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Hearing Aid Essentials: Prescriptive Fitting Approaches

Presenter: Erin Picou, AuD, PhD

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

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Hearing Aid Essentials: Prescriptive Fitting Approaches

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MAY 4, 2016

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Disclosures

Financial relationships
- Honorarium for today’s talk
- Industry support for research
  - Including Sivantos, Sonova, GN Resound, Oticon

Non-financial relationships
- None

Bentler, R., Mueller, H.G., & Ricketts, T.A. (2016). Modern Hearing Aids: Verification, Outcome Measures, and Follow-Up. Plural Publishing: Sand Diego, CA.

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To be clear

This course is designed for someone just starting out or someone who needs a basic refresher

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Agenda

Motivation

History

Amplitude compression

Current prescriptions

Case studies

Summary & conclusions

Learner Outcomes

As a result of this webinar, participants will be able to:

1) Briefly describe the history of hearing aid prescriptions

2) Compare and contrast two current, popular prescriptive methods

3) Explain how to estimate approximate appropriate gain based on a patient's hearing threshold

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Why do you need a prescription?

To assist with hearing aid selection

To provide a target for verification

To provide a starting point for setting gain / output

To get the best hearing aid fitting

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Defining the "best" fit

What makes it "best"…

- Highest audibility?
- Highest speech recognition score?
- Maximizing comfort?
- Providing good sound quality?
- Best user acceptance?

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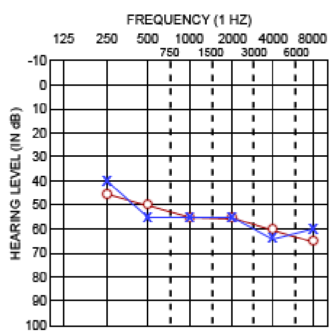
Case study

Mr. O'Dears came into your clinic complaining that his wife mumbles and he can't hear his business deals – he is anxious for help



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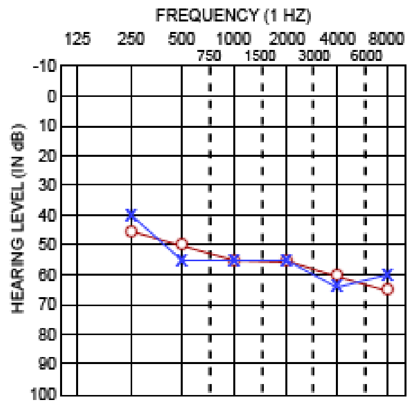
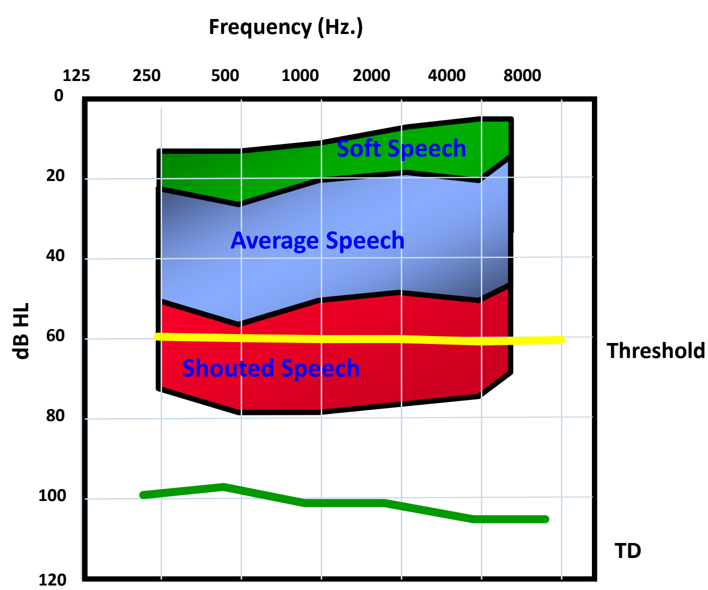
Case study

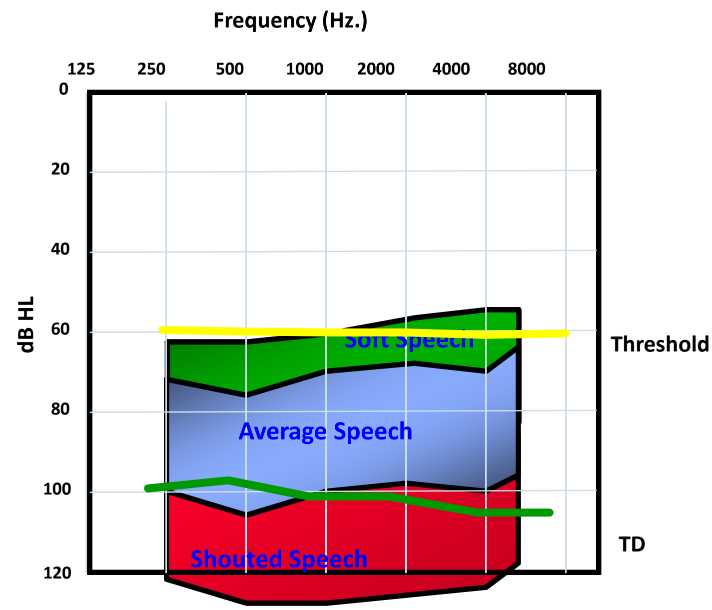
You chose an instrument with 49 dB HFA reference test gain – is that appropriate for this patient?

You verify 50 dB insertion gain – is that a reasonable starting point for this patient?

How much gain is enough?







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History

1930s – 1940s

- Harvard Report
  - Patient-specific information might not be that critical
  - Relatively flat frequency response with +6dB / octave upward slope
- Lybarger
  - 1/2 gain rule
  - Amplify average inputs so they were near most comfortable level
  - Evolved to be frequency specific
    - 1/2 gain for frequencies over 1000 Hz
    - 1/3 gain for 500 Hz

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History

1940s – 1970s

- Carhart method
  - Extensive 12-step protocol for selecting amplification
  - 3-4 hearing aids pre-selected
  - Comparative testing with speech testing
  - Fitting goals (Carhart 1976)
    - To restore to the user an adequate sensitivity for the levels of speech and of other environmental sounds he finds too faint to hear unaided
    - To restore, retain or make acquirable the clarity (intelligibility and recognizability) of speech and other special sounds occurring in ordinary, relativity quiet environments
    - To achieve the same potential insofar as possible when these same sounds occur in noisier environments
    - To keep the higher intensity sounds that reach the hearing aid from being amplified to intolerable levels

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History

1970s

Comparison procedures fell out of favor

- Prescriptive methods become more popular
  - Pascoe (1975)
    - applied gain so speech reached average MCL
  - Shapiro (1976)
    - defined gain based on measured MCL at 0.5, 1, 2, 3, and 4k Hz
    - tested speech discrimination to ensure goodness of fit

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History

1980's

- Berger (1976 & 1984)
  - first to consider frequency-specific gain and also maximum output
  - corrections for bilateral fitting and also style
  - procedure verifying gain via soundfield thresholds
- Prescription of Gain and Output (POGO; McCandless & Lyregaard, 1983)
  - objective was to develop a simple, practice method
  - based on preferences of previous hearing aid users
  - similar to ½ gain rule with less gain at 250 and 500 Hz

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History

Since 1980s

- Prescriptive methods proliferate
- Multi-channel hearing aids
- Probe microphone technologies for verification

http://www.besthearingaidguide.com/h_history.html

National Acoustic Laboratories

Byrne and Tonisson method (1976)
- Developed around the same time as Berger and POGO
- Goal to amplify speech so it is equally loud across all frequencies
- Goal to maintain comfort
- 4.6 dB of gain for every 10 dB of hearing loss
- Corrections for long term speech shape and equal loudness

NAL-R (Byrne & Dillon, 1986)
- Equal loudness across frequencies
- Modification for sloping hearing loss
- Validated by comparing with alternative responses

NAL-RP (Byrne, Parkinson, & Newall, 1990)
- Modification for severe-to-profound hearing losses
- Additional gain for hearing loss above 60 dB HL

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University of Western Ontario

Desired Sensation Level (Seewald et al, 1985)
- Developed to be systematic, science-based approach
- Considers factors unique to infants and children
- Goal to ensure audibility
  - Speech amplified to a certain sensation level
  - Support auditory learning via audibility of speech cues
  - Limit maximum output, but provide headroom
  - Maintain comfort

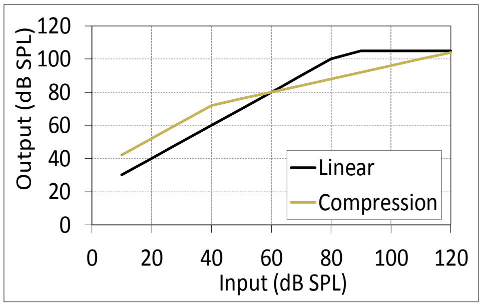
Non-linear Amplification

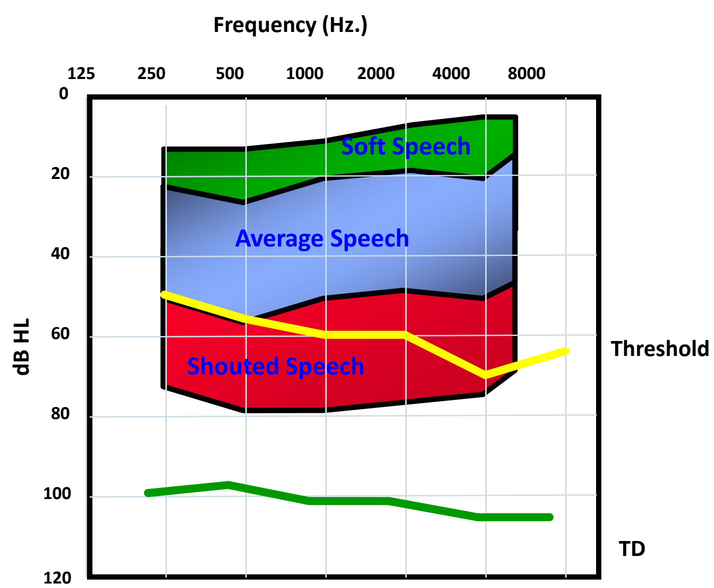
Prescriptions until now have been linear

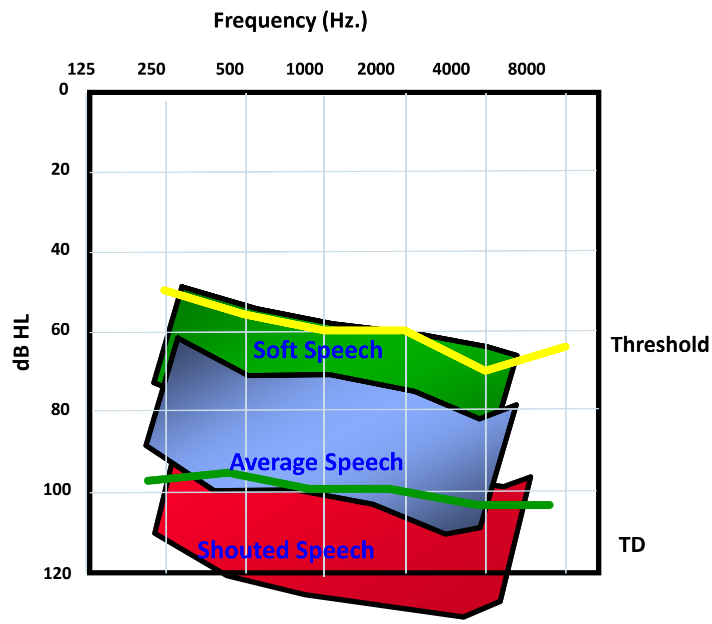
- Gain is independent of input level

Wide dynamic range compression

- Non-linear amplification
- Gain depends on input level
- More gain for soft sounds
- Less gain for loud sounds







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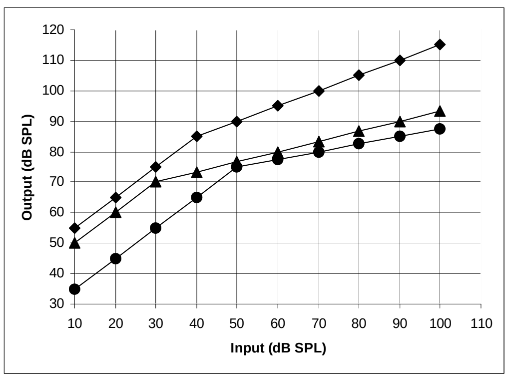
Non-linear terminology

Compression threshold (kneepoint) – threshold of activation

Compression ratio – amount of gain reduction above kneepoint



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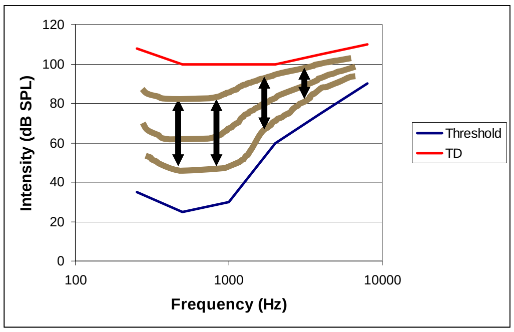
Non-linear terminology

Channel – range of frequencies created with digital filters

Band – range of frequencies controlled by a handle in programming software



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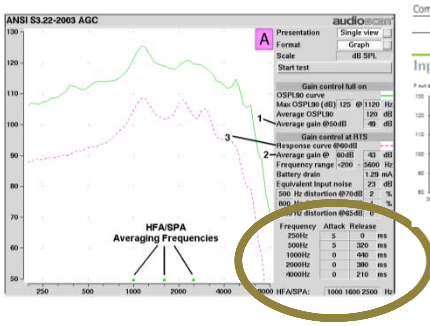
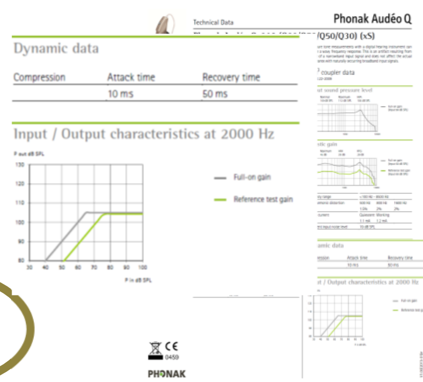
Non-linear terminology

Attack and release times – speed of gain change with change in input level





Early nonlinear prescriptions

Visual Input / Output Locator Algorithm (VIOLA; Cox et al, 1994)

- Based on loudness normalization
- Use Contour Test to estimate loudness growth
- Provided only 2cc targets

FIG6 (Killion, 1994)

- Based on loudness normalization of preferred dynamic range
- Used average loudness growth data

Ricketts and Bentler Method (Ricketts, 1996)

- Based on NAL-RP
- Prescribed compression based on loudness contours

Early nonlinear prescriptions

NAL-NL1 (Dillon, 1999)

- Goal to maximize speech intelligibility
- Goal to maintain overall loudness no greater than "normal"
- Similar to NAL-RP for moderate inputs

DSL [i/o] (Cornelisse, 1995)

- Goal to maximize audibility
- Compression based on listener's residual dynamic range
- Similar DSL for moderate inputs
- Validation studies confirmed appropriateness of targets

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Current prescriptive methods

NAL-NL2 (Keidser et al, 2012)

- Optimize speech intelligibility and comfort
- Overall reduction in loudness relative to NAL-NL1 (~3 dB)
- Findings that informed changes
  - Males prefer slightly more gain
  - Experienced users with moderate/severe loss prefer more gain than new users
  - Higher compression ratios than NAL-NL1
  - Less gain for bilateral fittings
  - Adjustments for tonal languages
  - Children prefer more gain than adults
    - More gain for low inputs
    - Less gain for high inputs
    - Higher compression ratios

Children versus adults

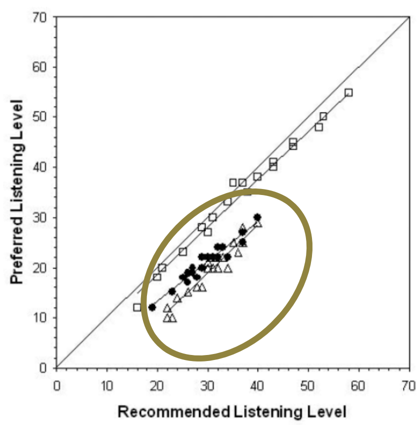

Figure 7. Recommended vs preferred listening levels (measured in 2-cc coupler gain at 2000 Hz) for three groups of subjects: children (□), new adult hearing instrument users (Δ), and experienced adult hearing instrument users (●). Regression lines (see text for details) are shown for each subject group, along with a diagonal line at target listening levels.

Scollie et al (2005)

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Current prescriptive methods

DSL v. 5 (Scollie et al, 2005; Bagatto et al, 2005)

- Family of targets based on type of fitting
- Targets vary as a function of age
- Considerations for pediatric fittings
  - ABR threshold estimates (nHL)
  - Updated RECD normative data
  - Infant-friendly RECD measurements
  - Targets for quiet and noise
  - Adjustments for conductive losses
  - Adjustments for bilateral fittings

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Comparing current methods

Gender

- DSL v 5.0:
  - no adjustment
- NAL-NL2:
  - 1 dB gain increase for males
  - 2 dB gain decrease for females

Comparing current methods

Bilateral fittings

- DSL v 5.0:
  - Targets for speech reduced by 3 dB for all inputs for bilateral fitting
- NAL-NL2:
  - Correction increases with level
  - Smaller corrections for asymmetrical losses
  - 2dB reduction for low levels
  - 6 dB reduction for high level inputs

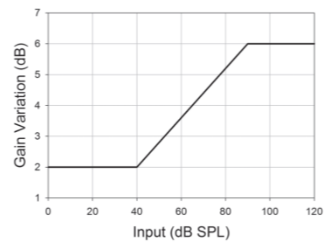

Figure 4–10. Adjustments to default NAL-NL2 prescribed gain derivations based on the binaural fitting of hearing aids. The correction for binaural summation is 2 dB at low input levels and up to 6 dB at high input levels for symmetric losses (but less for asymmetric losses).

(Bentler, Mueller, & Ricketts, 2016)

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Comparing current methods

Listening in noise

- DSL v 5.0:
  - Gain reduced by 3 – 5 dB for low-importance frequencies
- NAL-NL2:
  - No corrections

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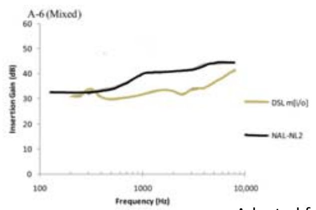
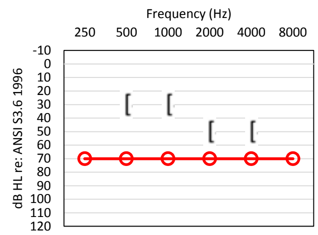
Comparing current methods

Conductive components

- DSL v 5.0:
  - Raises predicted ULC by 25%
  - Small corrections for gain for most audiograms
- NAL-NL2:
  - Prescribed gain for sensorineural component
  - Adds 75% of the air-bone gap





Adapted from Johnson & Dillon (2011)

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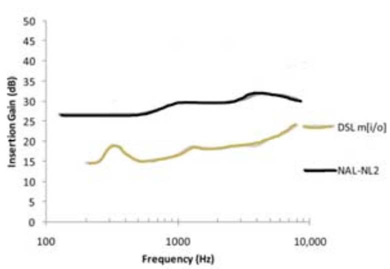
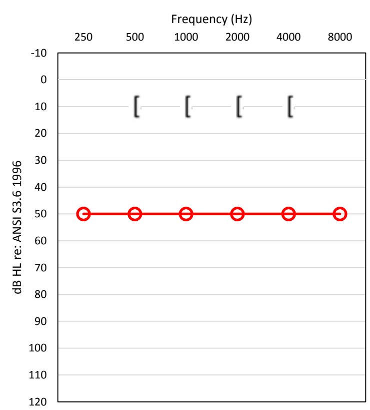
Comparing current methods





Adapted from Johnson & Dillon (2011)

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Comparing current methods

Loudness discomfort

- DSL v 5.0:
  - Will accept patient-specific loudness discomfort measures
  - Alters gain and output prescriptions for high input levels
  - Alters output prescription for low and average input levels
- NAL-NL2:
  - Does not alter its prescription of gain and output

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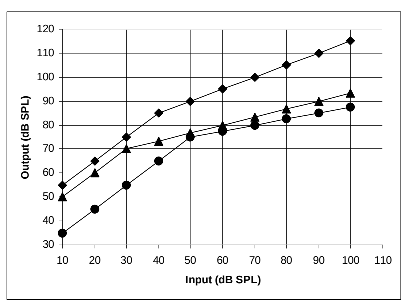
Comparing current methods

Compression parameters

- DSL v 5.0:
  - No prescription for attack / release times
  - No prescription for compression threshold
- NAL-NL2:
  - No prescription for attack / release times
  - No prescription for threshold
  - Higher compression ratios
  - Will account for channel summation



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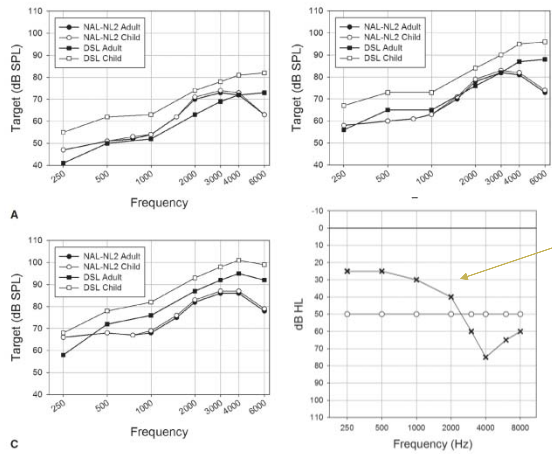
Comparing current methods

Soft speech

Average speech



Sloping loss

Loud speech

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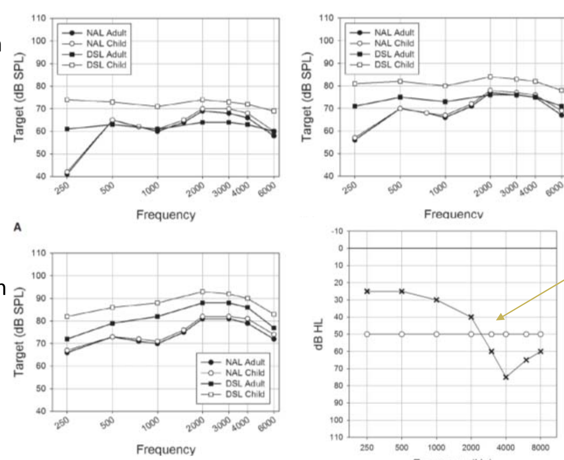
Comparing current methods

Soft speech

Average speech



Flat loss

Loud speech

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Comparing current methods

Loudness

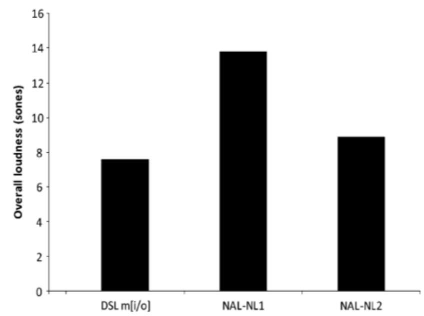

Figure 7. Overall loudness of each prescriptive method averaged across the five sensorineural hearing losses (A-1 through A-5) based on a 65 dB international long-term average speech spectrum input in quiet.

Comparing current methods

Speech Intelligibility

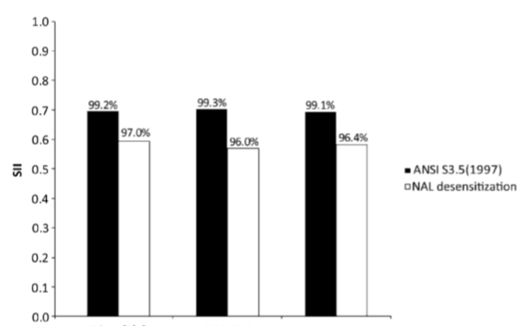

Figure 8. Average Speech Intelligibility Index (SII) value for speech in quiet across the five sensorineural hearing losses for each prescriptive method using both the ANSI S3.5-1997 and the National Acoustic Laboratories SII methods. Also shown is the SII transformed value into a predicted speech recognition score (% correct) for the Connected Speech Test (Cox et al, 1987) using the transfer function of Humes (2002).

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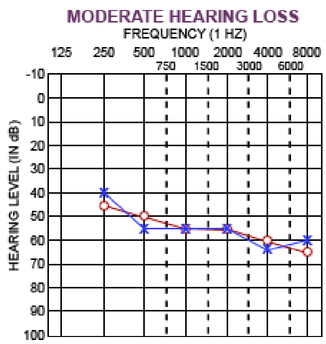
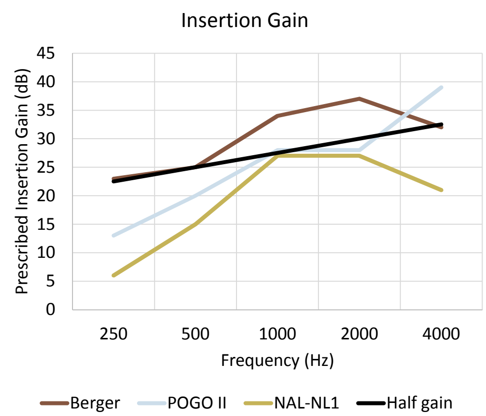
Returning to the case study

How much gain is enough?





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Returning to the case study

How much gain is enough?

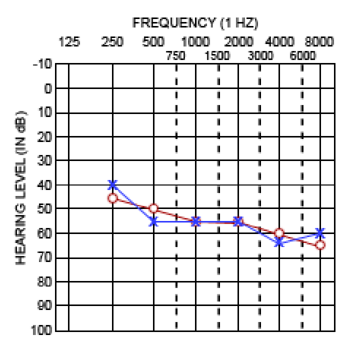
- Somewhere between 20 and 30 dB

You chose an instrument with 49 dB HFA reference test gain – is that appropriate for this patient?

- Probably okay

You verify 50 dB insertion gain – is that a reasonable starting point for this patient?

- Probably too loud



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Returning to the case study

How will you prescribe gain?

- Probably choose NAL-NL2 or DSL v 5.0
- If NAL-NL2
  - Consider entering gender, unilateral/bilateral fitting
- If DSL v 5.0
  - Consider indicating age, quiet/noise programs, unilateral/bilateral fitting

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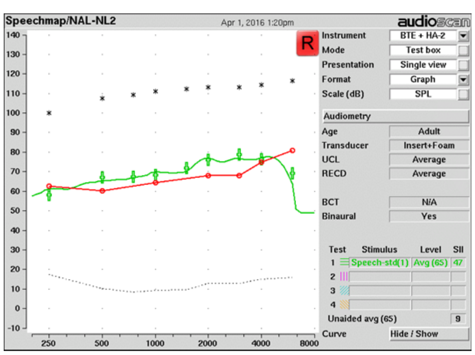
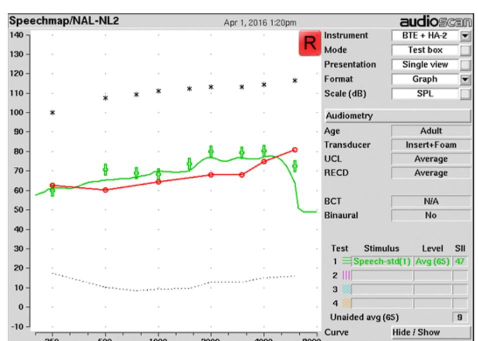
Mr. O'Dears

NAL-NL2 adult bilateral



NAL-NL2 adult unilateral



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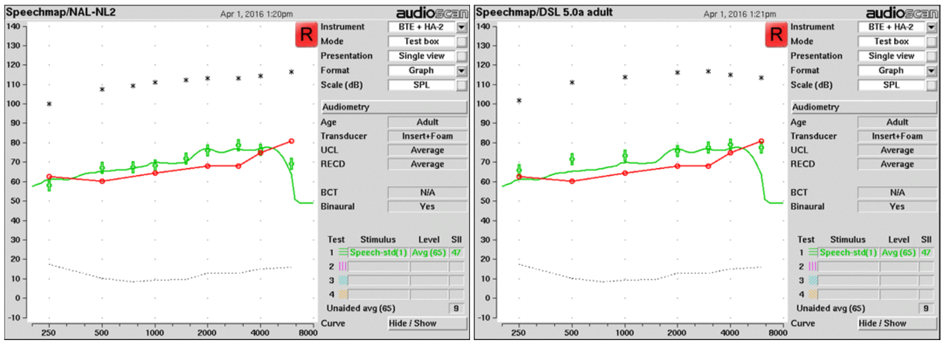
Mr. O'Dears

NAL-NL2 adult bilateral | DSL v 5.0 adult bilateral



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Mr. O'Dears' daughter

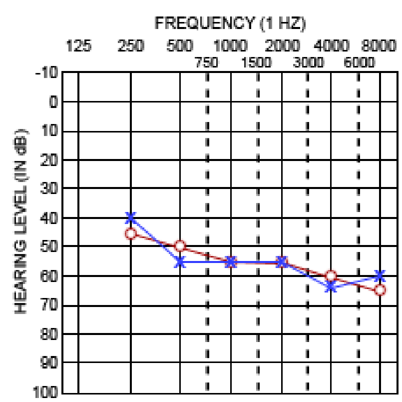
Coincidentally, Mr. O'Dears has a daughter, Leia, with an identical hearing loss – how would her prescription be different?

Patient name: Leia O'Dears

Age: 24 months

Etiology: congenital, but unknown

Middle ear status: normal



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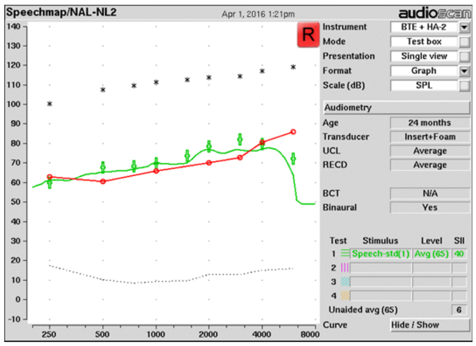
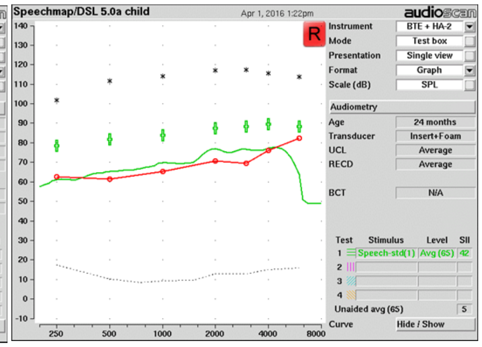
Leia

NAL-NL2 24 month old



DSL v 5.0 24 month old



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Mr. O'Dears' son

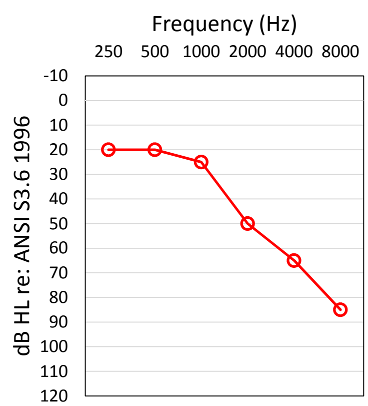
Mr. O'Dears also has a son, Luke, with hearing loss – let's look at some prescriptions with this hearing loss

Patient name: Luke O'Dears

Age: 48 months

Etiology: congenital, but unknown

Middle ear status: normal



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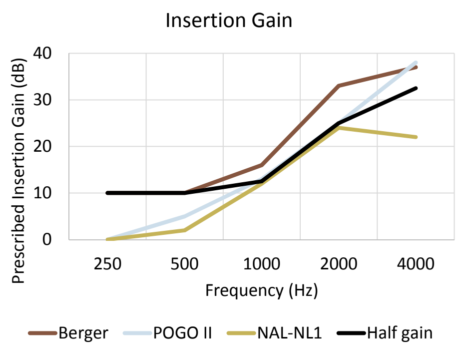
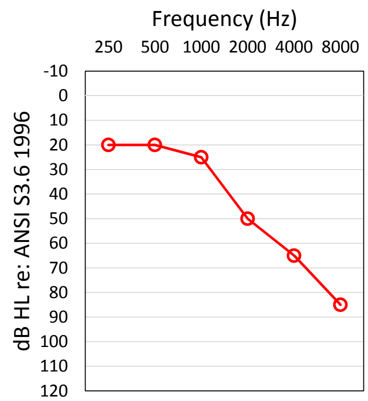
Mr. O'Dears' son





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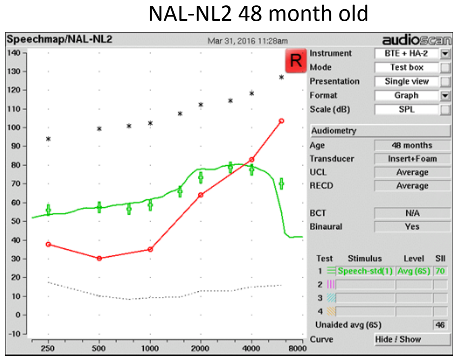
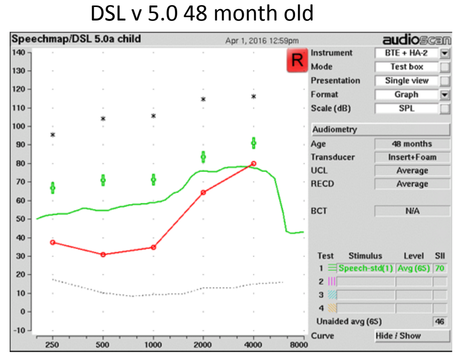
Luke

NAL-NL2 48 month old



DSL v 5.0 48 month old



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Uncle O'Dears

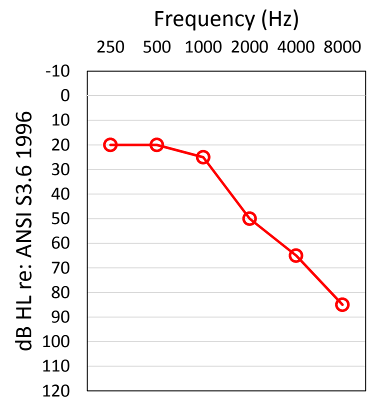
Finally, Mr. O'Dears has a step brother, Owen Lars, who developed hearing loss as a result of exposure to loud farming equipment

Patient name: Owen Lars

Age: 67 years

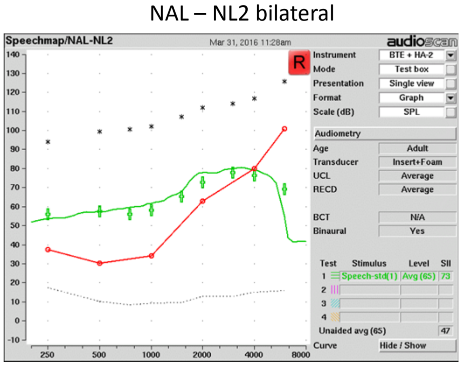
Etiology: noise exposure

Middle ear status: normal

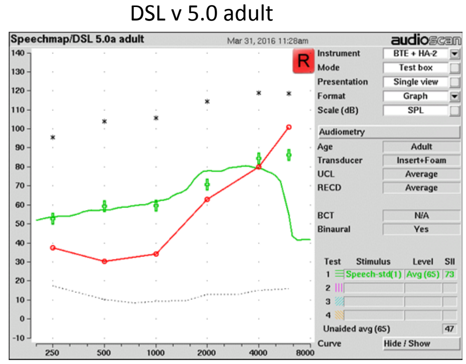


Owen Lars

NAL – NL2 bilateral

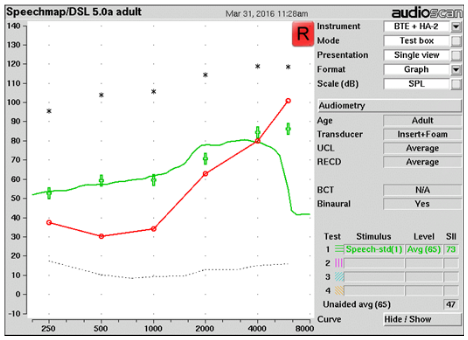


DSL v 5.0 adult

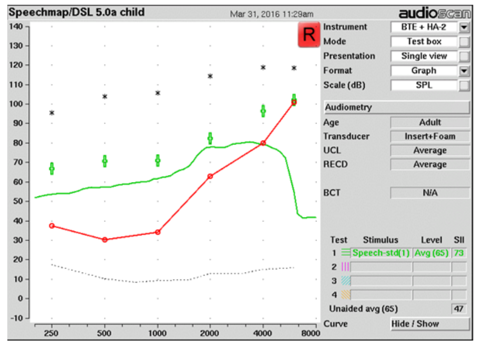


Owen Lars

DSL v 5.0 adult



DSL v 5.0 child – age “adult”



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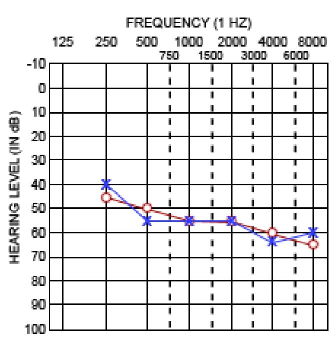
Case study

Mr. O’Dears came into your clinic complaining that his wife mumbles and he can’t hear his business deals – he is anxious for help



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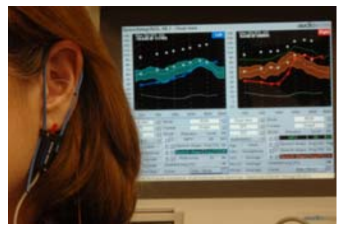
Importance of verification

You haven’t actually used a prescriptive method unless you verify it

Verification methods

- Functional gain
- Probe microphone measures



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Importance of verification

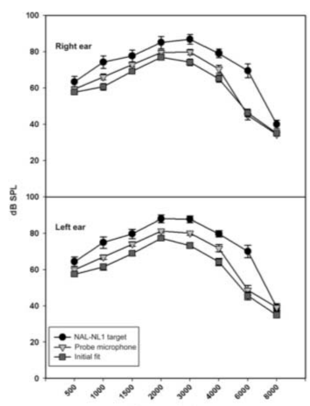

Figure 1. Mean (±2 SE) NAL-NL1 target data (circles), verified prescription REAR (triangles), and initial-fit approach REAR (squares) for the right ear *(top panel)* and left ear *(bottom panel)*.

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Evidence for prescription

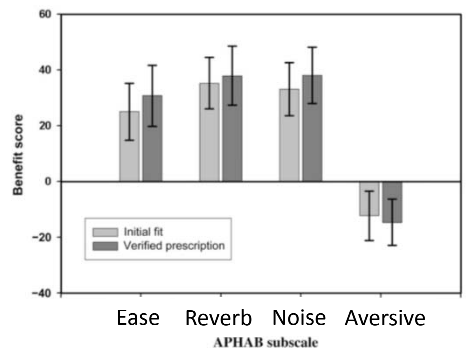

Figure 2. Mean (±2 SE) APHAB benefit scores as a function of type of fitting.

15 of 22 preferred NAL-NL1 response

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Summary & Conclusions

History of prescriptive methods
- ½ gain rule to non-linear prescriptions

Current methods
- NAL-NL2
- DSL v 5.0

Differences between methods
- Largest differences for children (DSL targets are higher)
- NAL-NL2 bilateral less gain

Case studies

Importance of verification
- Verifies use of prescriptive methods
- Can improve hearing aid outcomes

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