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Hearing Aid Essentials: Prescriptive Fitting Approaches

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Hearing Aid Essentials: Prescriptive Fitting Approaches

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MAY 4, 2016

Disclosures

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

Non-financial relationships
◦ None

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

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

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
Defining the “best” fit

What makes it “best”...
- Highest audibility?
- Highest speech recognition score?
- Maximizing comfort?
- Providing good sound quality?
- Best user acceptance?

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
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?
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
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, relatively 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

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
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

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

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

![Graph showing linear and compression amplification]

![Graph showing frequency response of speech levels]

- Soft Speech
- Average Speech
- Shouted Speech

**Threshold**
Non-linear terminology

Compression threshold (kneepoint) – threshold of activation
Compression ratio – amount of gain reduction above kneepoint
Non-linear terminology

Channel – range of frequencies created with digital filters

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

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
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 2cc coupler gain at 2000 Hz) for three groups of subjects: children ( ), new adult hearing instrument users ( ), 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)
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

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
  - 2 dB reduction for low levels
  - 6 dB reduction for high level inputs

(Bentler, Mueller, & Ricketts, 2016)

Comparing current methods

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

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
Comparing current methods

Soft speech

Average speech

Loud speech

Sloping loss

Flat loss
Comparing current methods

Loudness

**Figure 1.** Overall loudness of each prescriptive method averaged across the five unequated hearing losses A through F based on a 75 dB international long-term average speech spectrum input in quiet.

Comparing current methods

Speech Intelligibility

**Figure 2.** Average Speech Intelligibility Index (SI) values for speech in quiet across the five unequated hearing losses for each prescriptive method using both the ANSI S3.5-1997 and the National Acoustics Laboratories-NI method. A-starred in the SI transformed values into a predicted speech recognition score (% correct) for the Universal Speech Test (Fletcher et al., 1969) using the transfer function of Peters (2003).
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
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
Mr. O’Dears

NAL-NL2 adult bilateral

DSL v 5.0 adult bilateral

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
Leia

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
Mr. O’Dears’ son

Luke

NAL-NL2 48 month old

DSL v 5.0 48 month old
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

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
Importance of verification

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

Verification methods
- Functional gain
- Probe microphone measures

Figure 5. Mean ±1 SD NAL-NL1 target data (circles), verified prescription (BEAR, triangles), and initial fit approach (BEAR) (squares) for the right ear (top panel) and left ear (bottom panel).
Evidence for prescription

Summary & Conclusions

History of prescriptive methods
- \( \frac{3}{2} \) 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
References


Prescription References


Prescription References


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