The Devil is in the Fitting Details

Why all NAL (or DSL) targets are not created equal

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August, 2012
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What they share in common…

- Evidence based prescriptions with a host of literature validating them as tools for best practice
- Use of speech-like signals as stimulus of choice
- Differing targets for soft, average, and loud inputs
- Provide a consistent fitting approach regardless of make, model, manufacturer of device

NAL-NL2

- PREMISE: Loudness EQUALIZATION
  - Aims to equalize perception of loudness over a range of frequencies instead of having low frequencies dominate loudness
  - maximizing predicted speech intelligibility while constraining loudness
- EVOLUTION:
  - From LINEAR approach to COMPRESSION approach.
  - From INSERTION-GAIN (tones) to include AIDED Gain (speech) targets
- VALIDATION/EVIDENCE: modifications from NAL-NL1 included patient preference/comfort findings

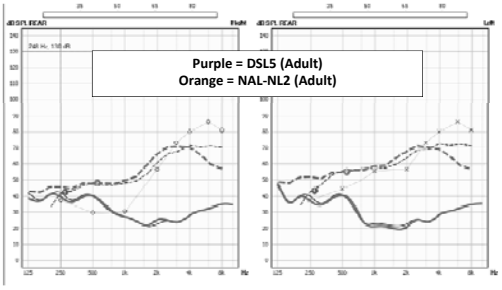
Johnson, E. and Dillon, H., 2011

Desired Sensation Level Multistage Input/Output (DSL m[i/o])- DSL v5.0

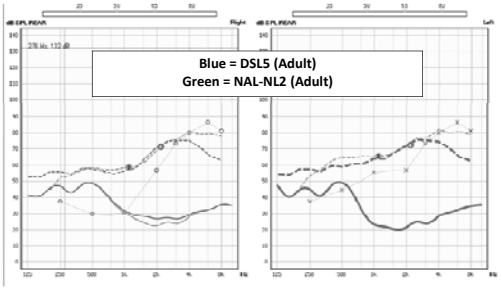
- PREMISE: Loudness NORMALIZATION
  - Aims to restore, at each frequency loudness perception of the hearing impaired listener to that of a normal hearing listener
  - Goals of avoiding loudness discomfort, providing audibility of speech across a wide range of input levels, and accommodating the prescriptive targets for both quiet and noisy environments, as well as for infants versus children versus adults
- EVOLUTION:
  - **From pediatric-focus (earlier versions) to both pediatric and adult versions.**
  - Modifications for 'noise programs' made
  - Correlates with data on Preferred Listening Levels (PLL)

Johnson, E. and Dillon, H., 2011

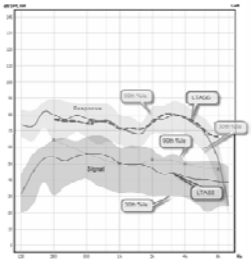
Where are they now? Soft (55dB) input



Where are they now? Average (65) input



Aided Response - Average Speech



INTER-SYSTEM DEVIATIONS

PAGE 10

Whose NAL-NL fitting method are *you* using?

By Todd A. Ricketts and H. Gustav Mueller

There are many factors to consider in selecting hearing aid gain and output for a patient. Do you choose the fitting that maximizes audibility? The fitting that optimizes speech understanding? The fitting that "sounds the best" to the patient? The fitting recommended by the manufacturer?

Using these or other possible "gold

correction factors during the programming and verification process. With infants and young children, it may be necessary to measure the RECD and then use these values to derive estimated real-ear output. With adults, equipment and protocols are available to conduct real-ear verification measures directly.

ABBREVIATIONS

DSL: Desired Sensation Level

NAL-R: National Acoustic Laboratories-Revised

POGO: Prescription of gain and output

REAG: Real-ear aided gain

Ricketts, T.; Mueller H.G. (2009).

Five factors which can affect accuracy of the verification process

- Target adjustments for the hearing aid/fitting type
- Conversions used to display hearing loss and targets in ear canal SPL
- Hearing aid-specific interactions with the measurement signal
- The level and shape of the input signal
- The analysis of the measured signal

Ricketts, T.; Mueller H.G. (2009).

Inter-system deviations

- Compared NAL-NL1 targets for open and occluded fittings across 3 verification systems, using "system defaults."
- Randomly select one of the systems to fit to target and then measure (without adjustments) on the other two systems, and repeated cycle with the other two systems as "baseline."
- Calculated a deviation from NAL-NL1 targets for each system.
- Found results on Verifit and MedRX systems to be similar, but the Fonix system resulted in a desired fitting that was approximately 3-4 dB lower in the low frequencies, and up to 8-10 dB higher in the high frequencies.

Ricketts, T.; Mueller H.G. (2009).

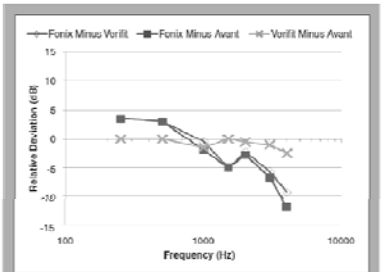


Figure 2. *The average intersystem deviation from NAL-NL1 targets across three probe-microphone systems for one closed fitted instrument. All values were calculated as described in Figure 1.*

Ricketts, T.; Mueller H.G. (2009).

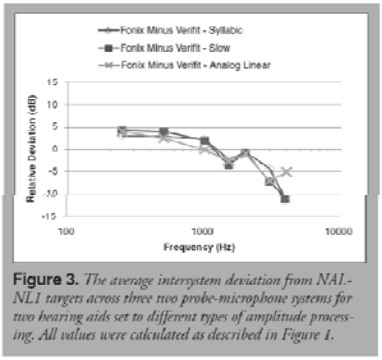


Figure 3. *The average intersystem deviation from NAL-NL1 targets across three two probe-microphone systems for two hearing aids set to different types of amplitude processing. All values were calculated as described in Figure 1.*

Ricketts, T.; Mueller H.G. (2009).

Five factors which can affect accuracy of the verification process

- Target adjustments for the hearing aid/fitting type
- Conversions used to display hearing loss and targets in ear canal SPL
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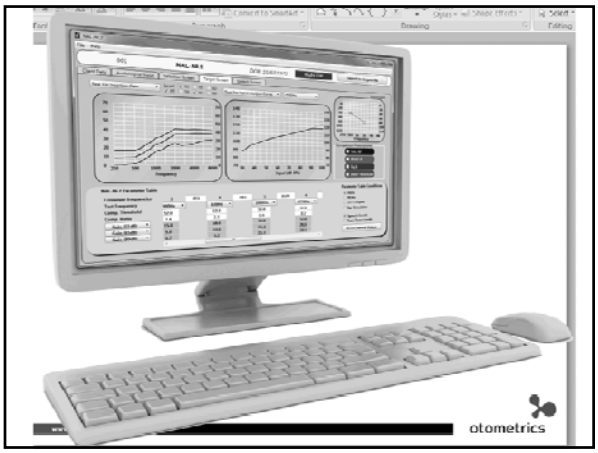
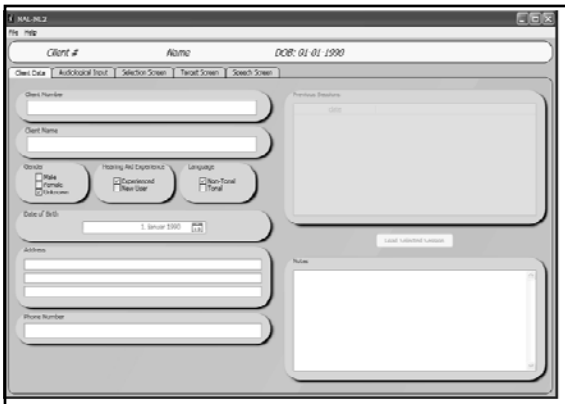
Ricketts, T.; Mueller H.G. (2009).

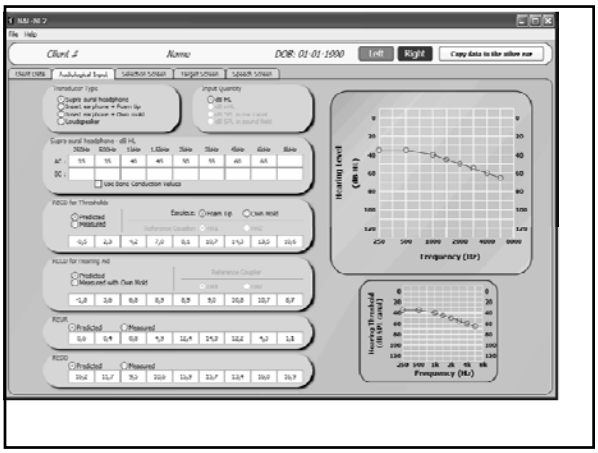
NAL



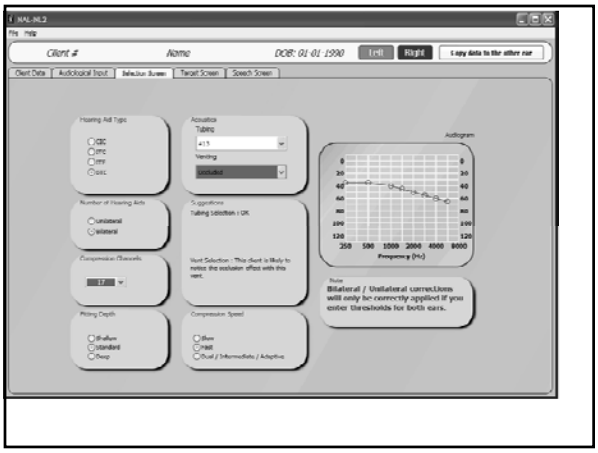
NAL NL2

- ***The only mandatory inputs from the user are the air conduction hearing thresholds at 500 Hz and 2 kHz.***




NAL-NL2
Client #
Name
DOB: 01-01-1990
Left
Right
Copy data to the other ear
Client Data
Audiological Input
Selection Screen
Target Screen
Speech Screen
Transducer Type
Supra aural headphone
Insert: ear phone + Foam tip
Insert: ear phone + Own mold
Loudspeaker
Input Quantity
dB HL
Supra aural headphone - dB HL
Use bone conduction values
REUR for Thresholds
Predicted
Measured
Earplug
Foam tip
Own mold
Reference Coupler
REUR for Hearing Aid
Predicted
Measured with Own Mold
RECD
Predicted
Measured
Hearing Level (dB HL)
Frequency (Hz)
Hearing Threshold (dB SPL canal)
Frequency (kHz)


NAL-NL2
Client #
Name
DOB: 01-01-1990
Left
Right
Copy data to the other ear
Client Data
Audiological Input
Selection Screen
Target Screen
Speech Screen
Hearing Aid Type
CIC
IIC
ITC
ITE
Number of Hearing Aids
Unilateral
Bilateral
Compression Channels
Fitting Depth
Shallow
Standard
Deep
Acoustics
Tubing
Venting
Occluded
Suggestions
Tubing Selection : OK
Vent Selection : This client is likely to notice the occlusion effect with this vent.
Compression Speed
Slow
Fast
Dual / Intermediate / Adaptive
Audiogram
Frequency (Hz)
Note
Bilateral / Unilateral corrections will only be correctly applied if you enter thresholds for both ears.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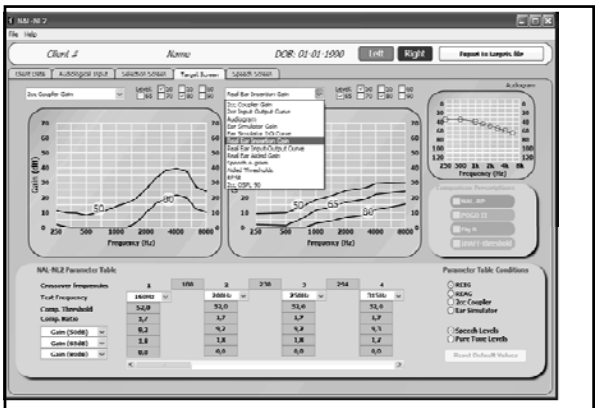
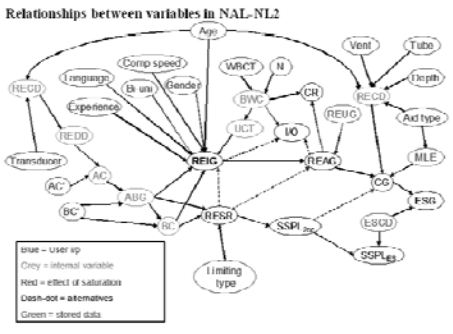


Why does venting not appear to influence Real Ear SPL targets?

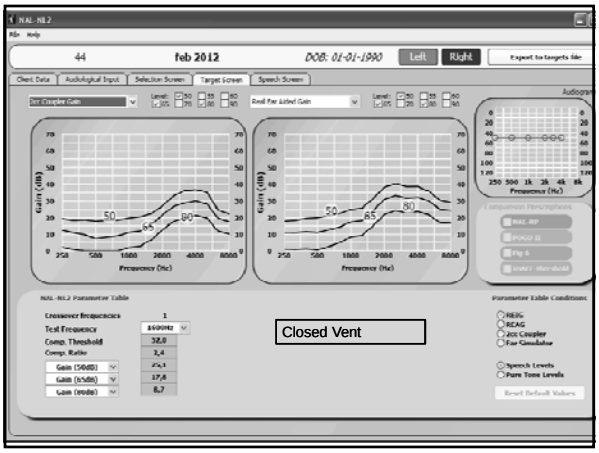


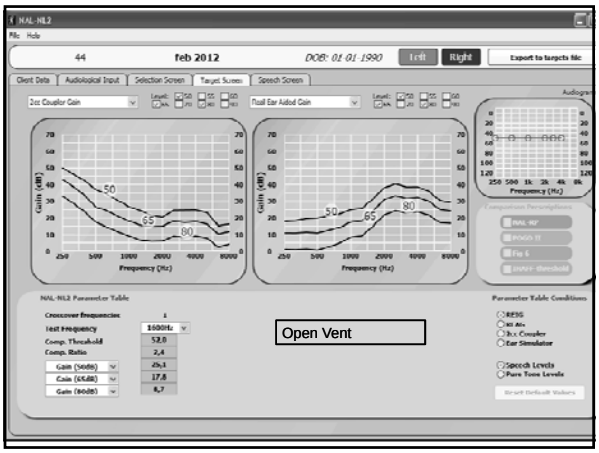
Taken from the NAL-NL2 Algorithm implementation documentation

Why does venting not appear to influence Real Ear SPL targets?

"There is no reason why changing the size of the venting should change the ear canal SPL that is optimal for a person at any frequency."

Dillon, H. 2006. What's new from the NAL in hearing aid prescriptions? *Hearing Journal* 10:10–16.



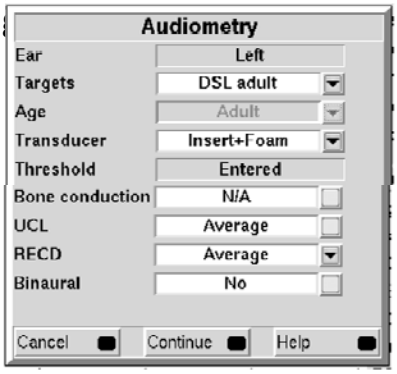


Summary of variables and their effect

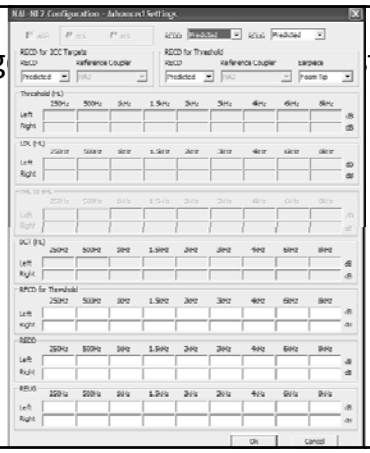
Category	Parameter	REIG	REAG	2cc CG
Client information	Air conduction thresholds	√	√	√
	Bone conduction thresholds	√	√	√
	Gender	√	√	√
	Age	√	√	√
	Hearing aid experience	√	√	√
	RECDt	√	√	√
	REC1lb			√
	REDD	√	√	√
	REUG		(√)	√
	Language type	√	√	√
Hearing aid information	Bilateral - unilateral	√	√	√
	Compression speed	√	√	√
	Limiting type	√	√	√
	Tubing			√
	Venting			√
	No of channels (w/b stimuli)			
	No of channels (n/b stimuli)	√	√	√
	Hearing aid type			√
	Aid insertion depth			√
Options	Wideband CT	√	√	√
	Limiting type	√	√	√
	Reference position		√	
	Reference orientation		√	
	Target type for coupler gain			√

Taken from the NAL-NL2 Algorithm implementation documentation

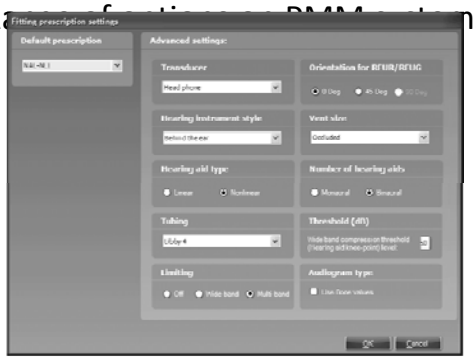
Ran ems



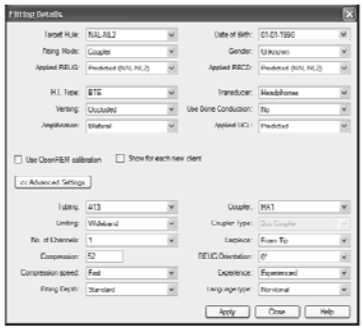
Rang tems



Ra ms



Range of options on PMM systems

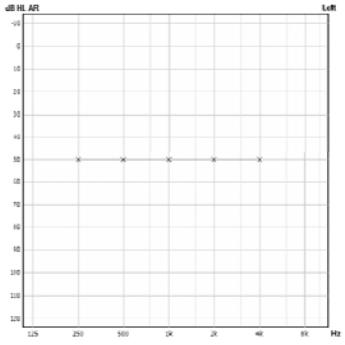


CONVERSION FACTORS

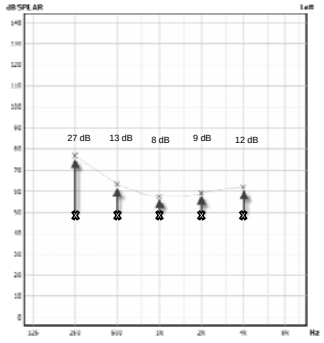
NAL-Potential sources of inter-system variance

- Defaults assumed by each system may vary
- HL to SPL conversions (RECD, REUG, REDD) for each system may vary
- Transducer selection may not be aligned

REDD Headphone



REDD Headphone



HL to SPL Conversion in AURICAL

- In correspondence with the transducer selection, the RECD, REUG and any parameter impacting their calculation influences the HL/SPL conversion. 3 basic formulas apply (ANSI 3.6:2004):

For HL to SPL (real ear)

- For inserts: Threshold [dB SPL] = Threshold [dB HL] + Applied RECD (mold or tip) + insert phone RETSPL (HA1 or HA2)
- For sound field: Threshold [dB SPL] = Threshold [dB HL] + Applied REUG (0, 45, or 90 degree) + Sound field RETSPL (0, 45, or 90 degree)
- For headphones: Threshold [dB SPL] = Threshold [dB HL] + real ear-to-6cc transform + RETSPL
- (For SPL to HL, the above formulas apply in reverse.)

For SPL (real ear) to SPL (2cc)

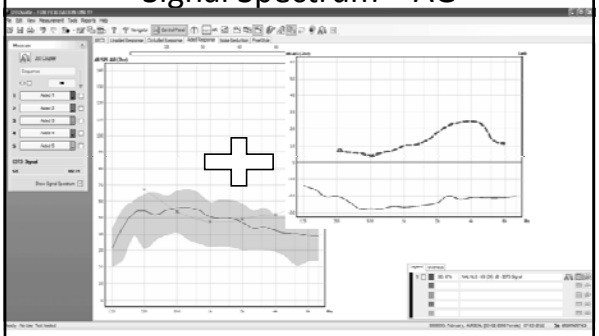
- Threshold [dB SPL 2cc] = Threshold [dB SPL real ear] - Applied RECD

SIGNALS AND TARGETS

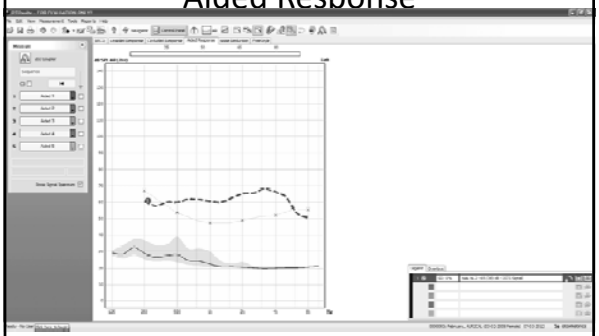
NAL-Potential sources of inter-system variance

- NAL doesn't provide REAR or coupler SPL targets
  - Derived by adding the AG to the input signal
  - Customized REAR/ Coupler SPL targets may differ amongst systems
    - E.G. Otosuite applies the known signal spectrum in order to achieve appropriately differing output targets for various signals

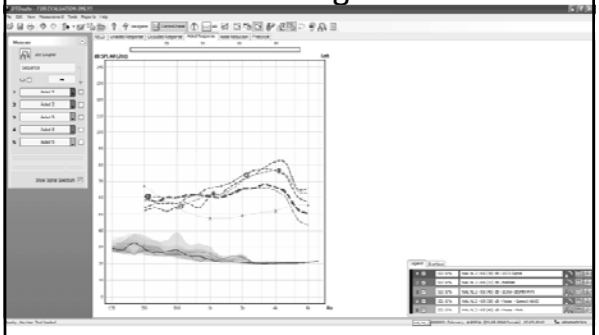
Signal Spectrum + AG



Aided Response



Various Signals

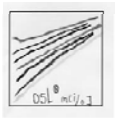


NAL-Potential sources of inter-system variance

- Bilateral/Unilateral settings may not be aligned
- Experience settings may not be aligned
- Proprietary Coupler Output for Flat Insertion Gain (CORFIG) Hawkins D, Cook J. Hearing aid software predictive gain values: how accurate are they? *Hear Jour.* 2003;56(7):26-34.

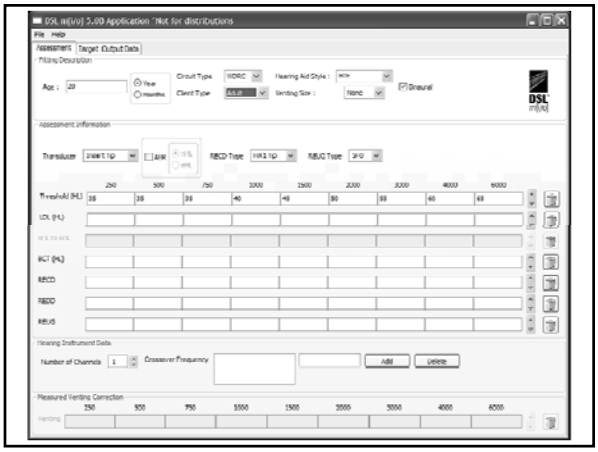
DSL

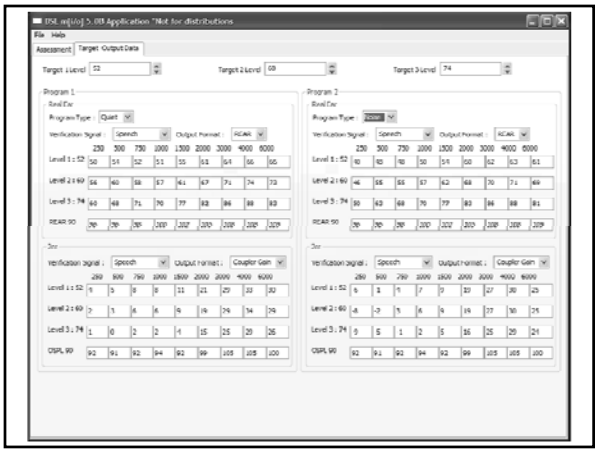
The Desired Sensation Level (DSL) Method Version 5: DSL®m[i/o]



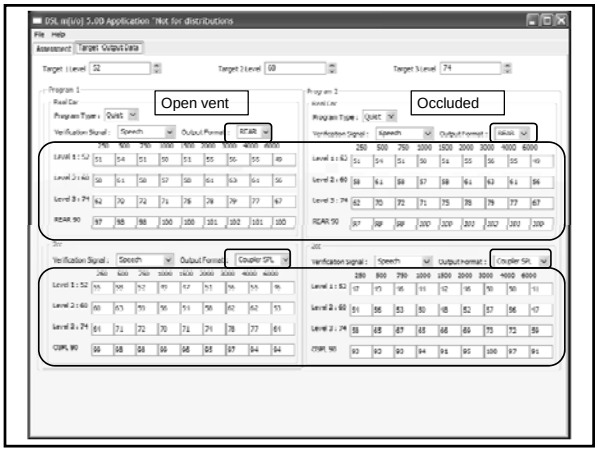
DSL v5.0b m[i/o] -Required Inputs

- ***Age***
- ***Client Type***
- ***Transducer***
- ***Audiogram including BC***
- ***LDLs/UCLs***
- ***Handling of ABR***
- ***REUG and measurement conditions***
- ***RECD and measurement conditions***
- ***Linear vs. WDRC***
- ***HI Style***
- ***Monaural/Binaural***
- ***# Channels***
- ***Vent Size***
- ***Signal type and multi-level***
- ***Quiet vs Noise program***

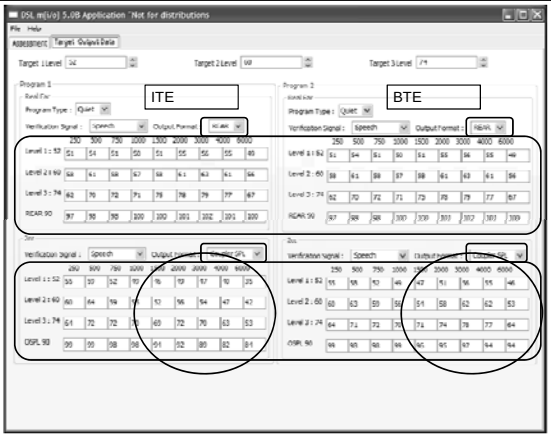




What influence does venting have for DSL?

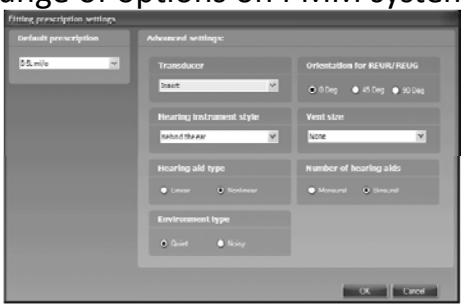


What about HI Type?

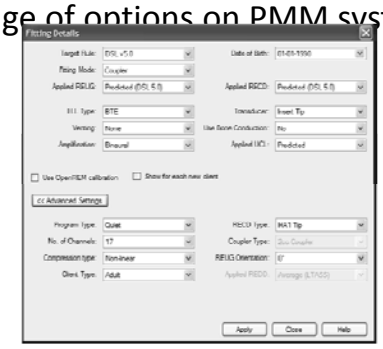


Ran ems

Range of options on PMM systems



Range of options on PMM systems

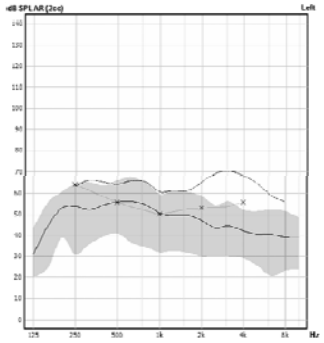


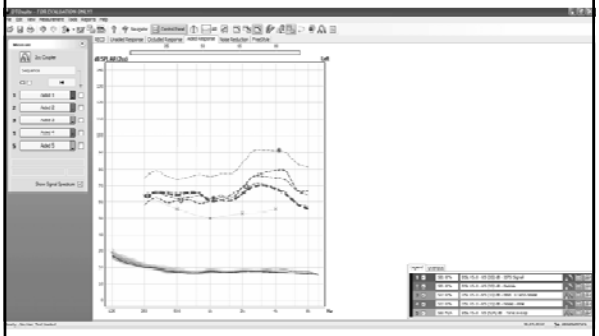
DSL-Potential sources of inter-system variance

- Defaults assumed by each system may vary
- HL to SPL conversions (RECD, REUG, REDD) for each system may vary
- UCL applied by each system may vary
- Transducer selection may not be aligned
- Bilateral/Unilateral settings may not be aligned
- Experience settings may not be aligned
- Quiet versus noise targets may not be aligned
- Proprietary Coupler Output for Flat Insertion Gain (CORFIG) Hawkins D, Cook J. Hearing aid software predictive gain values: how accurate are they? *Hear Jour.* 2003;56(7):26-34.

DSL-Potential sources of inter-system variance- signals

- DSL provides SPL targets but varies them by type; speech, speech noise, pure tone
- Signals may be classified differently across systems
- DSL provides customized targets when the signals spectrum is provided to the algorithm
  - E.G. Otosuite feeds all available signal spectra to derive custom targets





So why the difference in targets shown in the fitting software and the PMM system?

Primary sources of difference between fitting and verification software

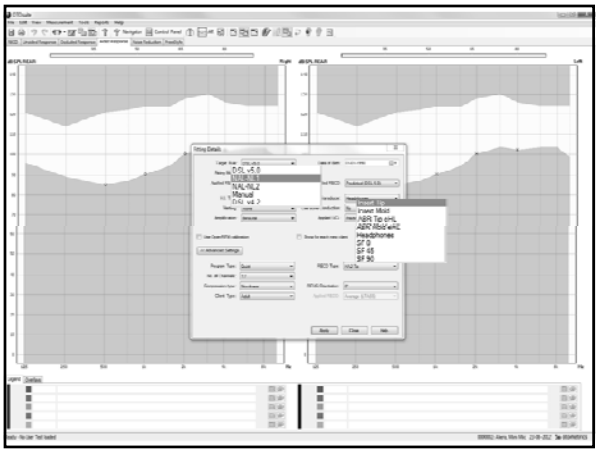
- Mismatch in understanding of what it means to fit to a prescriptive target versus selecting a prescription as the applied algorithm
- Mismatched signal types
- Mismatched versions of prescriptive target
- Mismatch in use of predicted versus measured REUG or RECD
- Mismatch in Binaural vs Monaural fitting selection
- Mismatch between Adult vs Pediatric or experience type

What can I do about it

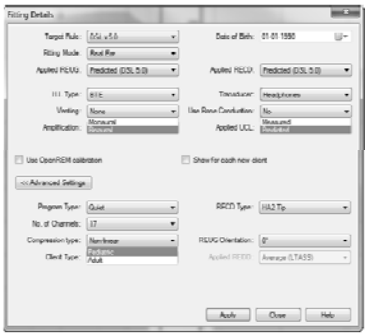
- Familiarize yourself with the prescription you are applying to your fittings
  - Keidser G, Dillon H, Flax M, Ching T and Brewer S (2011). The NAL-NL2 prescription procedure. *Audiology Research*, 1:e24:88-90.
  - Scollie, S., Seewald, R., Cornelisse, L., Moodie S., Bagatto, M., Laurnagaray, D., Beaulac, S., and Pumford, J. (2005). The Desired Sensation Level Multistage Input/Output Algorithm. *Trends in Amplification*, 9(4): pp. 159-197.
  - Johnson, E., & Dillon, H. (2011). A comparison of gain for adults from generic hearing aid prescriptive methods: Impacts on predicted loudness, frequency bandwidth, and speech intelligibility. *Journal of the American Academy of Audiology, 22, 441-459.*
- Check the settings in your PMM system and fitting software when you see a mismatch
- Consult reference manuals and clinical support from both

QUESTIONS???

What impact do some of the various settings have on the prescription?



DSL



NAL

So do I have to make selections in Fitting Details???

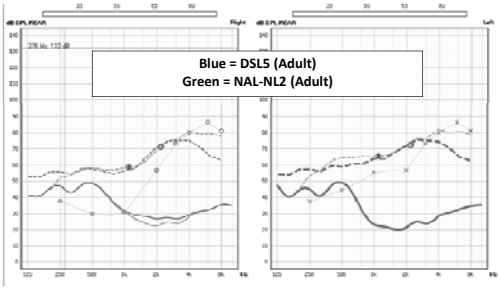
Why does the target sometimes fall at or below the clients hearing threshold levels?

Why does the target sometimes fall at or below the clients hearing threshold levels?

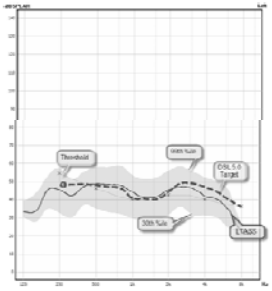
- Restoration of LTASS audibility of high frequencies is not always desirable
- In the case of NL2, the effective audibility factor it applies assumes that as hearing loss becomes more severe less information can be extracted from the speech signal
- Prescribed insertion gain may not aim to achieve audibility at higher frequencies

Keidser et al, 2011

Average speech target sloping hearing loss



Soft speech target and aided response for mild hearing loss



Thank you!!!