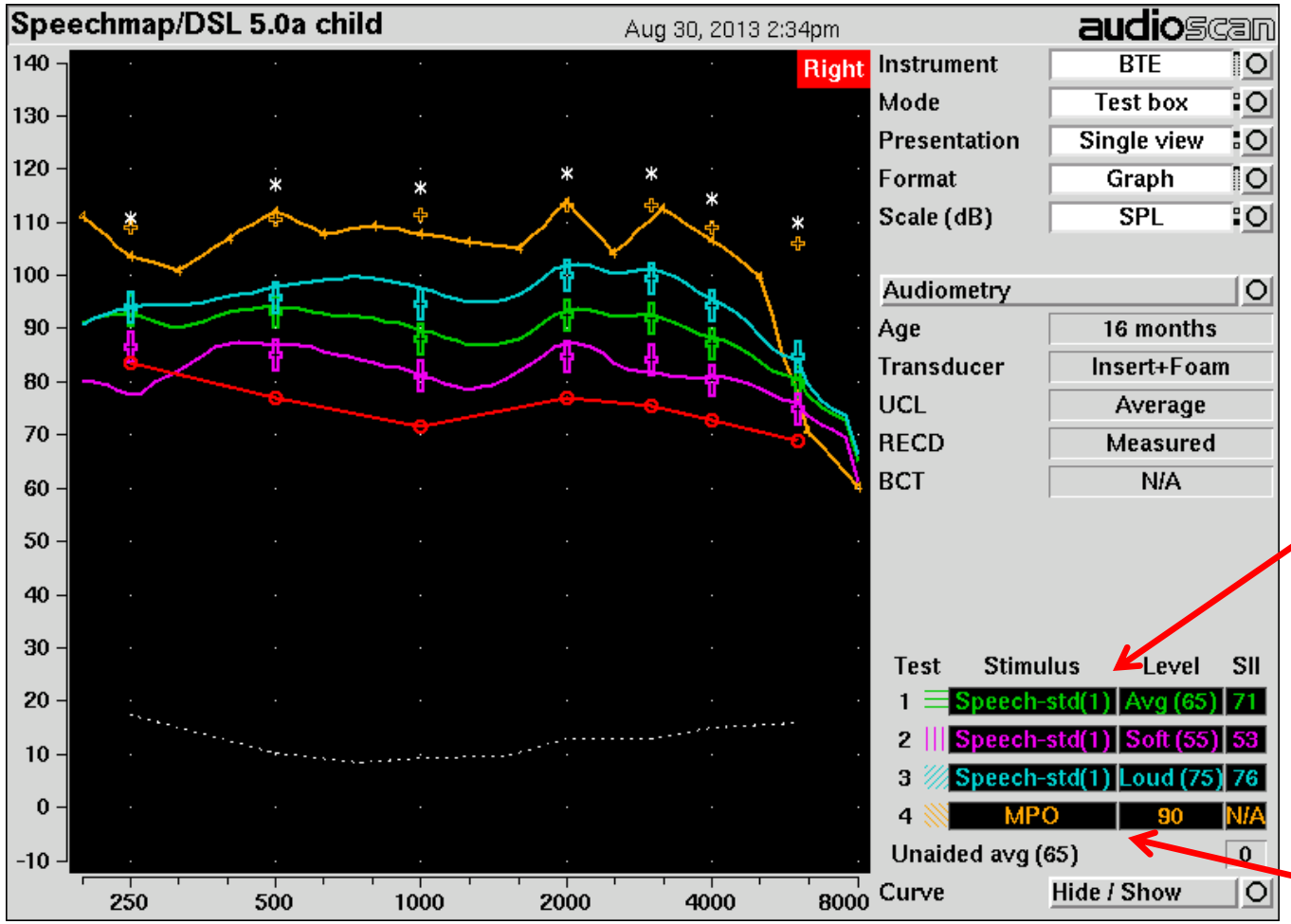
Real Ear Probe Microphone Measurement (In Situ)

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

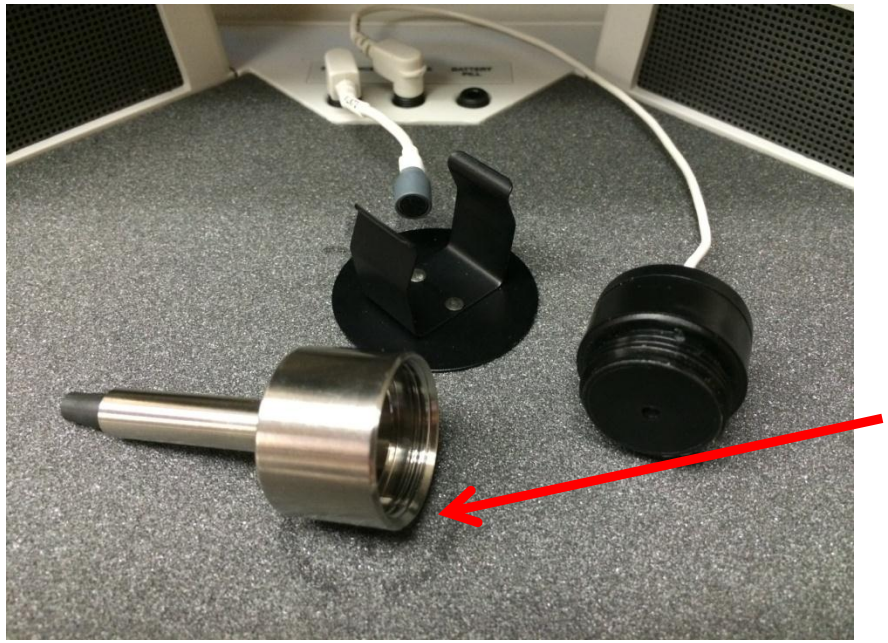
Ensure Comfort & Safety

High-Level Swept Pure Tone

What do I do with wiggly babies?

Simulated Real Ear Probe Microphone Measures (Coupler)

Coupler Measurements in Infant Fittings



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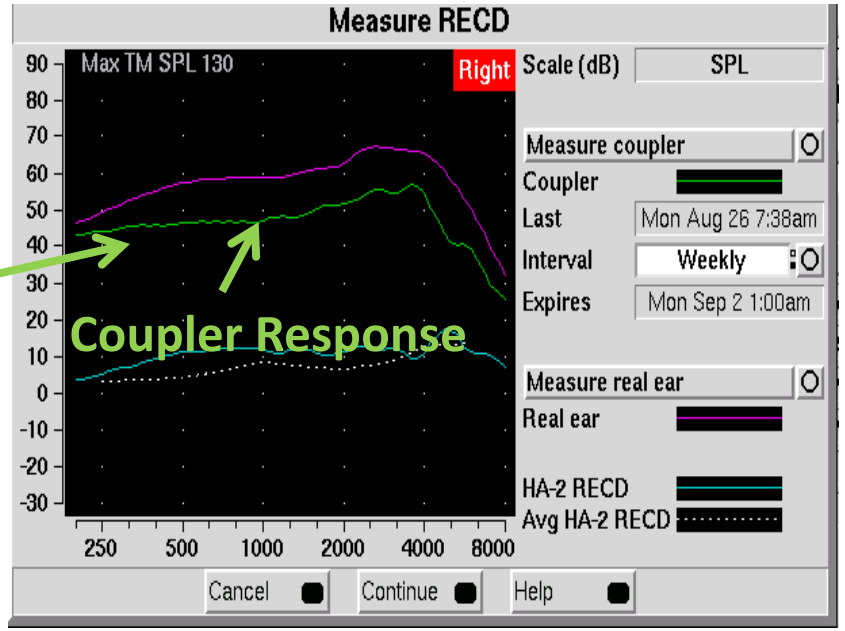
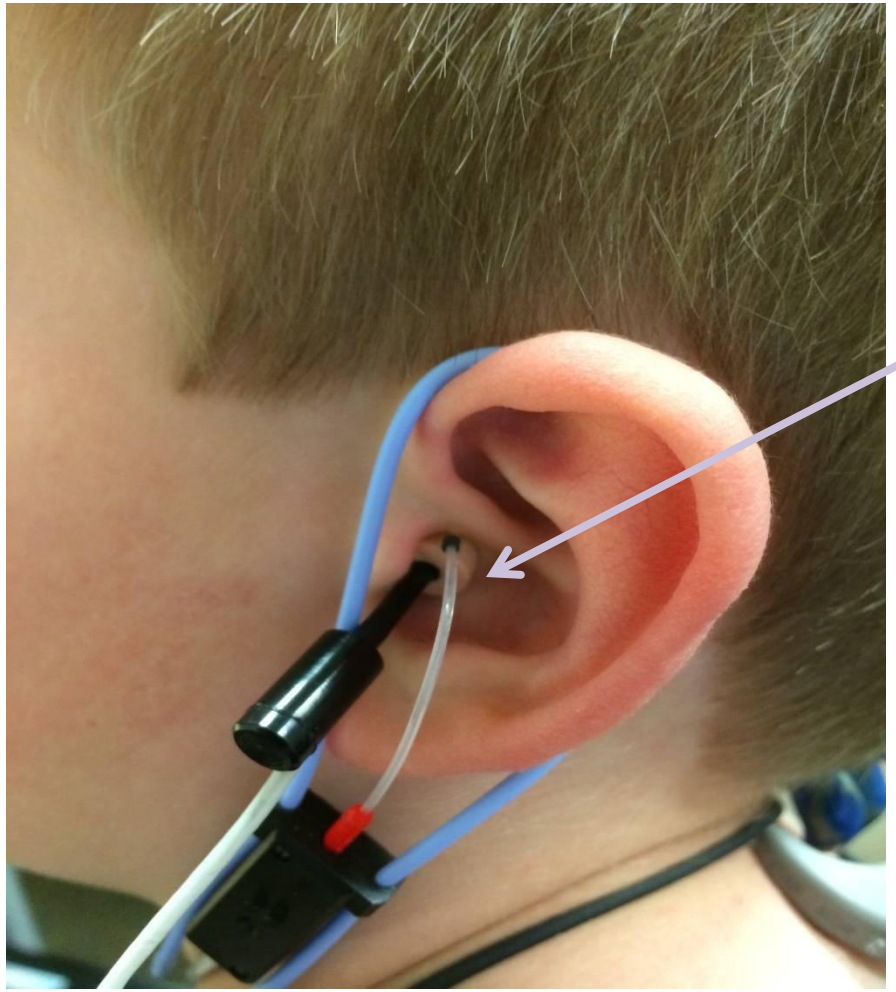
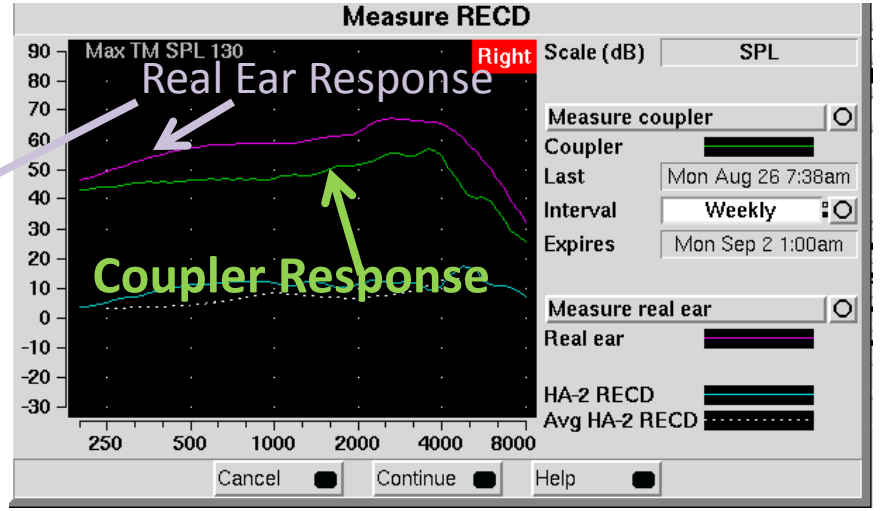
Real-Ear-to-Coupler Difference



Real-Ear-to-Coupler Difference





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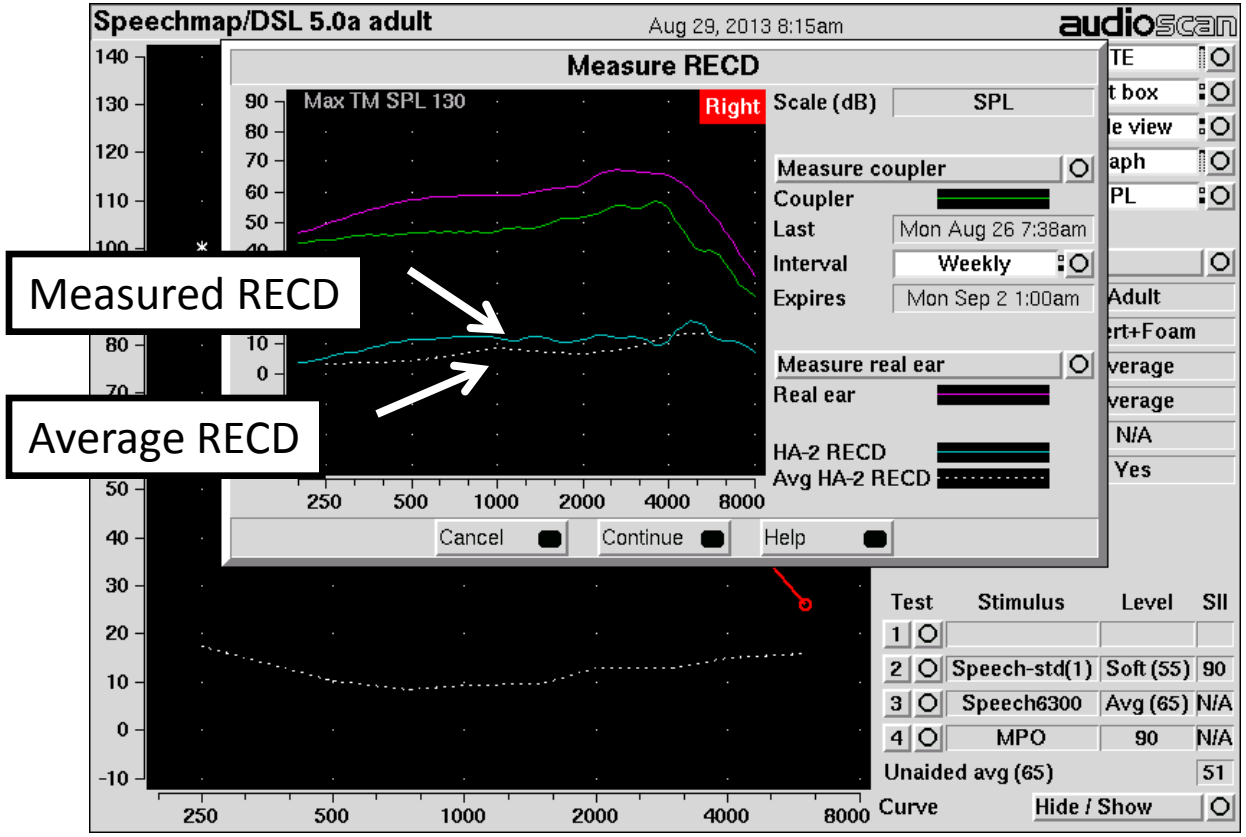
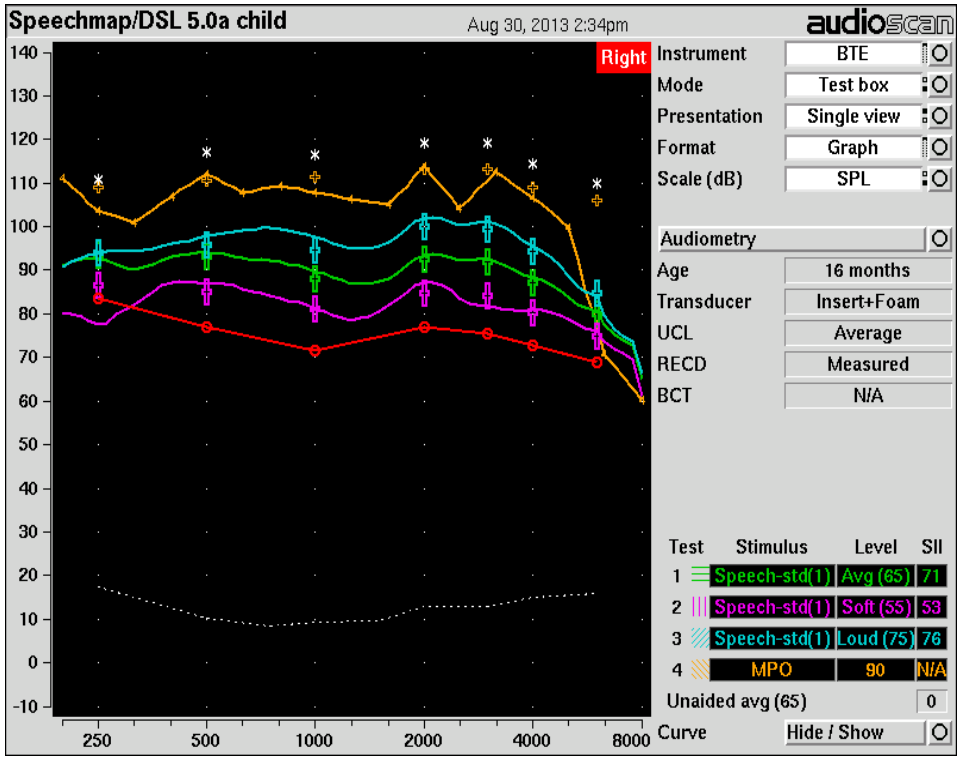
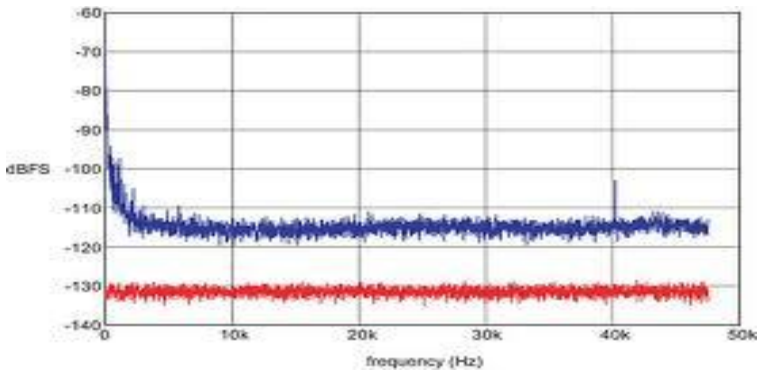


Figure 10: An illustration of an real-ear-to-coupler difference response (RECD) measured from an adult hearing aid wearer. This RECD is higher than the average value (dotted line).

Simulated Real Ear Probe Microphone Assessment



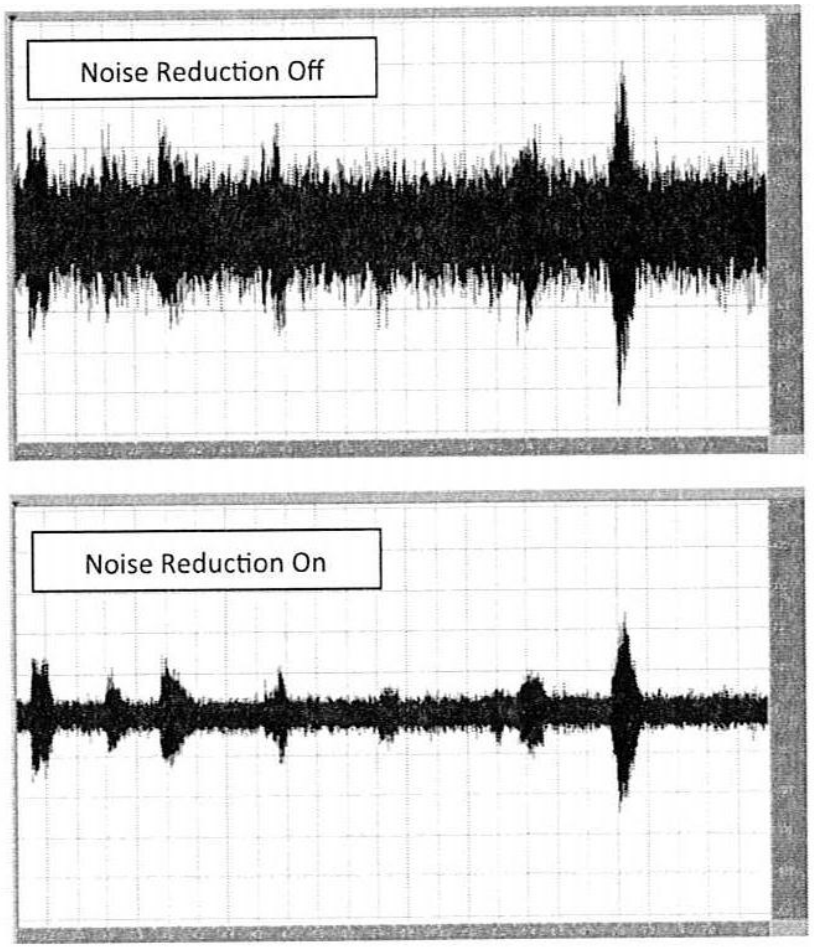
- Hearing Aid Features for Children



DIGITAL NOISE REDUCTION IN CONTEMPORARY HEARING AIDS

Digital Noise Reduction

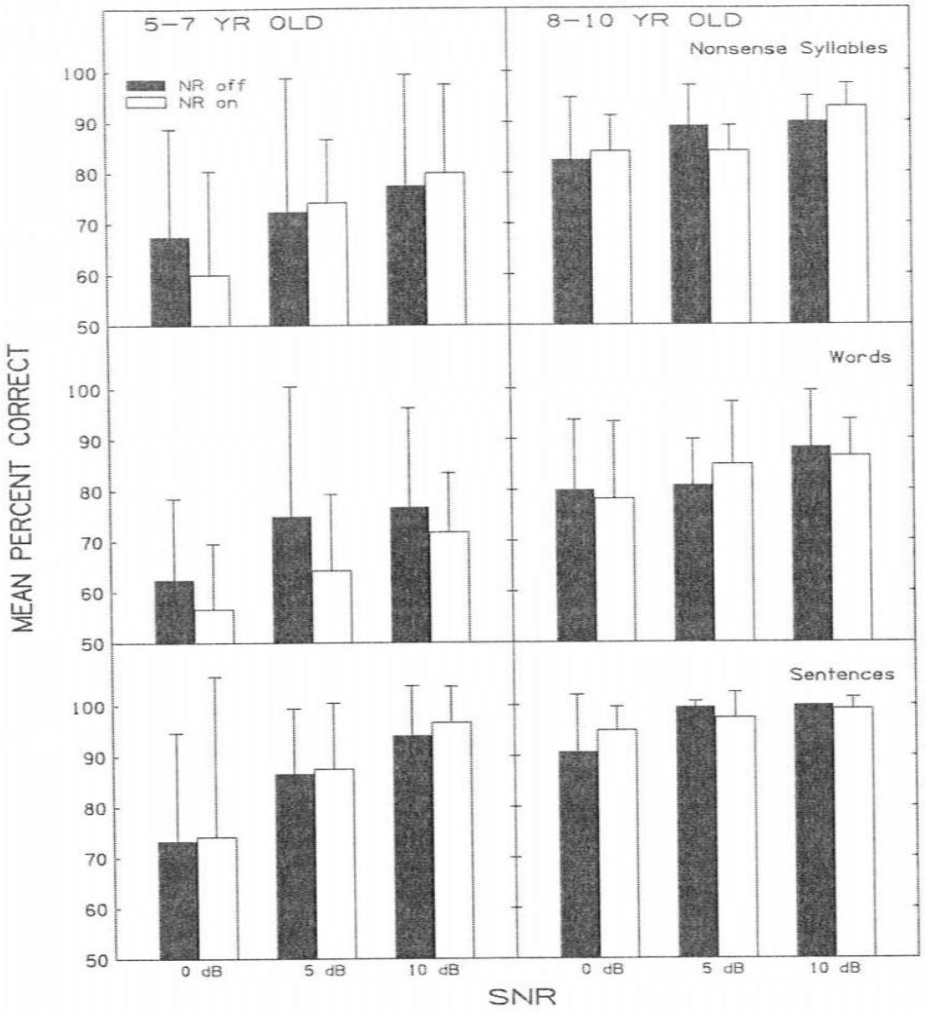
- Classifies the input as either speech or noise
- Reduces gain when the input to the aid is primarily noise
- Wide variety in implementation of DNR across manufacturers
- Studies with adults
  - no change in speech recognition
  - Improvement in noise tolerance, listening ease, comfort, and cognitive load



Stelmachowicz et al., (2010) Ear and Hearing

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

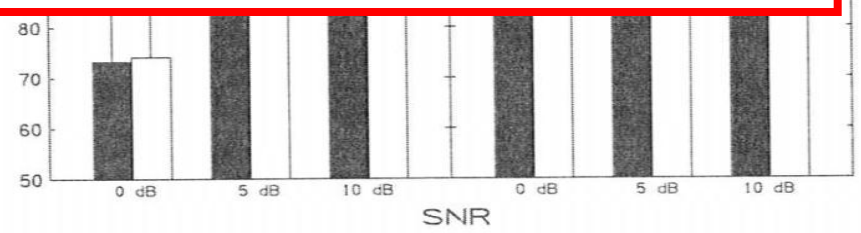
- 16 children with mild to moderately severe HL
  - 8: 5-7 years old
  - 8: 8-10 years old
- Evaluated speech recognition in noise with and without DNR (-6 dB)



Stelmachowicz et al., (2010) Ear and Hearing

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

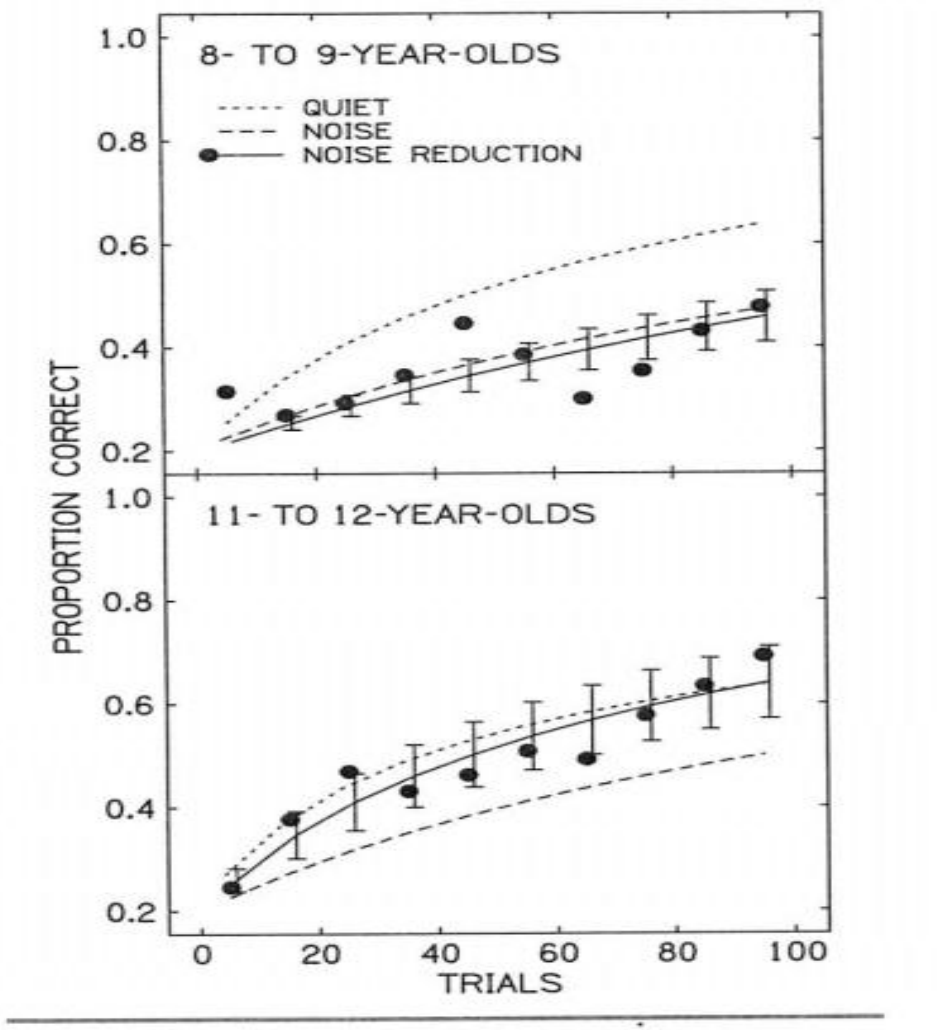
- Other studies examining auditory performance for school-aged children have also shown no degradation in speech recognition in noise with the use of DNR.
- -- Auriemmo et al., (2009), J American Acad Audiology
  --Pittman (2011a), J Speech Language Hearing Research



Pittman (2011) 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?

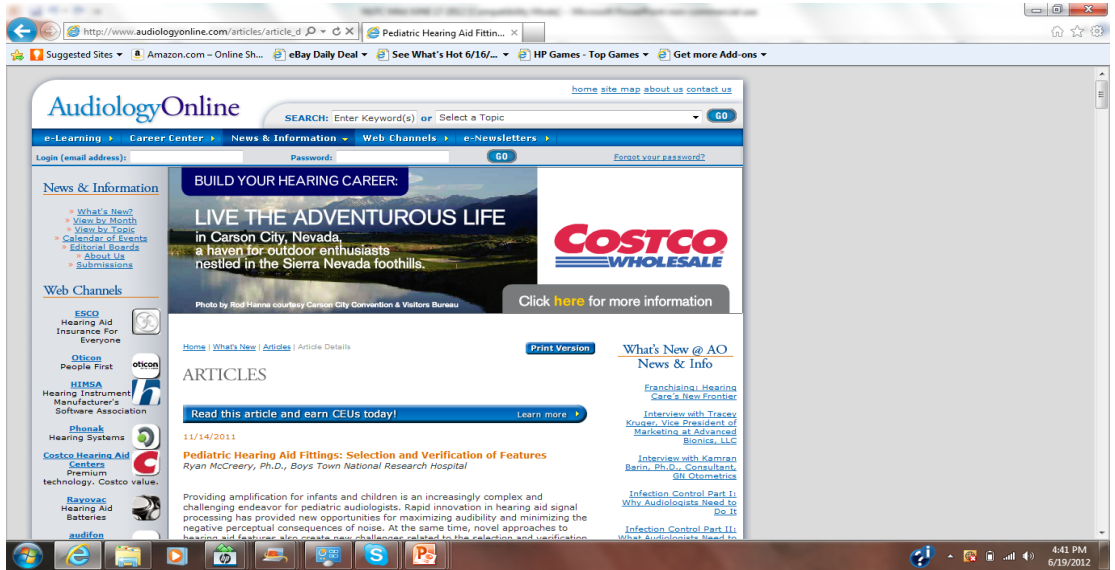
- Maybe

- We must verify that gain will not be reduced when audible speech is present.

Ensuring DNR does not sacrifice audibility

- Inspired by
  - Stelmachowicz et al (2010)

  - McCreery (2011) – AudiologyOnline.com

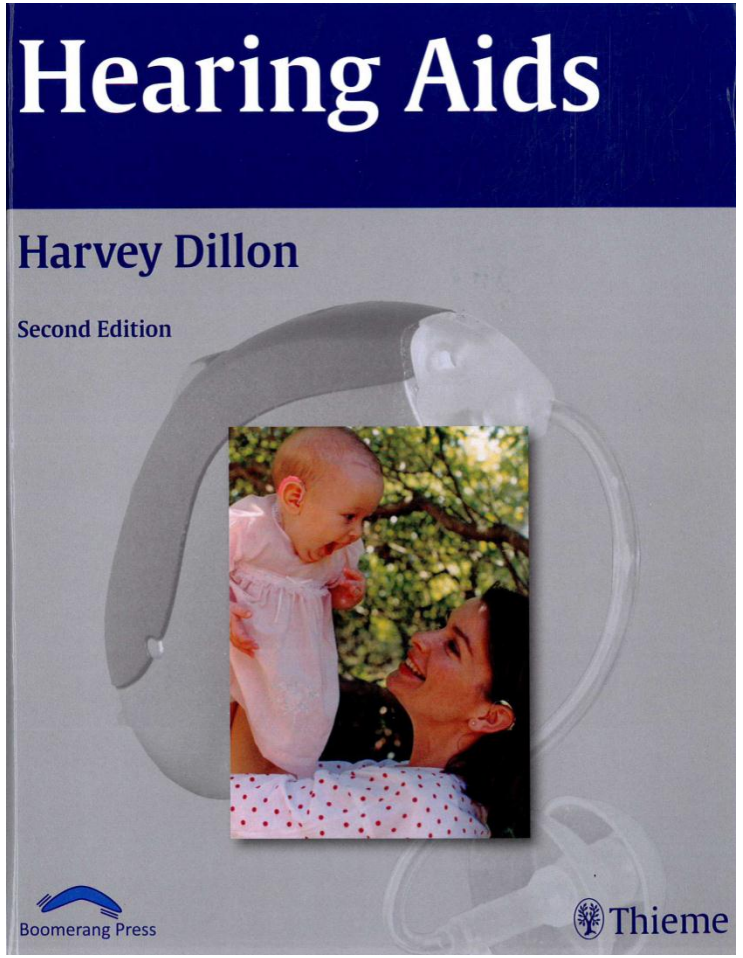


Directional Technology for Children

- 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 expert do condone directional mics for infants



16.4.4 Signal processing features

Each of the features in this section has been covered in detail in Chapters 7 and 8. The following discusses the applicability of these features to infants and young children.

Directional microphones

Switchable directional microphones are probably as useful for older children as they are for adults. Hearing aids permanently in directional mode are as unacceptable for infants and young children as

or child for the other mode to be optimal.

While simply never using directional microphones for infants might at first seem like an appropriately cautious approach, this solution means that the only feature in modern hearing aids that significantly improves SNR in noisy places would be unavailable to those who most need it - young children. As reviewed in Section 16.4.1, young children need a higher SNR than adults if speech is to be intelligible. Like adults, infants and young children will have the greatest difficulty understanding speech when it is partially masked by noise, so it is worth finding a way for them to gain the benefit of directional microphones if at all possible.

The change to the signal caused by directional microphones is a linear, low-distortion effect, similar to just changing the noise level. Thus, the magnitude of the benefit (or disadvantage) in decibels of SNR change and the impact of the environment on benefit should be no different for infants and young children than that experienced by older children or adults, as reviewed in Section 7.3, and as directly observed in children.[645] It's just that younger children, who are still learning language, more often than anyone else *need* the SNR to be improved.

It is important to understand that current directional microphones are not all *that* directional, particularly indoors where reverberation limits the disadvantages of directional microphones just as much as it limits their advantages. That is, just as directional microphones typically improve SNR by only around 2 to 3 dB when the wearer is looking in the general direction of the talker, they also decrease SNR by only around 2 to 3 dB when the wearer is looking away from the talker. Greater benefits, and presumably disadvantages, are observable if children are tested at close distances in artificial low-reverberation environments, such as test booths.[645]

Measurement of the looking behavior of children

pl[illegible]es, directional microphones on average improved SNR by 2.4 dB when the children looked in the general direction of the talker and decreased SNR by 1.6 dB when they looked away. The overall "net benefit" that a directional microphone could provide can then be calculated by weighting its effect on SNR by the proportion of time it has this effect. The resulting net benefit averaged across listening situations was a 0.02 dB decrease in SNR – a change so small to be of no consequence. Furthermore, the effect of the directional microphone was assessed in the absence of any compression, which as outlined in Section 7.3.3, partly reverses the decrease in signal level caused by a directional microphone when a wanted talker is to the rear or sides.

This nil result suggests that infants and young children should routinely be fit with advanced directional microphones, and they should receive considerable benefit from them, for the following reasons:

- The experimental results were obtained on normal-hearing children, and children with hearing loss wearing omni-directional microphones. It is likely (but by no means proven) that children wearing directional microphones will notice that looking at the talker improves the clarity of the signal and will adapt their behavior to look at the talker more often than children wearing omni-directional microphones. A study of 4 to 17-year old children in the classroom indicated that

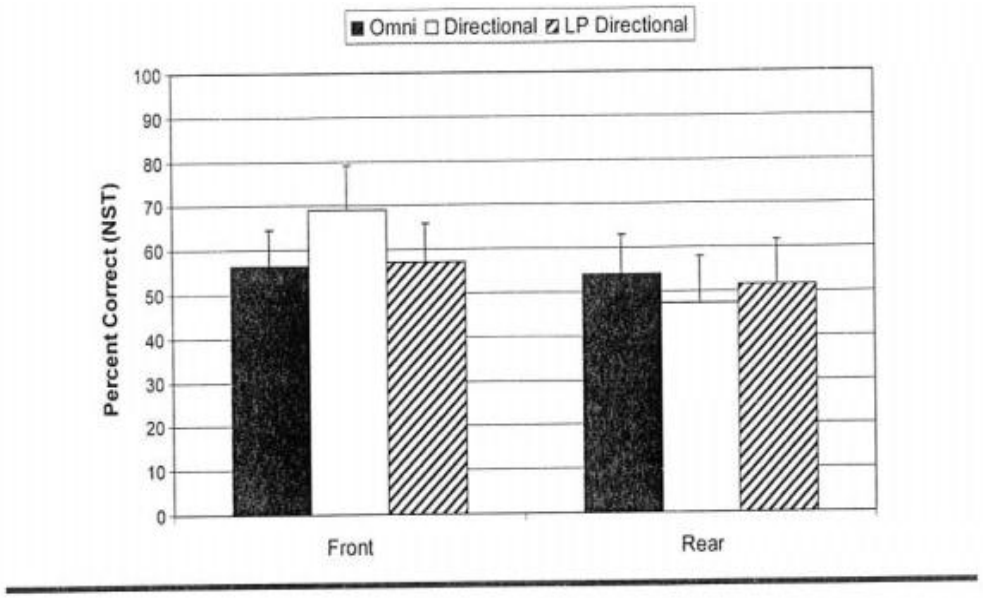
…infants and young children should routinely be fit with advanced directional microphones.

- 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

Directional amplification reduced performance when signal arrived from behind



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

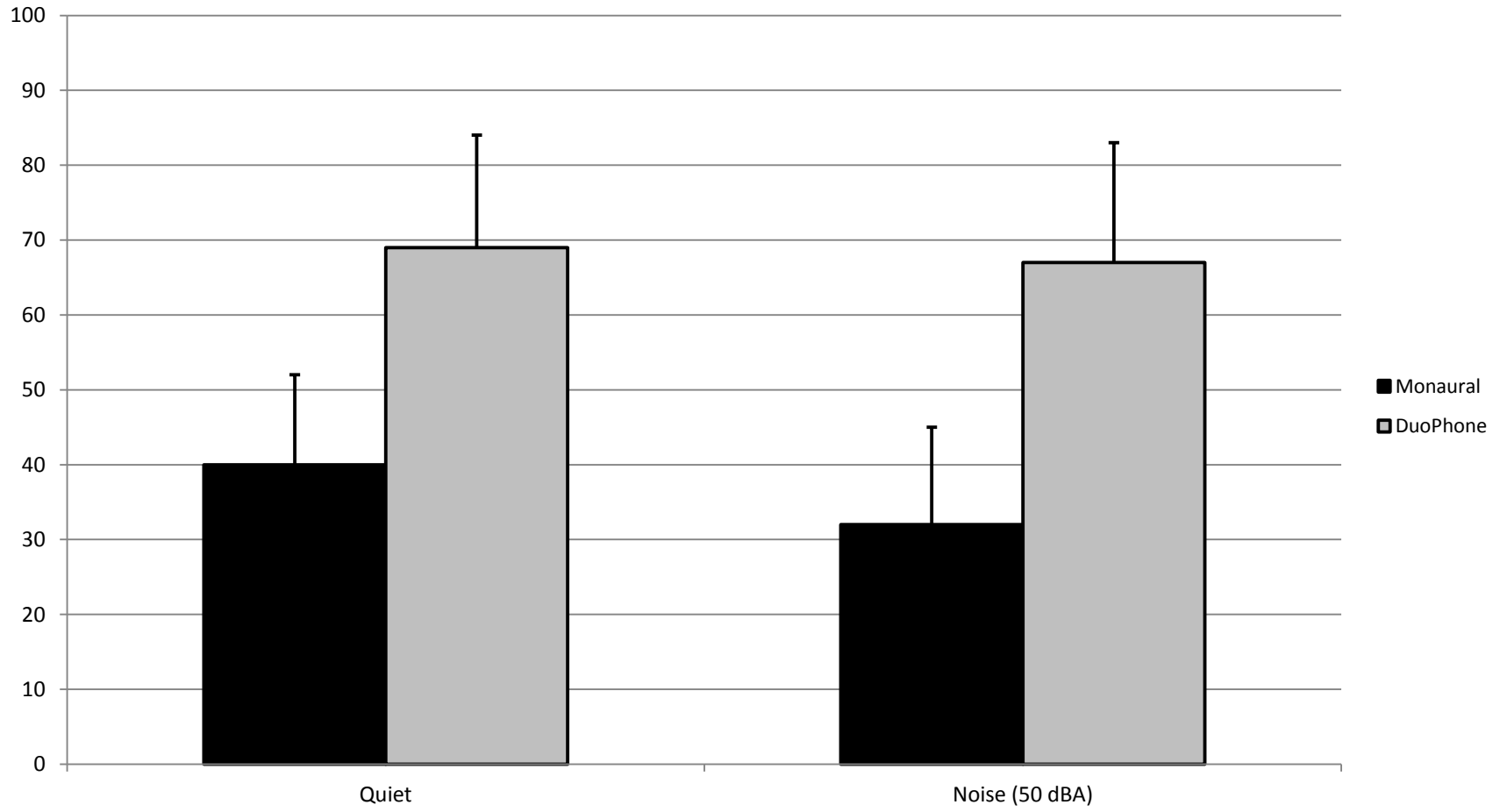
- It allows for binaural listening on the telephone.

- DuoPhone Telephone Study with Children

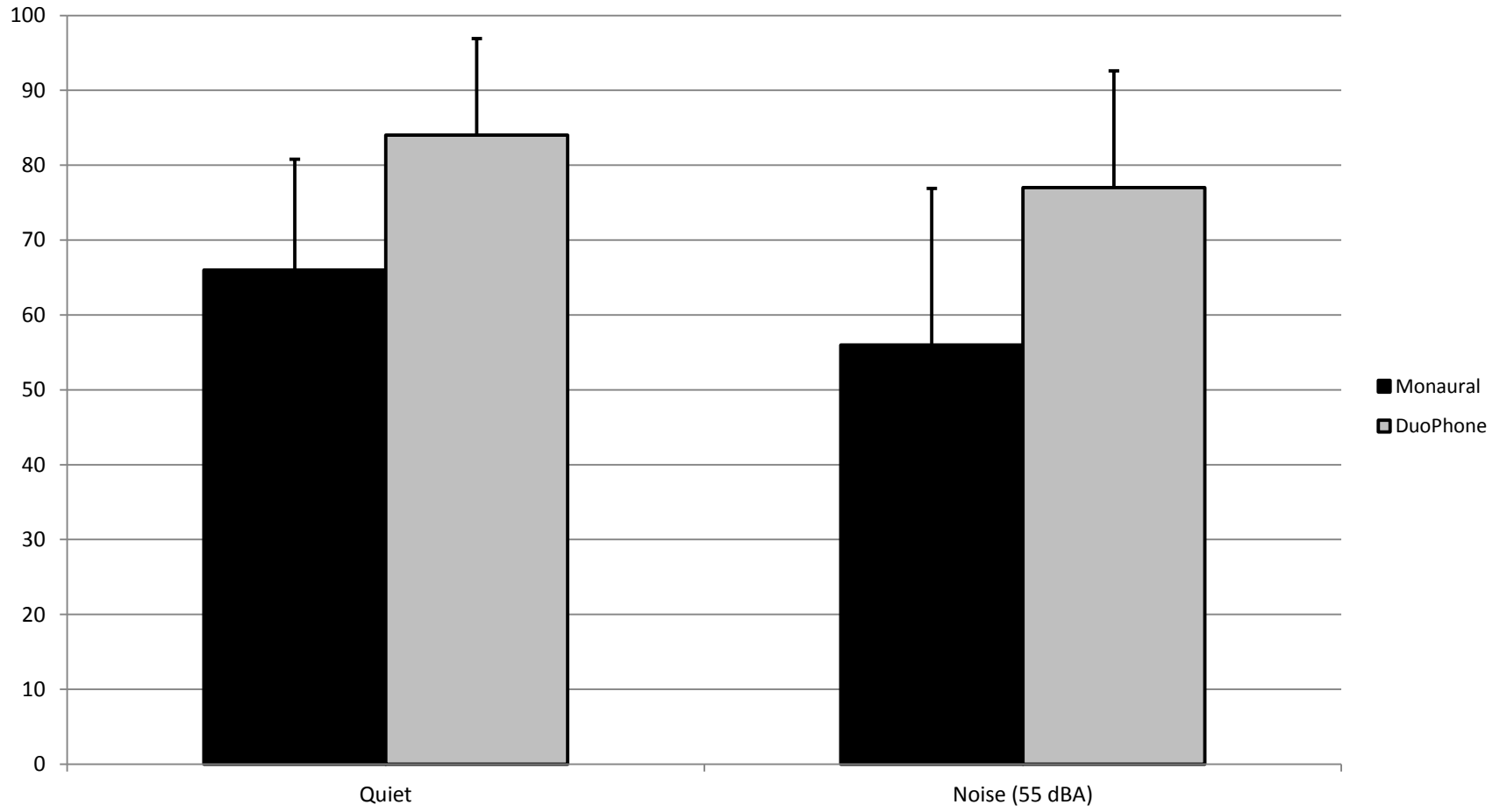
Subjects

- 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)

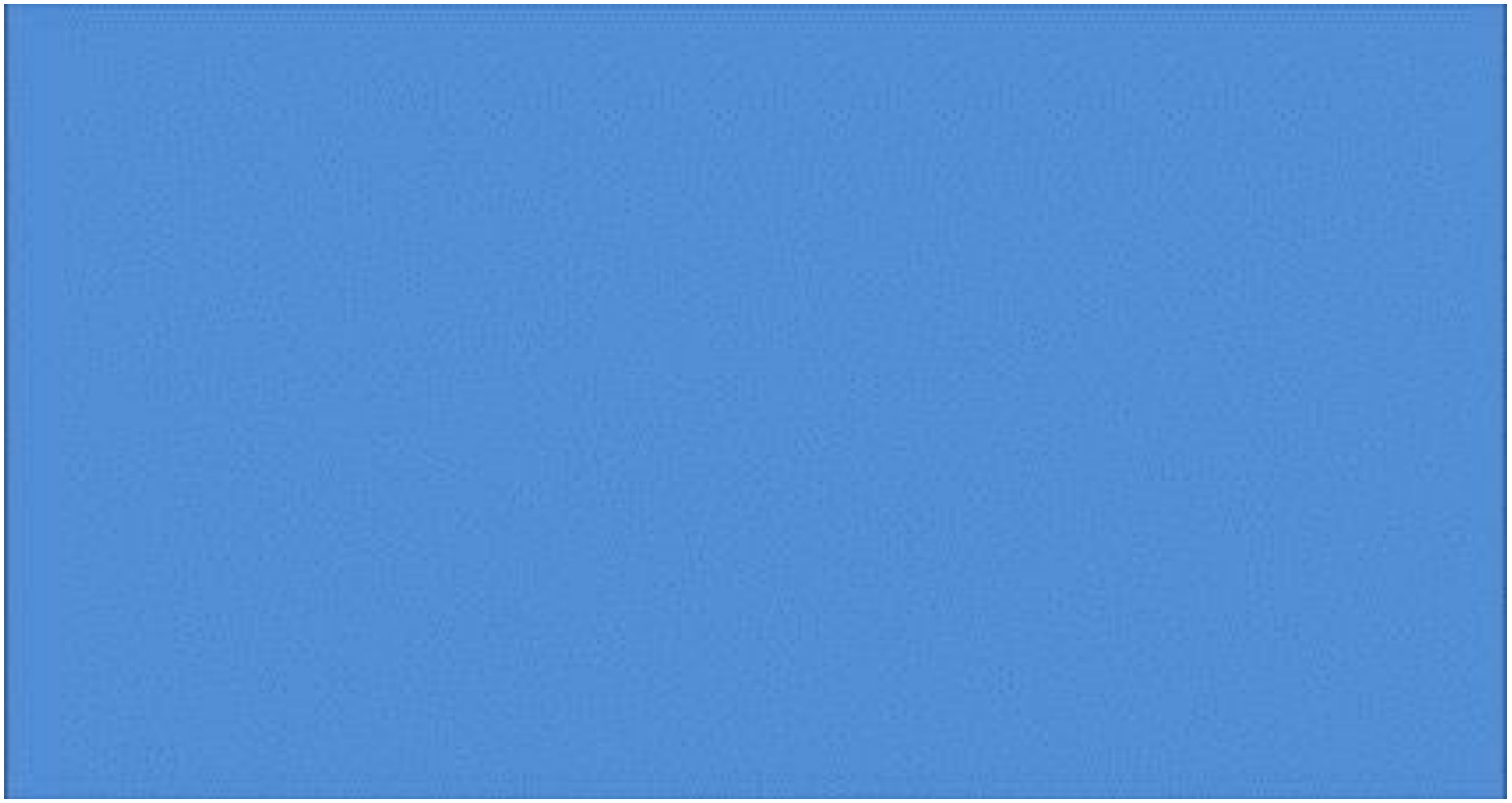
Mean CNC word recognition scores for older children (6-14 years-old)



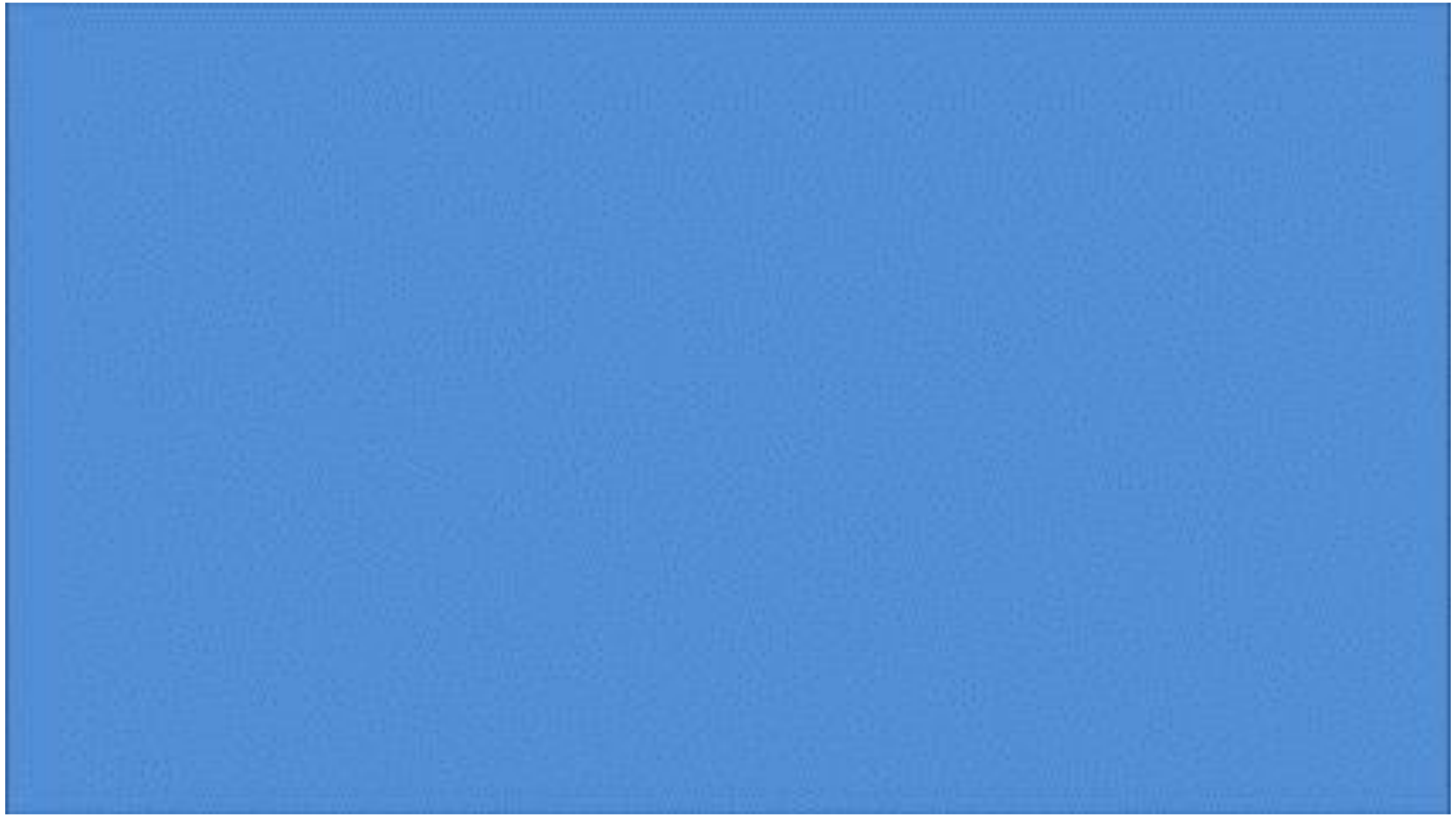
Mean NU-CHIP word recognition scores for younger children (2-5 years-old)



Hailey with Monaural Telephone Use

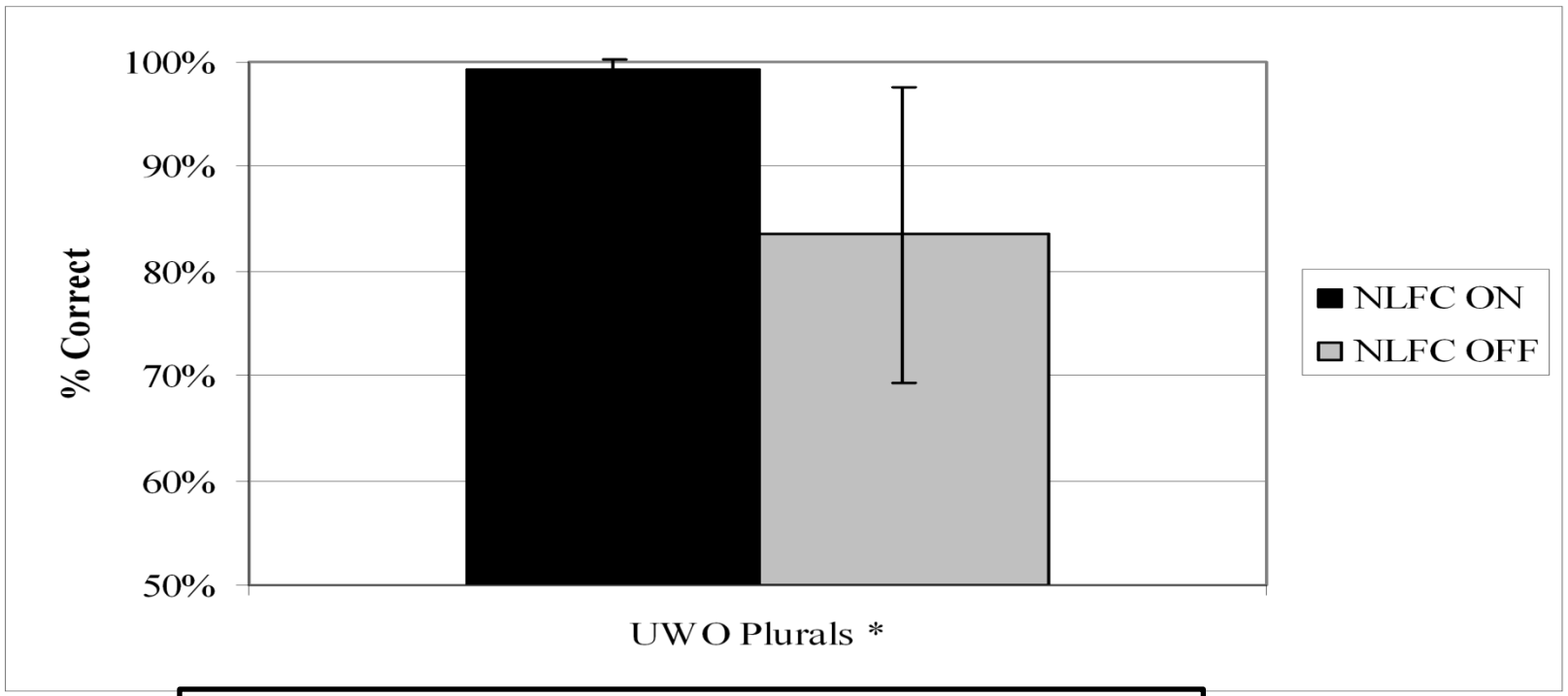


Hailey with the DuoPhone



- What about frequency-lowering technology?

UWO Plural Test
NLFC Off vs. NLFC On



NLFC improves speech recognition on UWO Plural Test by 16% points.

* P < .001

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

- Yes, it works.
- More from Andrea Bohnert!

Thank you for your attention!!!

www.heartsforhearing.org