Probe-mic and Speech Mapping Measures: Technique, Procedures, and Modern Applications

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Learning Outcomes

After this course, participants will be able to:

-List appropriate techniques for probe microphone measures

-Explain step-by-step procedures for using probe microphone measures for hearing aid fittings.

-Describe how REAR measures and speech mapping can be used to determine the appropriateness of a hearing aid fitting.

To be clear: This course is designed for someone just getting started conducting probe-mic measures, or someone needing a basic review.

Basic terminology:

Real ear vs. probe-mic vs. speech mapping

Four common reasons to conduct probe-mic measures:

- To verify prescriptive fitting targets such as the NAL-NL2 or DSLv5.0
- To obtain a general measure of audibility and earcanal output
- To assess the function of hearing aid special features
- To collect data that can be used as a correction factor (e.g. RECD)

Four considerations before starting testing:

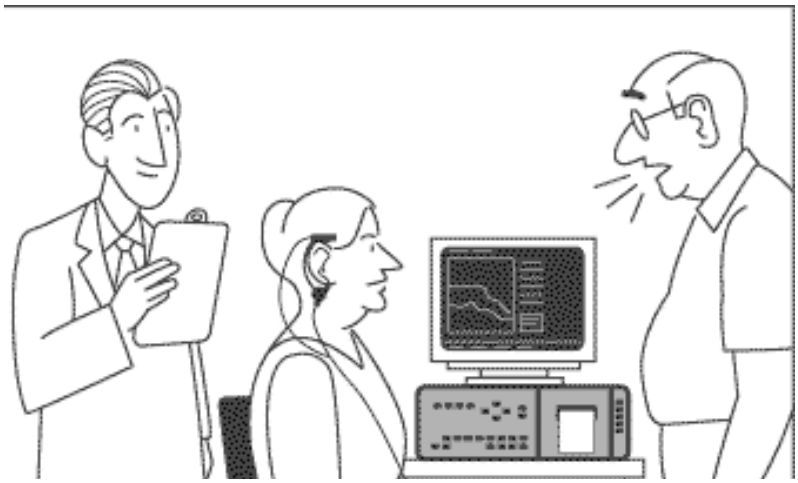
- What test signal to use
- Calibration of the equipment/sound field
  - Probe tube itself (for most equipment)
  - Calibration/monitoring of the field
- Positioning of the patient
- Positioning of the probe tube

Test Signals

- Equipment-specific real-speech signal (shaped to LTASS)
- Equipment-specific modulated noise signal (shaped to LTASS)
- ICRA noise (of different spectrums)
- International Speech Test Signal (ISTS); shaped to ILTASS
- Speech noise
- Pink noise
- Swept-tones

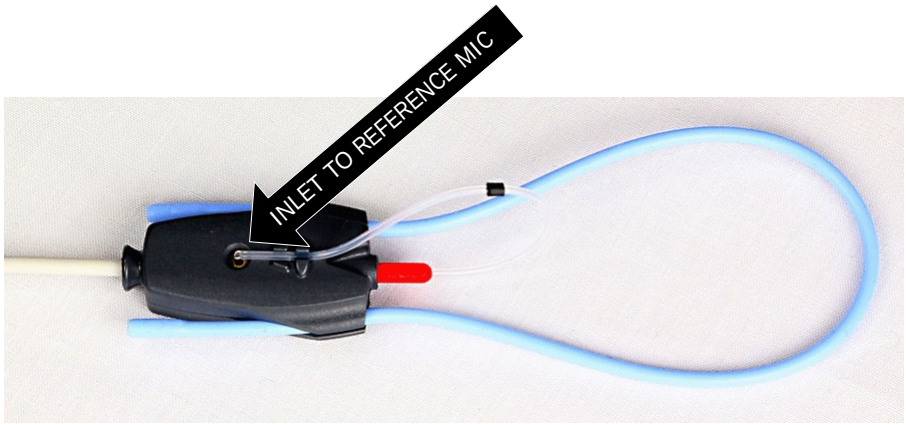
What about using live voice?

It might be helpful to "sell" hearing aids,
but not a very good way to "fit" hearing aids

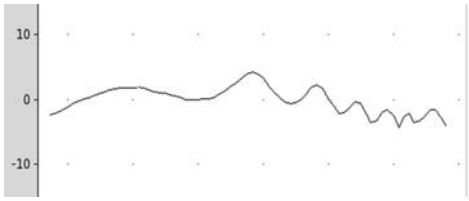


Probe-tube calibration

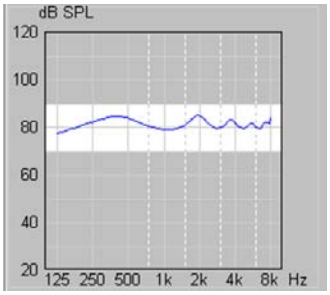
- In general, the purpose is to make the acoustic effects of the tube itself invisible.
- This can be accomplished, in the calibration mode, by placing the tip of the tube next the opening port of the reference microphone, and then presenting a signal.
- The machine will compare the two inputs (through the tube vs. direct to reference microphone), and automatically correct for the effects of the tube.



Typical calibration curve before effects of the tube have been equalized.



Manufacturer A



Manufacturer B

About probe tubes and probe tube calibration

- Can I reuse tubes on the same patient?
- Can I reuse the tubes on different patients?
- Can I use the tubes from one manufacturer on another manufacturer's equipment?
- When the tube is plugged, can I simply snip off the plugged end and use the tube?

More probe tube questions?

- With a tight fitting, does the tube get squashed and not give correct values?
- With a tight fitting, does the tube cause a vent effect (slit leak)?

About the "reference mic." Sometimes called the "monitoring mic" or "regulating mic."

- Usually placed just below the earlobe.
- When enabled, monitors and controls the level of the signal from the loudspeaker, so that a valid and consistent signal is present at the ear.
- May be disabled for some types of measurements.

Example of reference mic located above the ear

Two choices for equalization:

Modified pressure method with concurrent equalization

- When this is used, equalization is not a separate step but occurs automatically during measurement through continuous monitoring of the signal by the reference microphone at the ear.
- If the patient were to turn head slightly to one direction or another, the input signal would be changed accordingly to compensate for head diffraction or shadow, so that a constant input always is present at the ear.

Two choices for equalization:

Modified pressure method with stored equalization

- Place the subject in the test position. Following the equipment manufacturer's instructions, record the stimulus at the field reference point.
- All objects that will be present during subsequent tests should be in position (including the operator).
- The recording shall be updated whenever there is a change in the test point, the field reference point, or the acoustic environment.
- Importantly: The patient must keep his head still in the calibrated position!

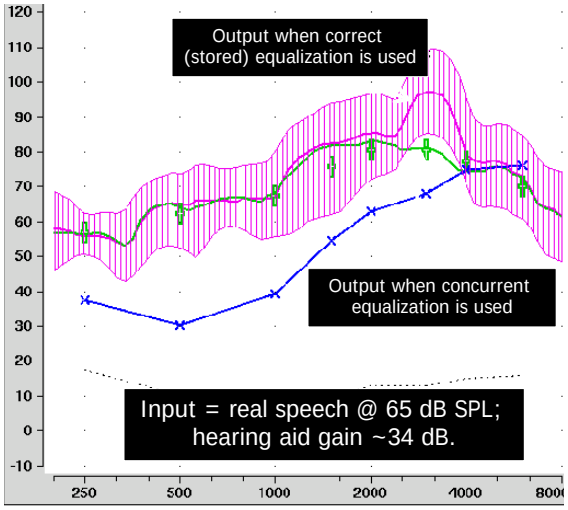
Why you can't use concurrent equalization with open fittings:

- Sound leaking out of ear is picked up by reference mic
- Sound leaking out of ear may be greater than the input to reference mic from loudspeaker
- Reference mic thinks it is output from loudspeaker, and so loudspeaker output to ear is then turned down
- The result will be less measured hearing aid output (and gain)

Magnitude of the problem probably related to:

- Gain/output of hearing aid
- Feedback reduction algorithm
- Location of reference mic
- Proximity of reference mic to hearing aid mic
- Openness of the fit
- Residual ear canal resonance of the patient

Note what happens when you increase gain in the highs!
The more gain is increased, the bigger the mistake will be.



About the reference microphone

- Is it okay to use the stored equalization method when the earcanal is closed?
- Is there anytime other than open fittings when it might be good to use the stored equalization approach?
- In simultaneous bilateral testing, how do the two reference microphones calibrate the signal?

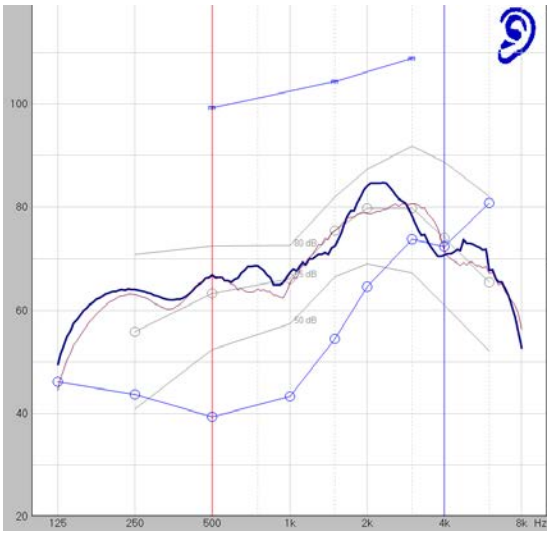
Positioning of the patient: General guidelines:

- Patient's head should be at 0 degree vertical azimuth
- Patient's head should be at 0 degree horizontal azimuth —around 3 feet distance. Close is good because it helps with room SNR:
  1. Can test at lower levels
  2. Prevents overdriving speakers for high inputs
- And remember, if using stored equalization mode, important that patient does not move head

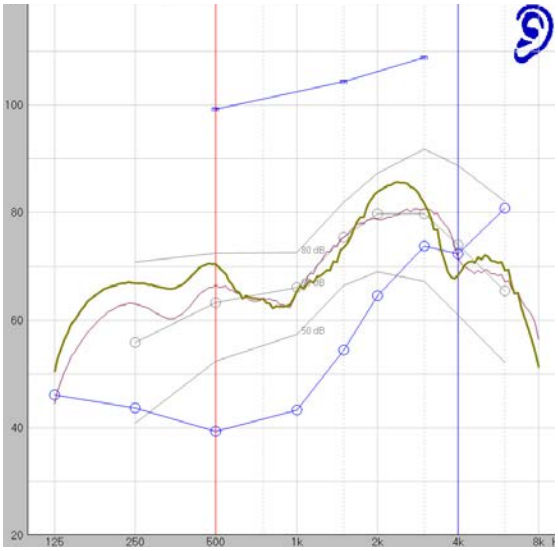
About positioning the patient

- Any tricks to get the patient to stay in the right place?
- Is positioning the same for all equipment from different manufacturers?
- Does it really matter is they aren't seated exactly the way they should be?

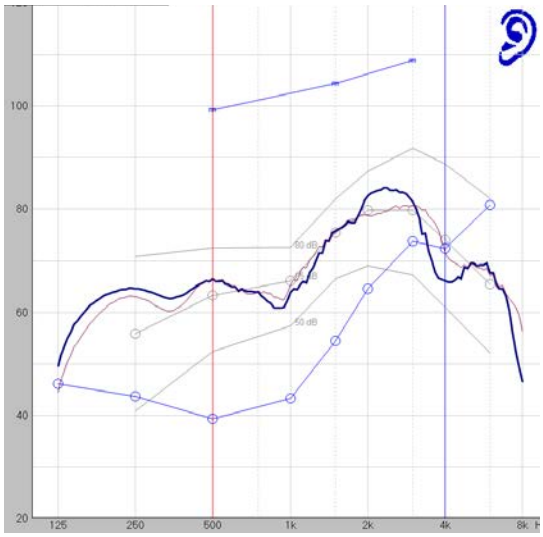
Patient turned head slightly away from loudspeaker (watching programming)



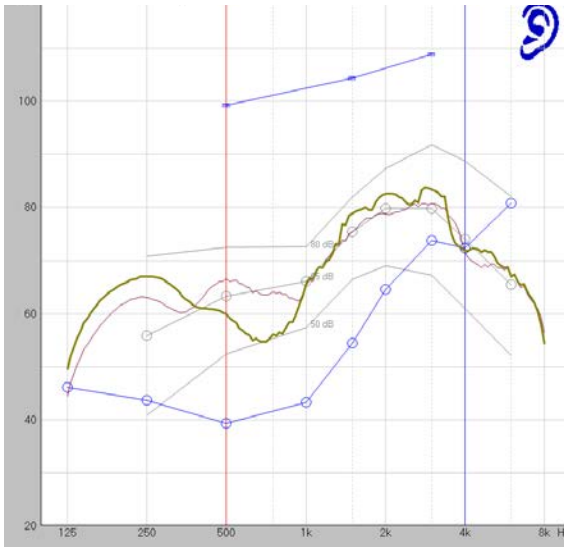
Patient seated too far away from the speaker (six feet rather than three feet)



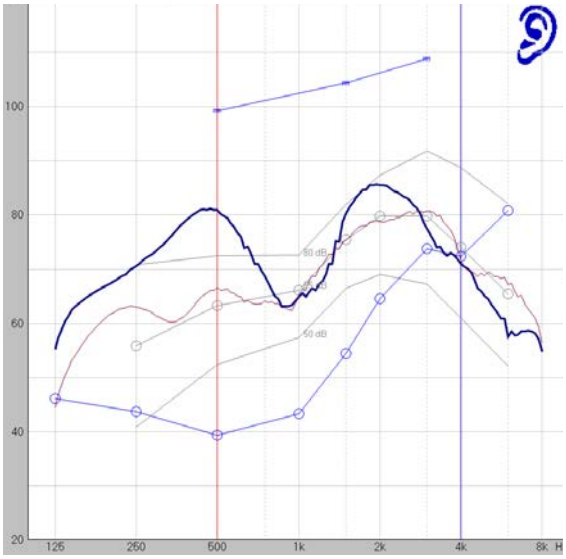
Loudspeaker positioned 12” too low



Loudspeaker positioned 12” too high

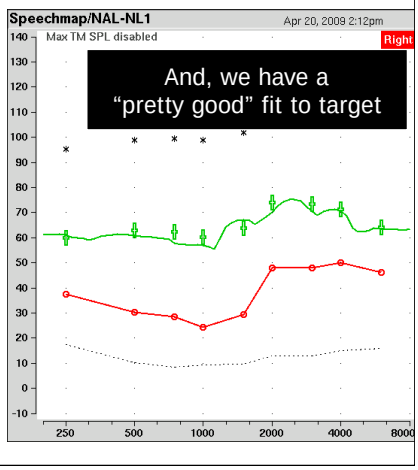


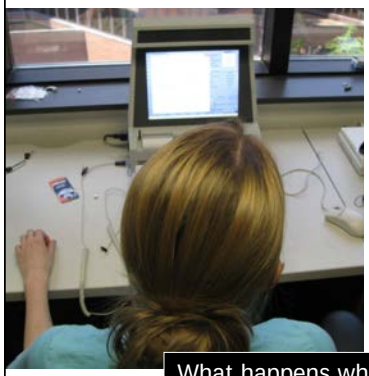
Patient coughed during signal presentation



If you're using "stored equalization", how much of a problem is head movement?

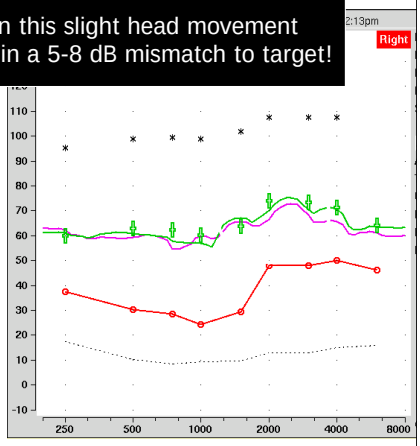
Our starting point
is correct head position



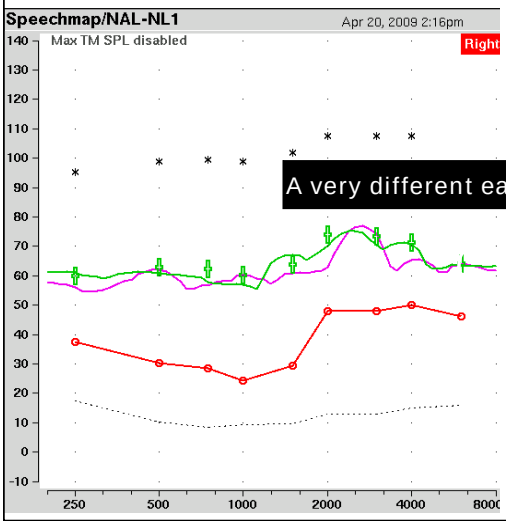


What happens when she turns her head a little to the right?

Even this slight head movement results in a 5-8 dB mismatch to target!



And what happens if she leans her head a little in toward the loudspeaker (as some patients do)?



A very different earcanal output!

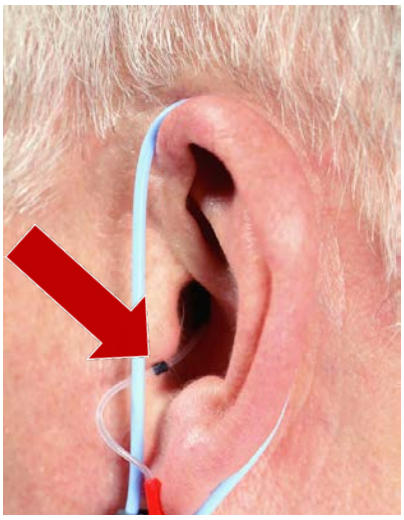
The general 5mm rule for positioning the probe tube

- The tip of the tube should be within 5mm of the eardrum
- The tip of the tube should be ~5mm beyond the tip of the hearing aid/earmold

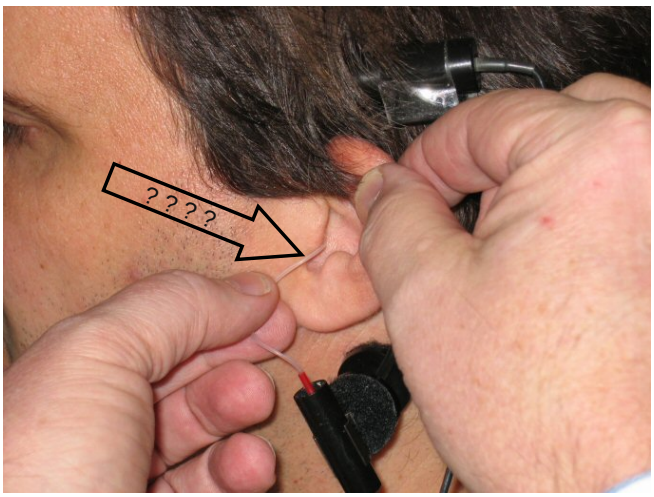
Methods to assure good probe-tube placement:

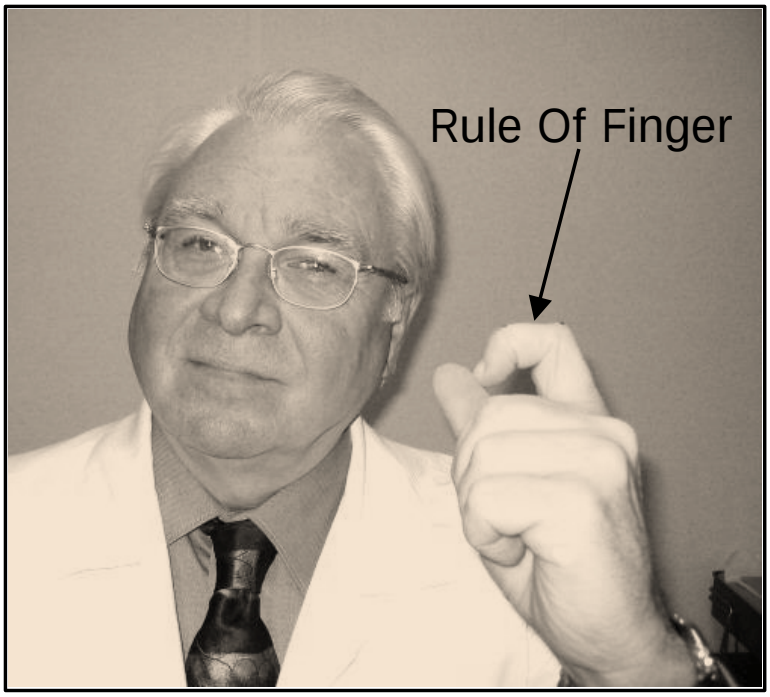
- Use marker as reference, positioned 28-30 mm from the tip of the probe, and then aligned with the inter-tragal notch.
- Use anti-resonance notch in response as guide; if present, should be 6000 Hz or higher
- Use earmold as guide (mostly used in infants and children)
- Use “bump and pull” (mostly used with snarly engineers who voice their opinion)

Example of marker at inter-tragal notch



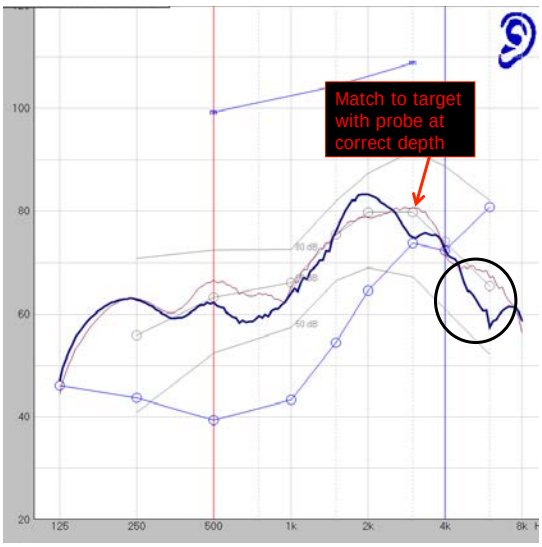
Marker needs to be at inter-tragal notch.
Don't lose sight of the marker!




Rule Of Finger

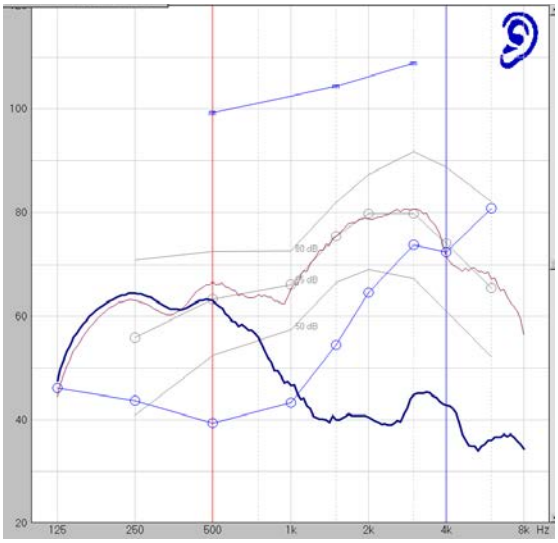
Use housing as a guide?

Probe tube 3-5 mm too shallow



Probe tube pulled back another 3 mm

Take a look at the bottom blue line: What happened here?



About probe tube placement

- Can I simply use the vent of the hearing aid or the earmold as a path for the probe?
- What about hard lumps of cerumen in the earcanal?
- What about patients with perfs and PE tubes?
- Can I do any harm if I do the "bump and pull" by accident?

Before we get seriously started . . . A review of some terms:

- If the term ends in an "R," it means that it is the absolute output in the real ear.
- If the term ends in a "G" it means that it is a difference value: The input subtracted from the output (e.g., REAG) or the reference REUR subtracted from the REAR (e.g., the REIG)

Before we get seriously started . . . A review of some terms:

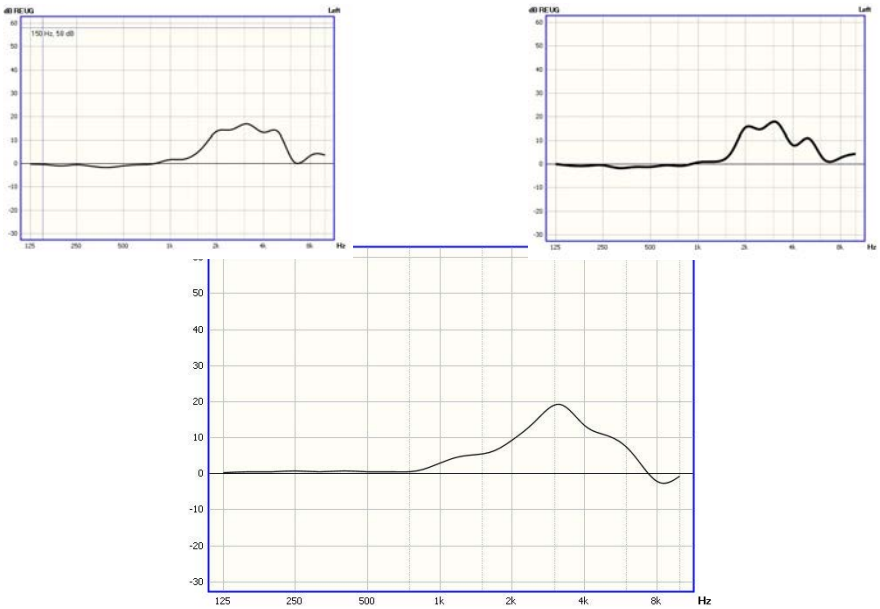
- REUR/REUG: The transfer function of sound from the free field to the eardrum.
- REOR/REOG: The effect that an earmold or hearing aid has on the REUG.
- REAR/REAG: The output of the hearing aid in the real ear

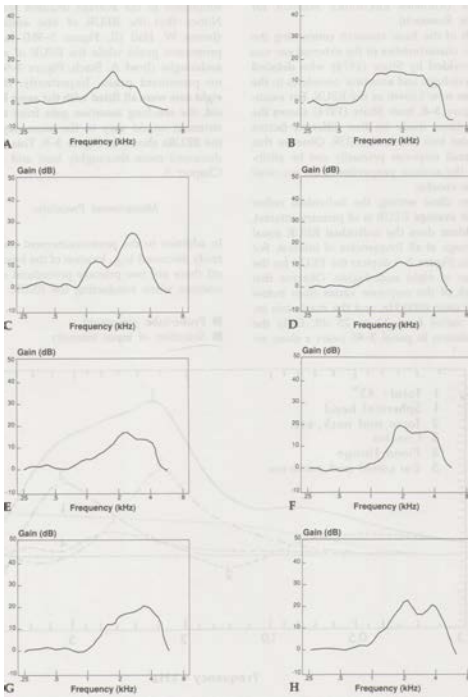
Before we get seriously started . . . A review of some terms:

- REIG: The difference between the open ear response (REUR), and the output of the hearing aid (REAR).
- REAR85/REAR90 (formerly the RESR): The MPO of the hearing aid in the real ear.
- RECD: The difference between the output of the hearing aid in the real ear compared to a 2-cc coupler.

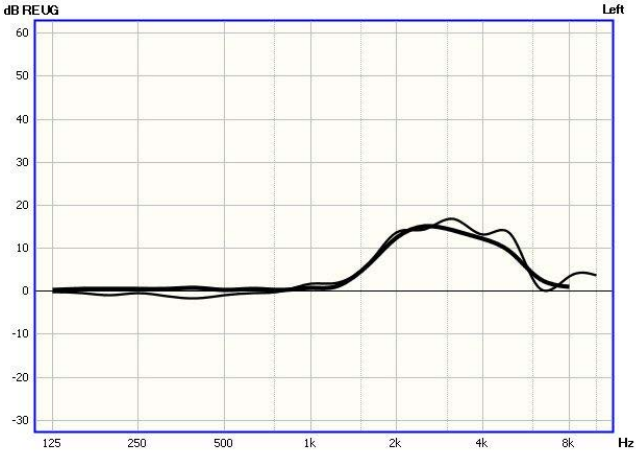
The REUR (REUG)

- What is it and how do we measure it?
  - Main components are the ear canal resonance and concha effects
- What are the primary clinical applications?
  - To calculate insertion gain





All probe-mic equipment has an “average” REUG stored, which can be used for REIG calculation:



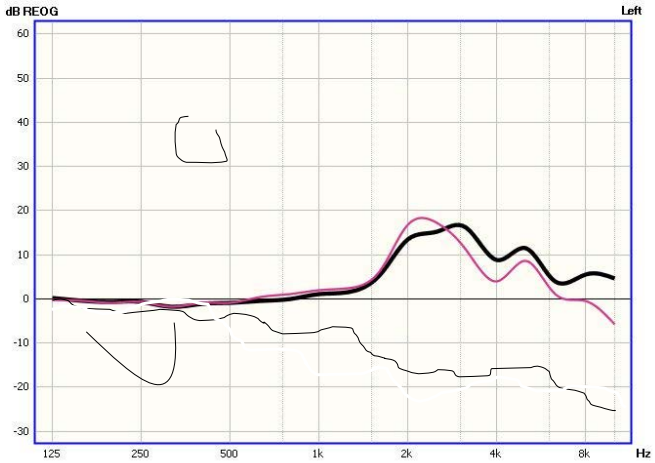
About the REUR/REUG

- Is it best to use the average REUG, or the individual's measured REUG?
- If a patient has an unusual REUR, is it best to fit the hearing aid to mimic that response?

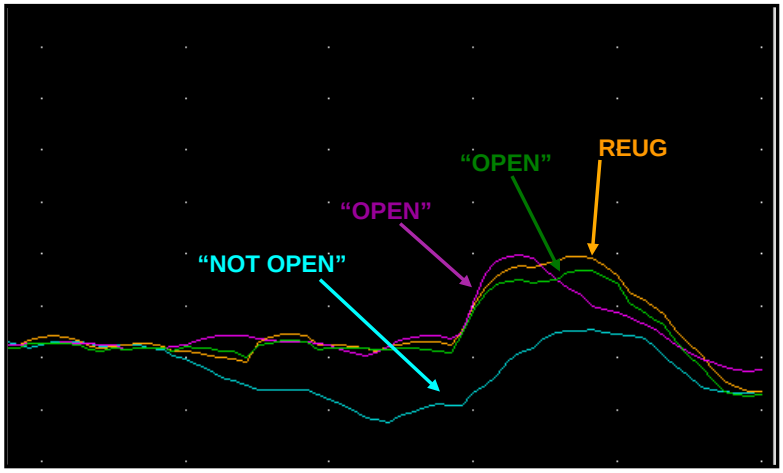
The REOR (REOG)

- What is it and how do we measure it?
  - How the earmold and/or hearing aid changes the REUG; attenuation effects and disruption of the earcanal and concha effects.
- What are the primary clinical applications?
  - To determine venting effects

Typical REOGs when an open fitting vs tight fitting is used:



Example of three different REOGs



About the REOR/REOG

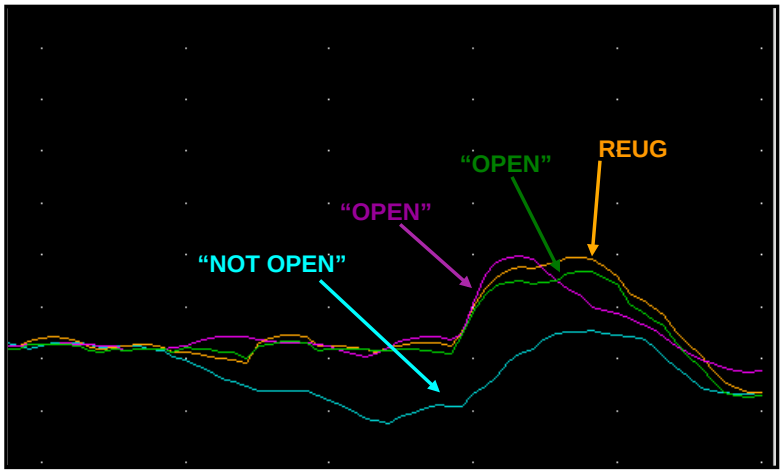
- Does a more negative REOG mean that more gain is needed to make up for this "insertion loss?"
- Do I alter my prescription fitting based on the REOG?
- Is the REOG a measure of the occlusion effect?

Important distinction:

The "occluded response" is different from the "occlusion effect"

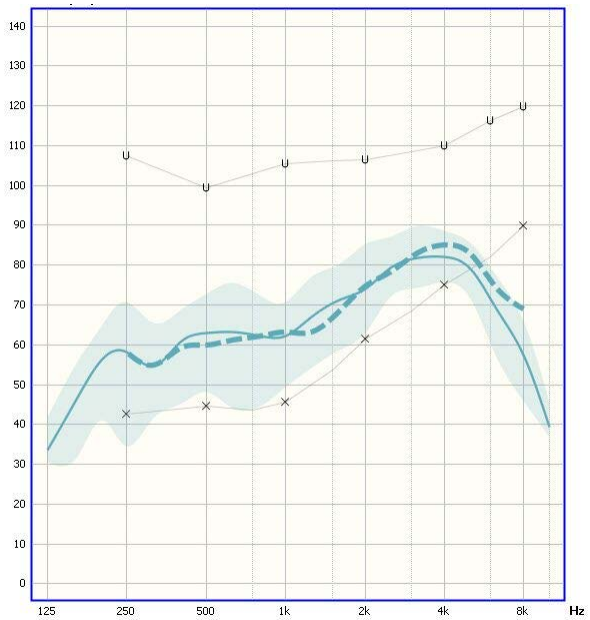
If the REOR is very similar to the REUR, then you can be fairly certain that there will be no occlusion effect

For the green curve below, there probably will be no occlusion effect.



The REAR (REAG)

- What is it and how do we measure it?
  - The output of the hearing aid expressed in earcanal SPL (if the input is subtracted it's the REAG).
- What are the primary clinical applications?
  - To verify fitting targets
  - To verify audibility
  - To assess special features


140
130
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2k
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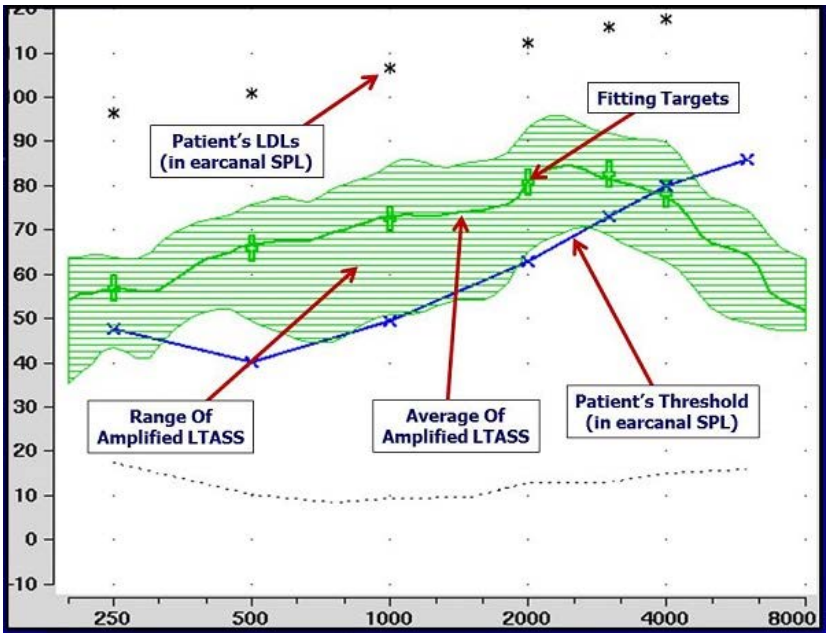
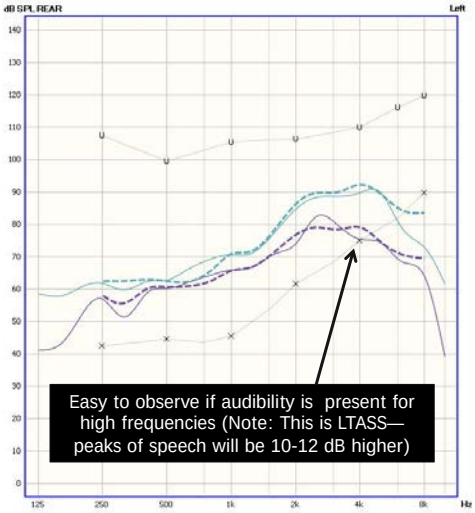
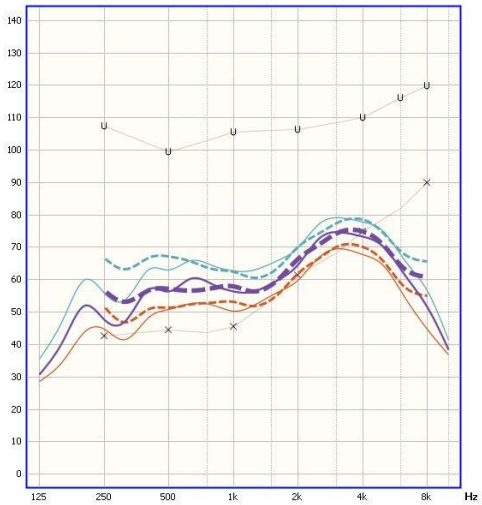
8k
Hz


Patient's LDLs
(in earcanal SPL)
Fitting Targets
Range Of
Amplified LTASS
Average Of
Amplified LTASS
Patient's Threshold
(in earcanal SPL)
250
500
1000
2000
4000
8000

Target match for soft and loud inputs



Typically, we would do REARs for three inputs: in this example, 55, 65 and 75 dB SPL



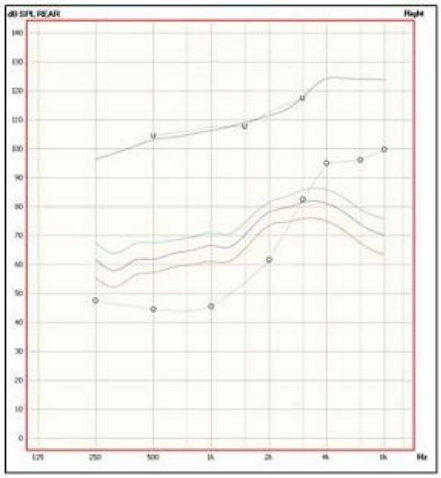
Sample protocol for fitting to prescriptive targets

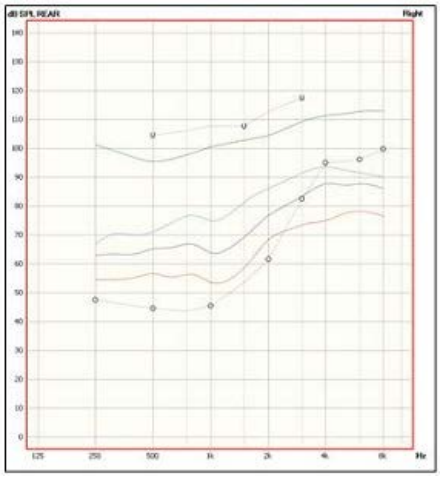
- Use fitting software to "pre-program" hearing aid to desired targets (software program should match verification program).
- Use real speech or speech-shaped signal in REAR (earcanal SPL) mode
- Deliver 50-55 dB SPL input. Adjust GAIN until target match is obtained.
- Deliver 75-80 dB SPL input. Adjust COMPRESSION until match is obtained.
- Deliver 65 dB SPL input. Observe. Should be close to target. Adjust when necessary.
- If adjusted for 65 dB SPL, do follow-up check for lower and higher inputs.
- Conduct final run of all three for documentation.

About the REAR/REAG

- Does the input signal matter?
  - Be careful when matching targets
- Why are fitting targets sometimes below the hearing thresholds?

Fitting targets compared to patient thresholds for NAL-NL2 (left) and DSL V5 (right)





Reasons why the targets are below the thresholds in the high frequencies:

- Consider the complete speech spectrum, not just the "average line."
- You only have so much loudness to use—use it effectively.
- There is a point where extra audibility does not equate to increases speech understanding.
- The overall fitting must be reasonably "comfortable" for patients, or they will turn down gain and reduce audibility for ALL frequencies.

Two different methods to verify hearing aid performance:

- Real ear insertion gain: Does the hearing provide the appropriate frequency-specific *gain* for speech?
- Real ear aided response: Does the hearing aid place amplified speech at the appropriate output?

Some reasons why using the REIG for verification is preferred over using the REAR:

- Easy to talk to one another about it (e.g., "that guy needs about 25 dB of gain at 3K")
- Easy to talk to lay people (and teachers) about it (e.g., "with that amount of gain, his aided threshold would be about 20 dB")
- Easy to communicate with manufacturers (e.g., "I don't believe you can get 50 dB of gain out of that instrument")
- It's what we've used with probe-mic measures for nearly 30 years
- You don't have to think as much about input signals when conducting verification (e.g., a difference is a difference—with REIG, two wrongs can make a right!)

Some reasons why most people find the REAR and real-speech an attractive option:

- You don't have to (directly) deal with the REUG
- Overall display and measurement more logical (as things get louder that are higher on the scale)
- Face validity of real speech
- Allows testing to be conducted with DNR-On
- Observation of effects of compression (including different time constants)
- Includes effects of channel summation and other signal processing
- Results more meaningful for patient counseling

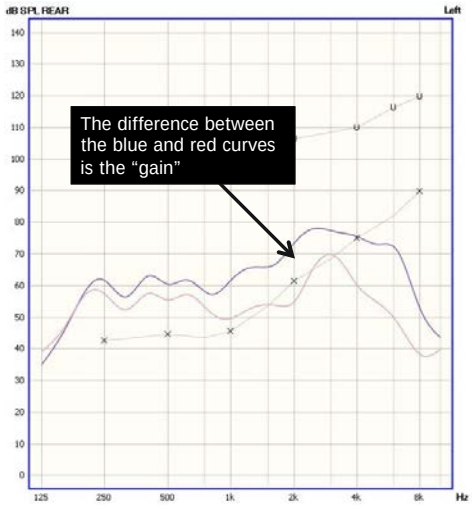
And by the way . . .

- The term "speech mapping" simply means that you are using a speech signal (or speech-like signal) when you conduct your REAR measure
- Speech mapping *IS* real-ear testing, which *IS* a probe-microphone measure (term trademarked by Bill Cole back in 1992)

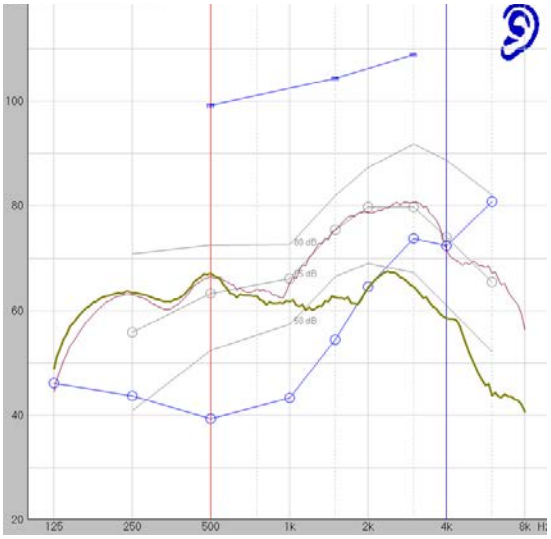
The REIG

- What is it and how do we measure it?
  - It's not a measurement, it's a calculation. REAR minus the REUR = REIG (or, REAG-REUG = REIG).
- What are the primary clinical applications?
  - To verify fitting targets
  - To obtain a "gain value" when that is desired or needed.

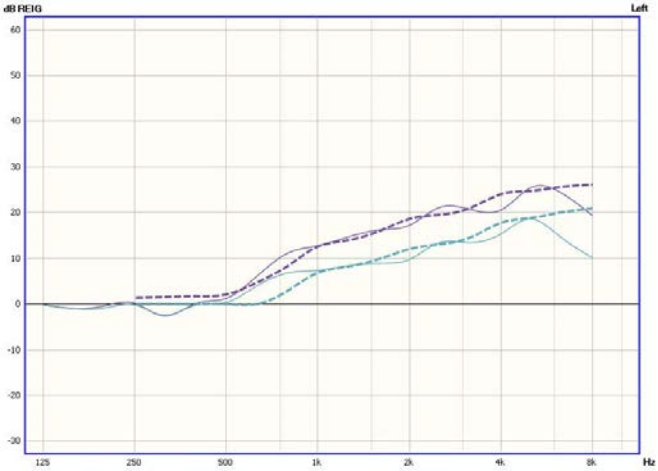
Understanding the concept of insertion gain (REIG)



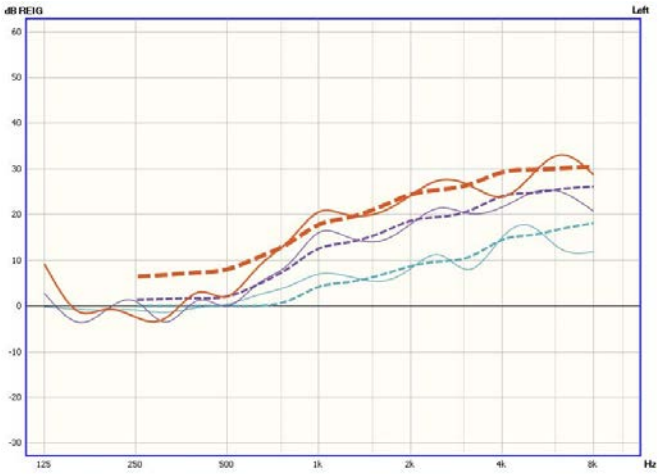
The REIG concept: Different patient, different equipment, different outcome.



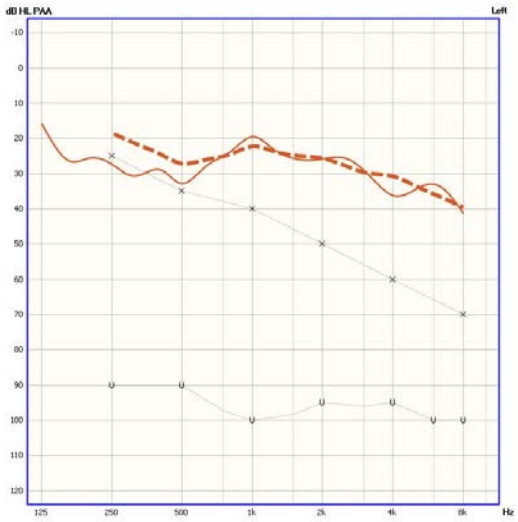
REIG target match for two different inputs:



Match to NAL-NL2 prescriptive targets for 55, 65 and 75 dB SPL inputs



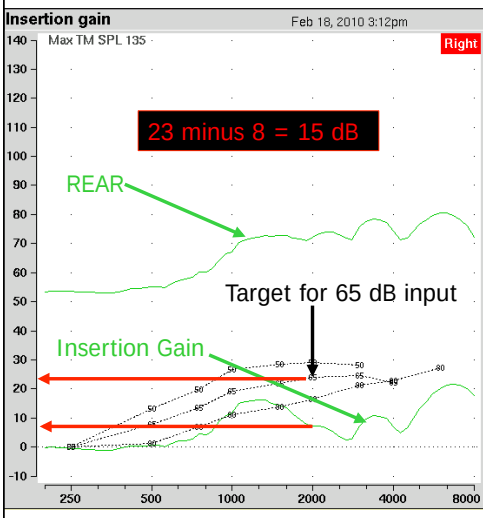
A handy use of insertion gain:



About the REIG

- Best way to get rid of peaks and dips in the REIG response?
- Is a good REIG fit always a good REAR fit, or can one be good and the other bad?

Comparison of REIG vs. REAR speechmapping for manufacturer's "First Fit" response: Same hearing aid, same settings, same patient; two different verification procedures.



The REAR85/REAR90 (formerly known as the RESR)

- What is it and how do we measure it?
  - The MPO of the hearing aid measured in earcanal SPL. Input must be great enough to place output at max.
  - Usually conducted at high VC setting to predict worse case (unless fixed VC)
- What are the primary clinical applications?
  - Comfort (not too high *or* too low) and safety

Amplification is good, but you can have too much of most any good thing!

What happens if we set the AGCo too high (loud sounds will be too loud)?

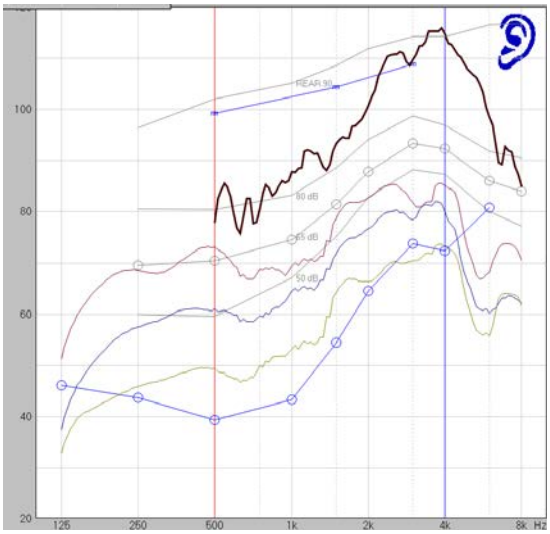
- The patient will turn down gain (and will then not have audibility for soft and average inputs).
- The patient will only use his hearing aids when he knows no loud sounds will exist (missing out on amplification for the majority of listening situations).
- The patient will have some initial negative experiences, and simply stops using his hearing aids.

What happens if we set the AGCo too low (loud sounds will be squashed)?

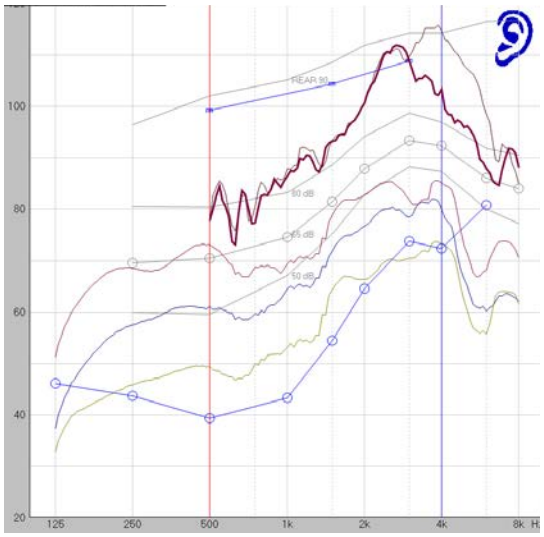
- Speech may sound distorted, as it often will be at the AGCo level.
- Speech may not have the necessary dynamics, as the peaks will be "clipped." Music may sound "dull."
- The range of loudness perceptions will be limited—average and loud inputs may only differ by a few dB following processing.
- For some speech-in-noise listening situations (positive SNR), AGCo could make the SNR more adverse.

We need our AGCo set not too “hot” and not too “cold”—but “Just Right”

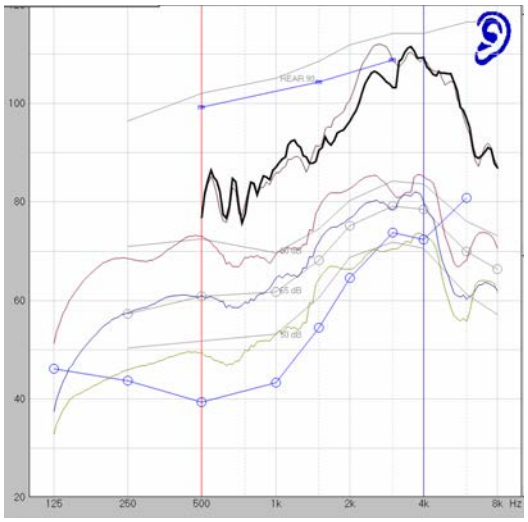
When the REAR85 doesn’t turn out so good:



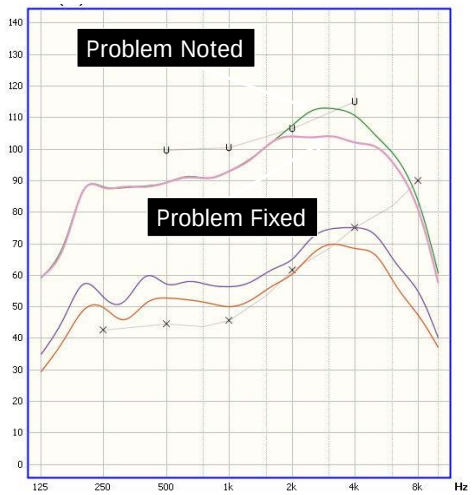
Lowering AGCo kneepoint in upper channels —too much?



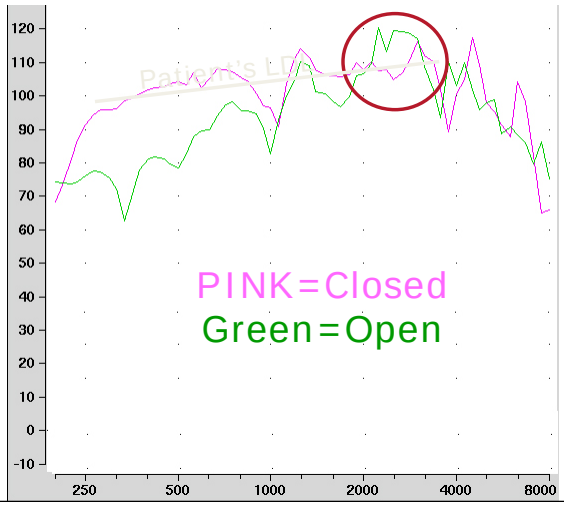
REAR85 following “final” adjustment



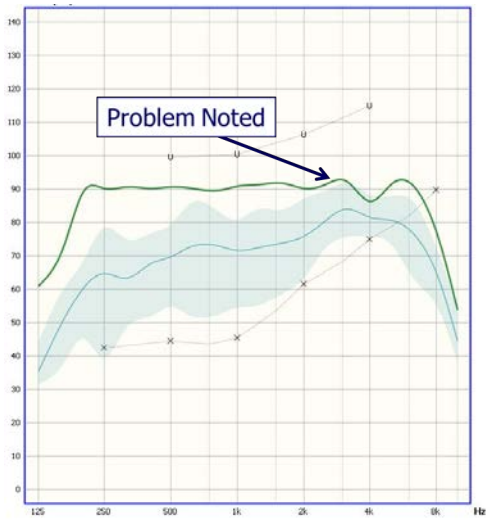
More REAR85 measures:



Typical finding for open versus closed REAR85: Note, output is greatest for OPEN, and that difference is around the residual earcanal resonance.



The solution is not to simply set the MPO very low:



Bonus fitting tip . . .

- It is very handy to use the input from your probe-mic equipment to behaviorally test aided LDLs.
- There are several different signals available (real world) and you can use the Cox Loudness Anchors.

The RECD (real ear coupler difference)

- What is it and how do we measure it?
  - It is the difference between the output of a hearing aid in a 2-cc coupler versus the output in a given patient's earcanal. The difference will be the largest when the residual earcanal is the smallest (e.g., infants and children).
- What are the primary clinical applications?
  - To predict earcanal output from coupler data
  - To allow for "fitting" hearing aid in the coupler.

Great AudiologyOnline course by Susan Scollie, PhD, on the RECD

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Course Details

Course # 26622
New RECDs and a New ANSI standard: Revisiting RECD Basics and Applications

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Preview Exam

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Course Learning Outcomes

- Participants will be able to describe key changes in the definition of the Real Ear to Coupler Difference due to a new ANSI standard.
- Participants will be able to explain how the RECD varies when measured with foamtips versus earmolds.
- Participants will be able to describe a new protocol for correcting the RECD that is applied in new Audioscan software systems.