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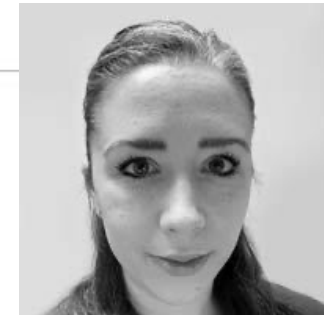


Unleashing the Power of Test Box and Real-Ear Probe Microphone Measurements in partnership with Seminars in Hearing

Lori Zitelli, Au.D., CH-TM

Catherine Palmer, Ph.D.

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Lori Zitelli, AuD

Lori Zitelli, AuD, joined the UPMC audiology department in 2012. She became Managing Audiologist in 2021. She received her clinical doctorate in audiology from the University of Pittsburgh, where she is now an Adjunct Instructor. Her areas of expertise include amplification, evaluation and treatment of tinnitus/decreased sound tolerance, clinical education, and interventional audiology. She is licensed to practice audiology in the Commonwealth of Pennsylvania. She is a member/volunteer of the American Academy of Audiology, a Jerger Future Leaders of Audiology (JFLAC) alumna, and a member of the American Speech-Language Hearing Association. Dr. Zitelli is also a Certificate Holder in Tinnitus Management.





Catherine Palmer, PhD

Catherine Palmer is Chair and Professor in the Department of Communication Science and Disorders at the University of Pittsburgh. In addition, she is a Professor in the Department of Otolaryngology and serves as the Director of Audiology for the UPMC Integrated Health System. Dr. Palmer conducts research in the areas of auditory learning post hearing aid

fitting, the relationship between hearing, cognitive health and health outcomes, and matching technology to individual needs. She has published over 100 articles and book chapters in these topic areas as well as provided over 200 national and international presentations. Dr. Palmer teaches the graduate level amplification courses at the University of Pittsburgh, serves as Editor-in-Chief of Seminars in Hearing, and served as the President of the American Academy of Audiology 2019-2020.



Disclosures

- **Presenter Disclosure:**

- Lori Zitelli
 - Financial: Lori is employed by UPMC, the University of Pittsburgh, Cranberry Hearing & Balance, and Treble Health. She received an honorarium for presenting this course.
 - Non-financial: Lori is a member/volunteer of AAA and ASHA.
- Catherine Palmer
 - Financial: employed by the University of Pittsburgh and UPMC. Editor-in-Chief of Seminars in Hearing, consultant NBME
 - Non-financial: member/volunteer of AAA and ASHA

- **Content Disclosure:** This learning event does not focus exclusively on any specific product or service.

- Note that examples are provided with one specific piece of equipment. However, the measurements discussed can be completed by any pieces of equipment with similar capabilities.

- **Sponsor Disclosure:** This course is presented by Seminars in Hearing, a publication of Thieme Medical Publishers, in partnership with AudiologyOnline.



Limitations/Risks

- The applicability and accuracy of the course content may vary by the clinical, geographical, and cultural context; you should evaluate the course accordingly.
- As healthcare is rapidly evolving, new findings may change the validity of the information presented in this course. Providers should always consult the latest research and guidelines from professional associations.
- The interventions discussed in this course may be limited in generalizability, requiring practitioners to consider specific individual and population factors.
- The course may not cover all possible risk factors, diagnostic methods, or treatment options, and complex cases may require additional considerations.
- Healthcare providers should apply cultural competence and sensitivity to ensure effective and respectful care based on their patients' diverse needs.
- Providers should always evaluate the limitations of diagnostic and screening tools, considering their potential for false results as well as any ethical implications.
- It is the responsibility of course participants to critically evaluate the evidence from multiple sources to guide professional practice.



Learning Outcomes

After this course, participants will be able to:

1. Explain the clinical relevance and interpretation of hearing aid test box and real-ear probe microphone measurements.
2. Discuss how to apply evidence-based strategies to integrate hearing aid verification into routine audiological practice using a problem-based learning approach.
3. Describe how the workbook can be used as a self-guided resource to reinforce clinical reasoning and support initial and continued learning in hearing aid verification.





Part 1:

Why are testbox and on-ear measurements important?

What value do they bring to our practice?

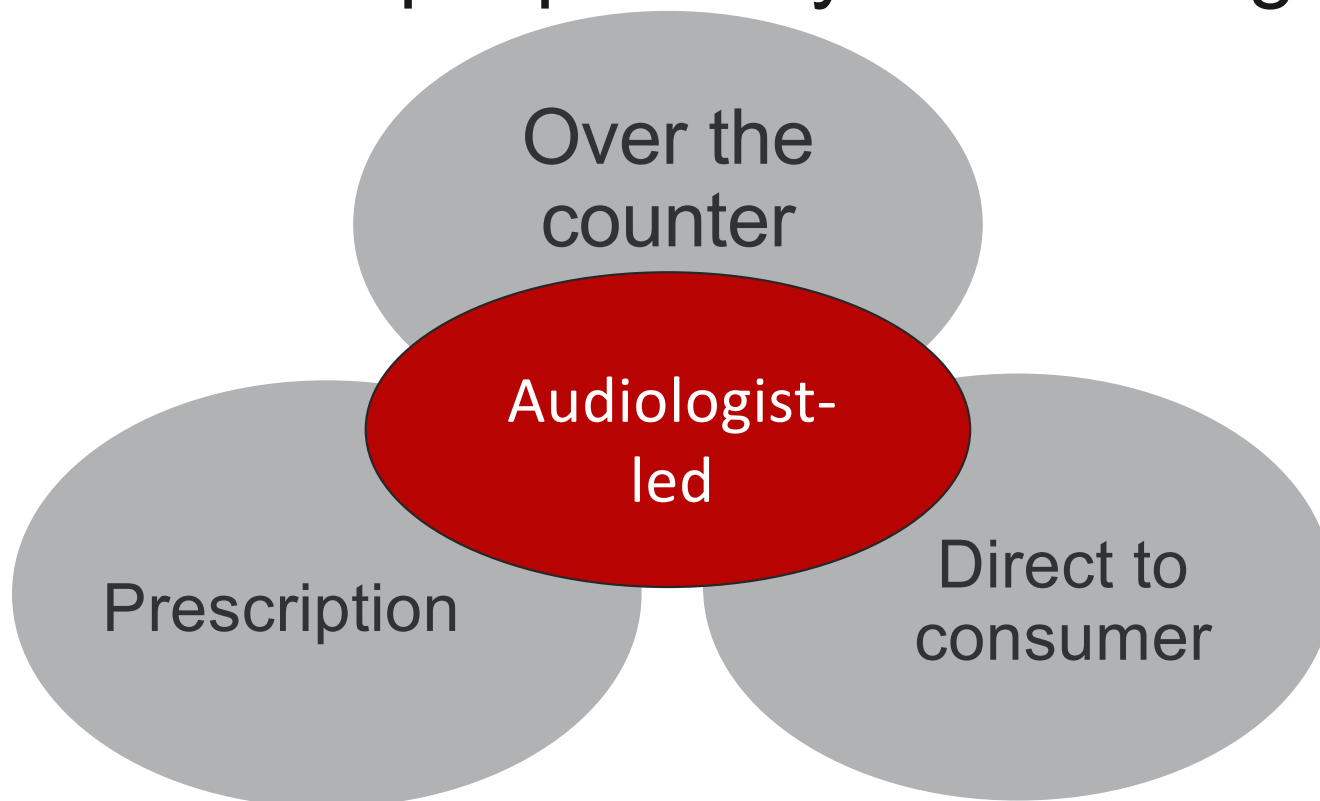
Who uses them and why?

Who doesn't and why not?

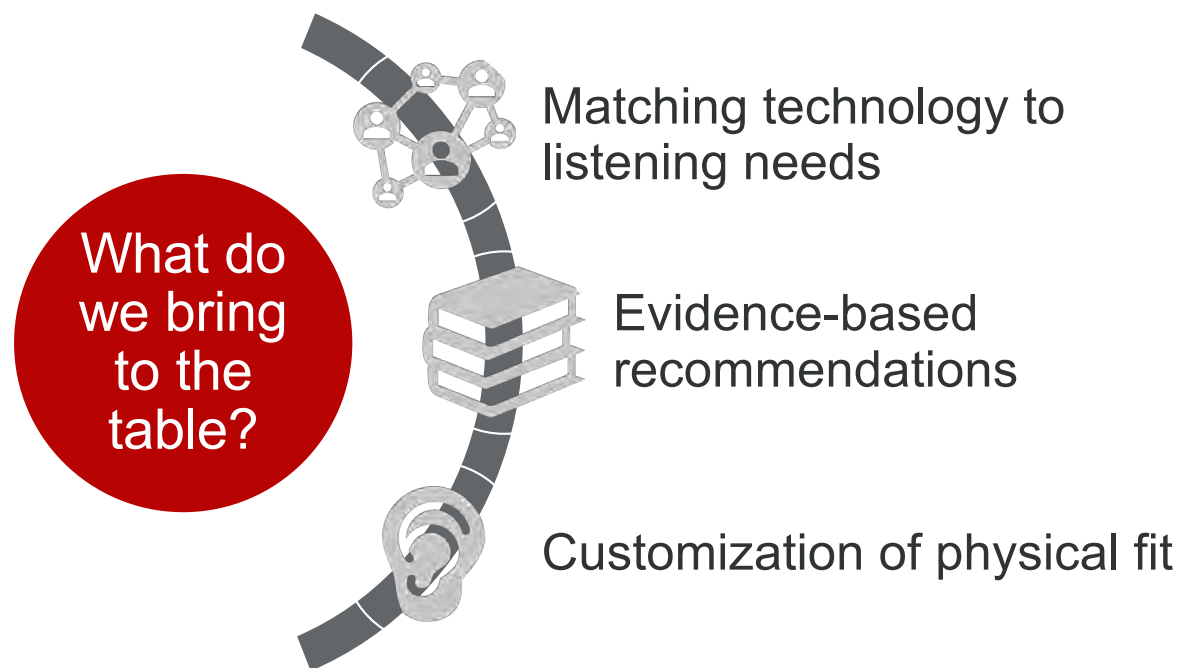
Can we increase the number of providers using them? How?



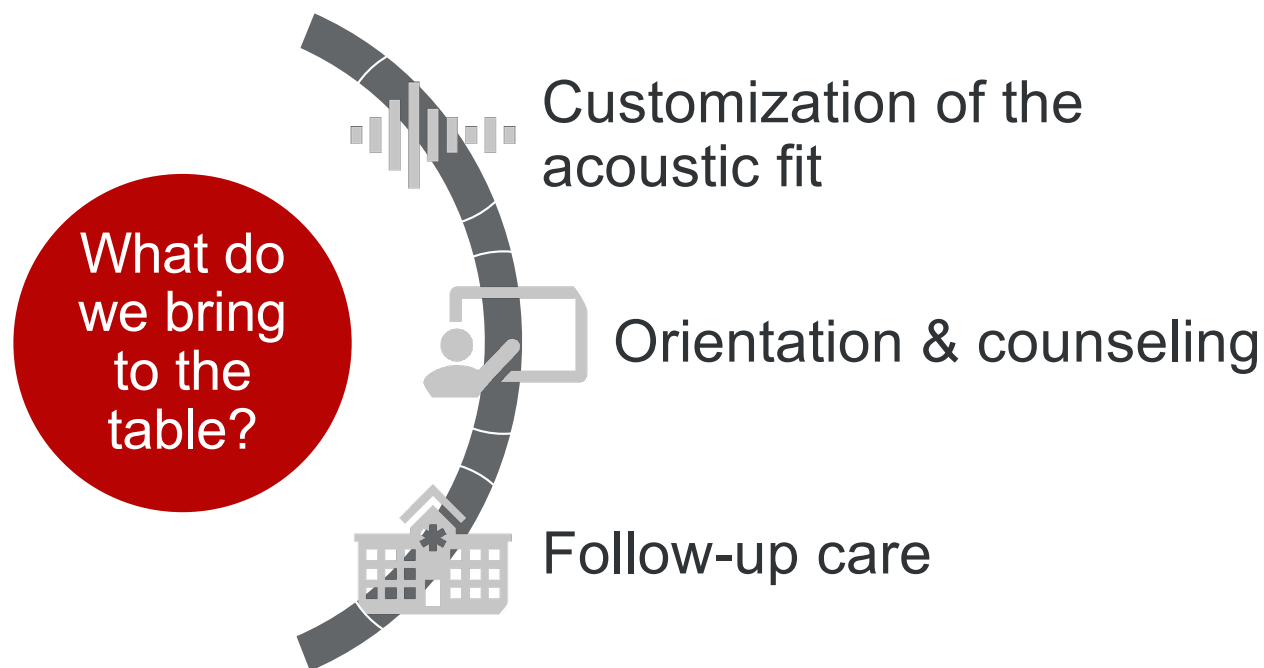
There are multiple pathways to hearing care.



Given these care options, why would a patient choose to see an audiologist?



Given these care options, why would a patient choose to see an audiologist?



The treatment for hearing loss is...

- ...audibility!
 - i.e., meeting evidence-based output targets such as DSL [i/o] v.5 or NAL-NL2
- Real-ear measurements are not a treatment. They are the way we verify that the treatment was achieved.





How many audiologists use real-ear probe-microphone measurements?



Image courtesy of Gus Mueller





How many audiologists use real-ear probe-microphone measurements?

20Q: Real-Ear Probe-Microphone Measures — 30 Years of Progress?

H. Gustav Mueller, PhD

January 13, 2014

[Articles](#) / [20Q with Gus Mueller](#) / [Hearing Aids - Adults](#) / [VA Selections](#) / [20Q: Real-Ear Probe-Microphone Measures — 30 Years of Progress?](#)

COVER STORY

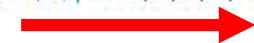
Probe-mic measures

Hearing aid fitting's most neglected element

Mueller, Gustav H.

[Author Information](#) ✓

The Hearing Journal 58(10):p 21-22,24,26,28,30, (



validity check

ARTICLE

Survey examines popularity of real-ear probe-microphone measures

Mueller, H. Gustav; Picou, Erin M.

[Author Information](#) ✓

The Hearing Journal 63(5):p 27-28,30,32, May 2010. | DOI: 10.1097/01.HJ.0000373447.52956.25





Why don't people use Real Ear Measurements?

High cost of equipment

Space demands

Time needed to perform the testing

Cumbersome nature of the real-ear measures (REM) equipment

A perceived uncertain correlation with hearing aid satisfaction

A misguided belief that REM cannot be used with digital hearing aids

Over-reliance on the manufacturers' "first-fit" algorithms

The belief that fitting software graphics are a good substitute for REM

Failure of training programs to emphasize the need for real-ear verification

Lack of best practices in clinics

Lack of dedication to best practices by some practitioners

The belief that procedures such as fitting the hearing aid in a sound field are superior to REM

“What have you tried already?”

Publication Date

September 1, 2006

Guidelines for the Audiologic Management of Adult Hearing Impairment

The specific goal of this guideline is to provide a set of statements, recommendations, and strategies for best practice in the provision of a comprehensive treatment plan for the audiological management of adults with hearing loss.

[READ MORE](#)

Task Force Members

Michael Valente, Chair
Harvey Abrams
Darcy Benson
Theresa Chisolm
Dave Citron
Dennis Hampton
Angela Loavenbruck
Todd Ricketts
Helena Solodar
Robert Sweetow

4	Test-retest reliability exceeding that demonstrated by other verification techniques has been demonstrated for probe microphone measurements. Deviations from target gain in a non-linear hearing aid may lead to reduced hearing aid benefit.	8-14	1	A	EF
4	Gain and output verification methods which are apparent alternatives to probe microphone techniques (namely functional gain and predicted gain) are limited in that (1) advanced signal processing features cannot easily be assessed; (2) ambient room noise, circuit noise, and low-level noise in the test environments may act as maskers; (3) artifacts with sloping hearing loss may lead to inaccurate results; (4) predicted gain measures are inaccurate.	15-18	2	B-C	EF

Valente, M; Abrams, H; Benson, D; Chisolm, T; Citron, D; Hampton, D; Loavenbruck, A; Ricketts, T; Solodar, H; Sweetow R.
 Guidelines for the audiologic management of adult hearing impairment. *Audiol Today*. 2006;18(5):1-44.

“What have you tried already?”

BEST PRACTICE It's a Matter of Ethics

PALMER, CATHERINE V.

Audiology Today 21(5):p 31-35, September-October 2009.

As a profession, it is
time to be expert.





“What have you tried already?”

Using real-ear
measurements to verify
hearing aid fittings....

Increases patient loyalty (Amlani, Pumford, & Gessling, 2017)

Results in fewer office visits (Kochkin, 2011)

Improves audibility (Aazh, Moore, & Prasher, 2012; Sanders et al, 2015; Leavitt & Flexer, 2012; Abrams et al, 2012; Aarts & Caffee, 2005; Hawkins & Cook, 2003)

Improves patient satisfaction (Kochkin et al, 2010, Beck, 2010)

Improves patient psychology toward audiology services and technology (Amlani, Pumford, & Gessling, 2016)

Improves real world outcomes (Valente et al, 2018)



Meet “Team HEARicane”



From left to right: Spencer Cheshire, AuD; Lori Zitelli, AuD; Trent Westrick, AuD; Jodi Baxter, AuD
JFLAC Class of 2018



Meet “Team HEARicane”



Team HEARicane Presentation
JFLAC Class of 2018; Reston, VA





AAA 2020 Member Connect Survey

Audiology Today

ONLINE FEATURE | The Results Are In: 2020 Member Survey of the Use of Real-Ear Probe Microphone Measurements

By Lori Zitelli, David Jedlicka, Tricia Scaglione, Leslie Cody, Allison Reitz, and Catherine Palmer

This article is a part of the *July/August 2021, Volume 33, Number 4, Audiology Today* issue.



Zitelli, L., Jedlicka, D., Scaglione, T., Cody, L., Reitz, A., & Palmer, C. ONLINE FEATURE - The Results Are In:
2020 Member Survey of the Use of Real-Ear Probe Microphone Measurements. *Audiology Today*. 2021; (July/August): 1-15.

Assess the stage of readiness first.

STAGE OF CHANGE	EXAMPLE QUESTIONNAIRE ITEM
1. Pre-Contemplation	I have never thought about using real-ear probe microphone measures
2. Contemplation	I have considered using real-ear probe microphone measures
3. Preparation	I have purchased equipment that will allow me to complete real-ear probe microphone measures
4. Action	I use real-ear probe microphone measures
5. Maintenance	I use real-ear probe microphone measures routinely
6. Relapse	I used to do real-ear probe-microphone measures, but have stopped

TABLE 2. Survey Items Corresponding to Stages of Change

QUESTION 3

FOR AUDIOLOGISTS - Please select the statement that most accurately reflects your behavior related to real-ear probe microphone measurements:

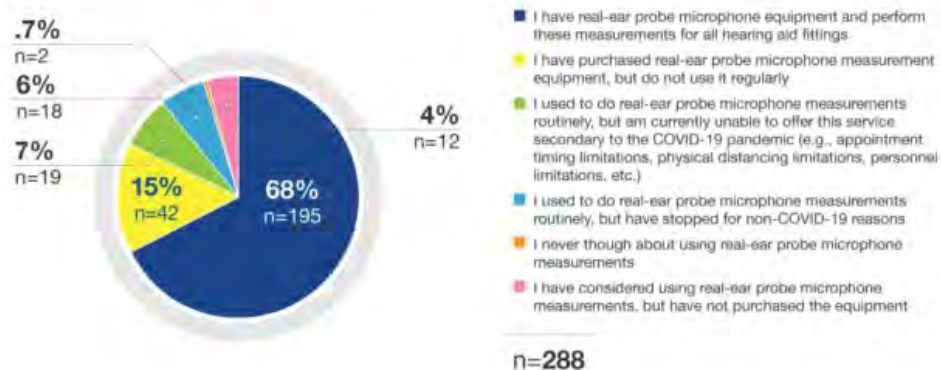


Image courtesy of Audiology Today

What are reported barriers to REM use?

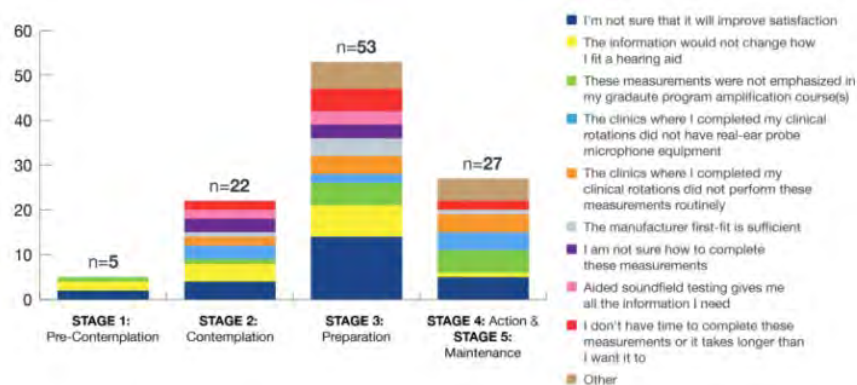


FIGURE 2. Barriers to Real-Ear Probe Microphone Use Reported by Audiologists in Stages 1-5

Image courtesy of *Audiology Today*

STAGE OF CHANGE

TOP 2 BARRIERS REPORTED

1. Pre-Contemplation (n=2)

I'm not sure that it will improve satisfaction.
The information would not change how I fit the hearing aid.

2. Contemplation (n=12)

3. Preparation (n=42)

4. Action and 5. Maintenance (n=195)

I'm not sure that it will improve satisfaction.
These measurements were not emphasized in my graduate program amplification course(s).

6. Relapse (n=37)

I'm not sure that it will improve satisfaction.
The information would not change how I fit the hearing aid.

TABLE 3. Top 2 Barriers Reported by Audiologists in Each Stage

Proposed solutions to increase REM use (provided by stakeholders)

STAGE OF CHANGE	TOP 2 SOLUTIONS PROPOSED
1. Pre-Contemplation	<i>(no solutions were submitted by this group)</i>
2. Contemplation	Employer must purchase equipment Make the equipment more affordable
3. Preparation	Allow longer appointment times Provision of newer equipment or equipment that is easier to use
6. Relapse	Waiting for the end of the COVID-19 pandemic Current employer must purchase equipment

TABLE 4. Solutions Proposed by Audiologists Not Using Real-Ear Probe Microphone Measurements

Zitelli, L., Jedlicka, D., Scaglione, T., Cody, L., Reitz, A., & Palmer, C. ONLINE FEATURE - The Results Are In: 2020 Member Survey of the Use of Real-Ear Probe Microphone Measurements. *Audiology Today*. 2021; (July/August): 1-15.

AAA Hands On Verification Pavilion





Bridging Part 1 and Part 2...

- Real ear probe microphone measures improve outcomes
- Providers who don't use these measurements routinely have told us that they want longer appointment times and equipment that is easier to use
- The goal of this resource is to increase familiarity with these measurements so that clinicians can be more efficient with their time and be confident that they are providing an audible signal





Part 2:

How to integrate this into curriculum for student use

How experienced clinicians can use this to learn new skills or brush up on older skills



Mead Killion Test Box Workbook circa 1984

(Larry Revit, teaching assistant)

ANSI testing – we could push the buttons
and explain the graphs, but unclear when
we would do these tests.



Image courtesy of Mead Killion

Guiding training by the clinical questions that will be posed by patients...

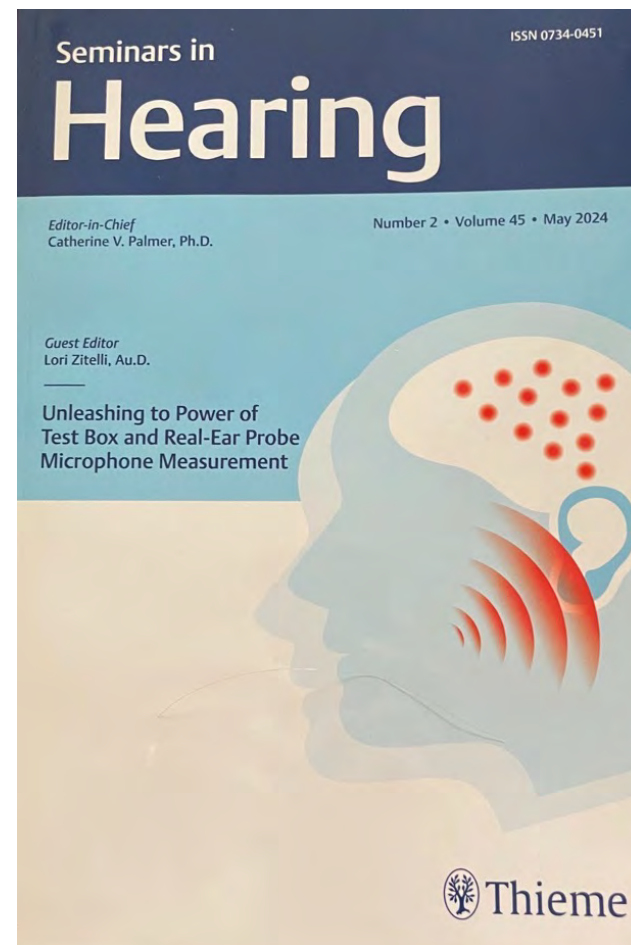
- Students who contributed to the Hearing Aid Test Box workbook in 2007 included A. Antoline, N. Beninati, K. Burkardt, G. Genna, W. Hurley, D. Jedlicka, A. Lao, D. Russell, M. Vargo, and R. Weyman
- In 2009, students of a new class contributed to the Probe Microphone workbook and included E. Becker, J. Cosey, L. Diethorn, K. Faunce, J. Fruit, J. Kisiday, H. Li-Korotky, K. Monahan, S. Morningstar, M. Mueller, R. Mulla, A. Ripepi, K. Rorabaugh, J. Shalles, S. Sohns, N. Stark, H. Taslov, M. Ulep, C. Variava, R. Williams, and L. Zitelli.
- Dr. Lindsey Jorgensen and her students, Michelle Novak and Emily Paris, updated the workbooks to be compatible with the Verifit 2 equipment in 2017 and 2019.
- Finally updated in 2024.



CONTINU^{ed}



Seminars in
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How to Use This Workbook

Chapter 1: Introduction and Getting Ready for Hearing Aid Test Box Measures

Chapter 2: My Hearing Aid Isn't Working Like It Used to...

Chapter 3: Setting the Hearing Aid Response and Verifying Signal Processing and Features in the Test Box

Chapter 4: Introduction and Getting Ready for Real-Ear Probe Microphone Measures

Chapter 5: Setting the Hearing Aid Response and Verifying Signal Processing and Features with Real-Ear Probe Microphone Measures

Chapter 6: What Else Can I Do with This Equipment?

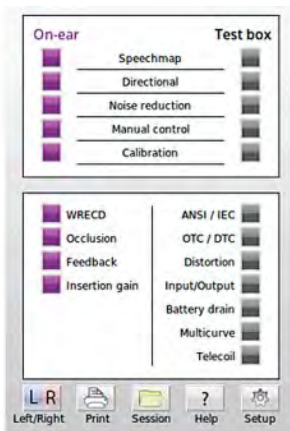
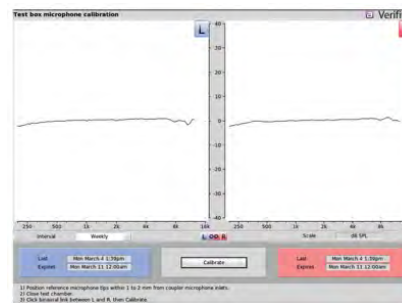
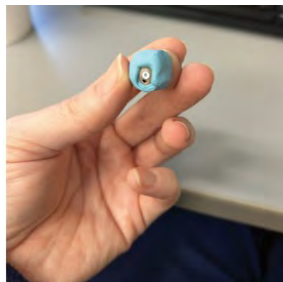




Chapter 1: Introduction and Getting Ready for Hearing Aid Test Box Measures

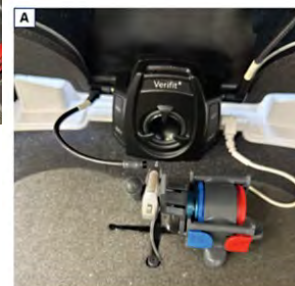
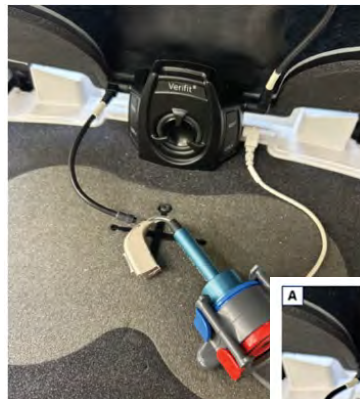


What to expect in every chapter



Use silver coupler(s)

Use blue coupler(s)





Chapter 2: My Hearing Aid Isn't Working Like It Used to...



ANSI tests

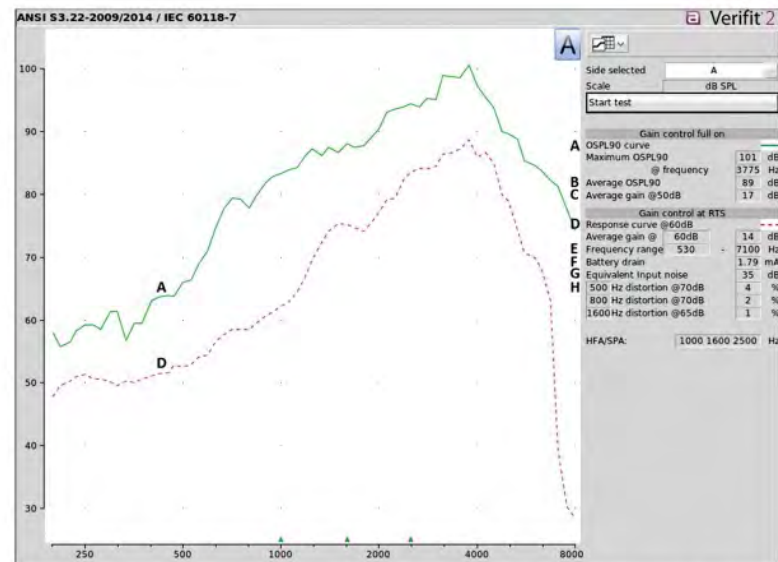


Figure 1 ANSI test results. A = OSPL90 curve; B = average OSPL90; C = average gain at 50 dB; D = frequency response curve; E = frequency range; F = distortion measurements; G = EIN; H = battery drain.

My hearing aid is weak.

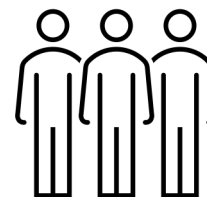
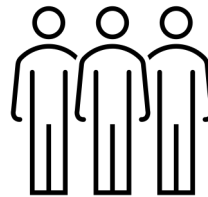
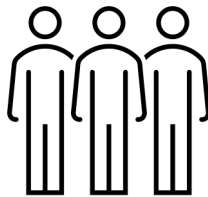
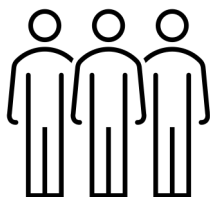
I have to replace the battery in my hearing aid every day.

My hearing aid sounds different.

My hearing aid is noisy.

My hearing aid is not working.

There is a lot of static in my hearing aid.



For every question...

- Introduction (tutorial)
- Materials needed for this activity
- Activities
 - Step by step instructions
 - Pictures of every step
- Helpful Hints related to clinical practice
 - e.g., If you have enabled the telecoil, take the time to practice with the patient so they know how to engage the telecoil and manipulate volume in this setting. Make sure they know they need to switch out of the telecoil setting to return to normal listening.



Example activity

Activity 9

1. Run a battery drain test on a hearing aid assuming your patient uses the hearing aid 15 hours per day.
2. How many days would you expect a battery to last in this hearing aid? Do you think this battery life would be acceptable to a patient?
3. What factors related to the patient's use of the hearing aid could impact this estimate?



Figure 11 Placement of the battery pill into a hearing aid.



Figure 12 Connecting a hearing aid to the correct coupler with the battery pill in place.



Chapter 3: Setting the Hearing Aid Response and Verifying Signal Processing and Features in the Test Box



Audiologist's Question

- How can I pre-set this hearing aid for a patient who can't sit through the testing?
- How do I know the telecoil is working?
- How do I know if the directional microphone is working correctly?
- How do I know if the frequency lowering feature is working?
- How do I know if the noise reduction feature is working?
- How do I verify that the amplification the patient receives through the hearing aid coupled to the remote microphone is correct?
- How do I know that the OTC hearing aid my patient purchased provides appropriate audibility for them?

Patient's Issue

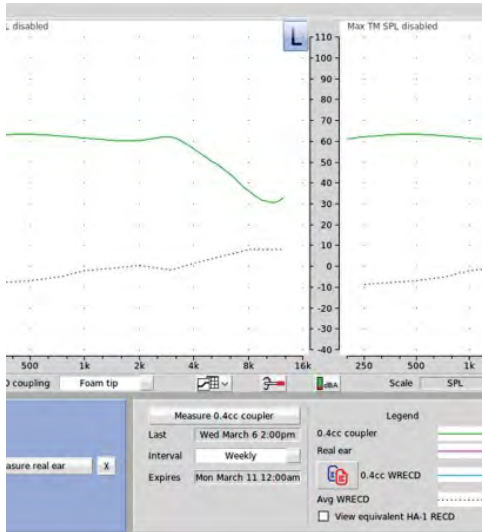
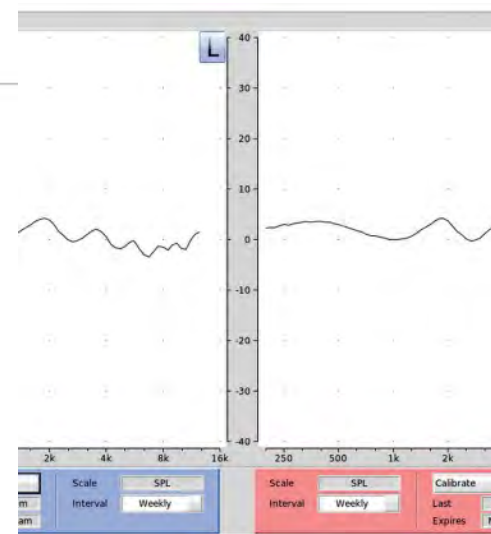
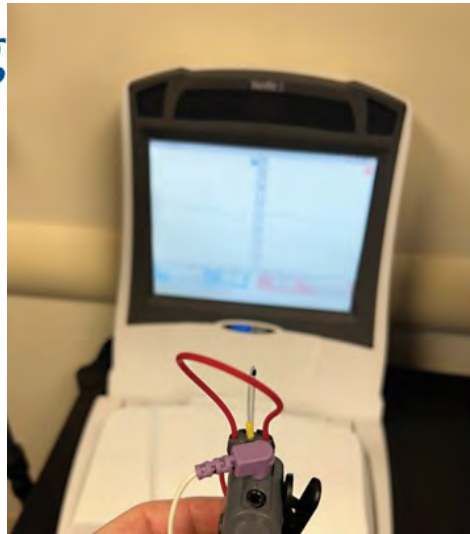
- Sounds are too quiet when I am listening on the phone through my telecoil.
- When I use my telecoil in my synagogue, the Rabbi sounds quiet.
- You told me about the advantage of directional microphones, but I'm not noticing a benefit.
- I still can't hear my phone ring. I can't hear my grandchildren.
- When I enter a noisy room, the hearing aid turns off and then comes back on slowly.
- I still can't hear my partner very well even when we use the remote microphone.
- I hear a lot of static in this hearing aid that I bought at the drug store.



Chapter 4: Introduction and Getting Ready for Real-Ear Probe Microphone Measures



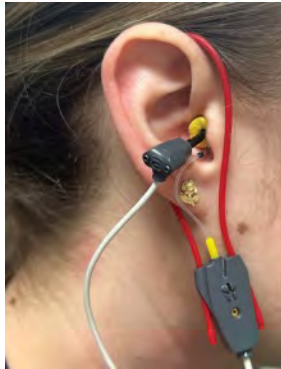
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Chapter 5: Setting the Hearing Aid Response and Verifying Signal Processing and Features with Real-Ear Probe Microphone Measures





Audiometry

Targets: DSL adult

Age: Adult

HL transducer: Insert + foam

RECD: Measure

RECD coupling: Foam tip

Binaural: Yes

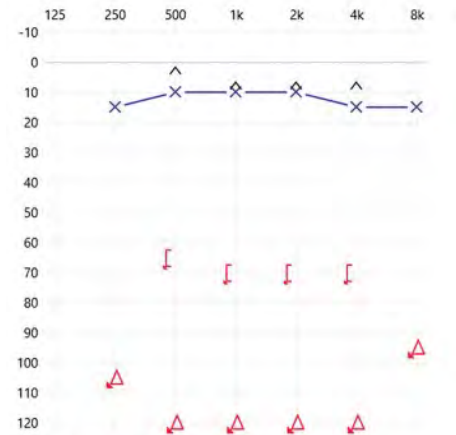


Figure 15 Audiogram for CROS fitting example.

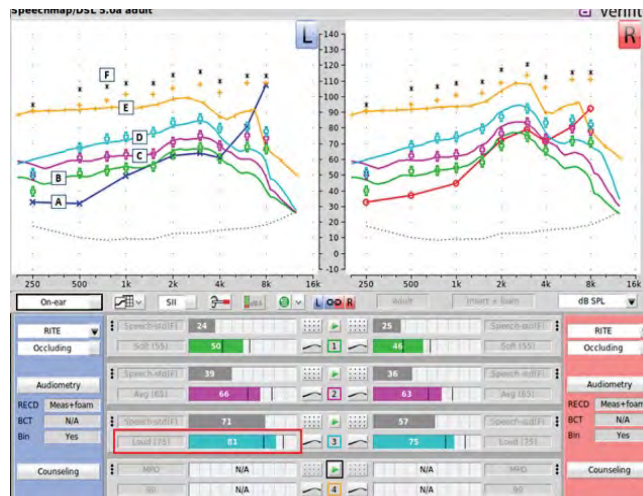


Image courtesy of OpenClipArt.org





Chapter 6: What Else Can I Do with This Equipment?





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Photo by [Unsplash](#) from [Freerange Stock](#)



Image created using ChatGPT



Image created using ChatGPT



See page for author, Public domain, via Wikimedia Commons



Hands on Set Up

- Do you do this as part of a lab?
- Is this independent work?
- Access to the equipment?
- Scheduled times for pairs of students?
- Provide the needed materials?
- Probe mics, earphones, hearing aid domes – students keep these for the semester.
- How are they turning in the assignments?





Students should access the User Manual for whatever equipment they are using.



Clinical Instructors

- Send them the link so they know what the students are learning.
- If there is down time in clinic, clinical instructors could pick an activity for the student to complete – great practice.
- The clinical instructor can reinforce this learning – “Given what the patient has just told us, what test do we have available that could help us figure out the problem?”





Bridging Part 2 and Part 3...

- Now that you know what's in this resource, let's look at some specific examples and think about how they may be useful in your clinical practice





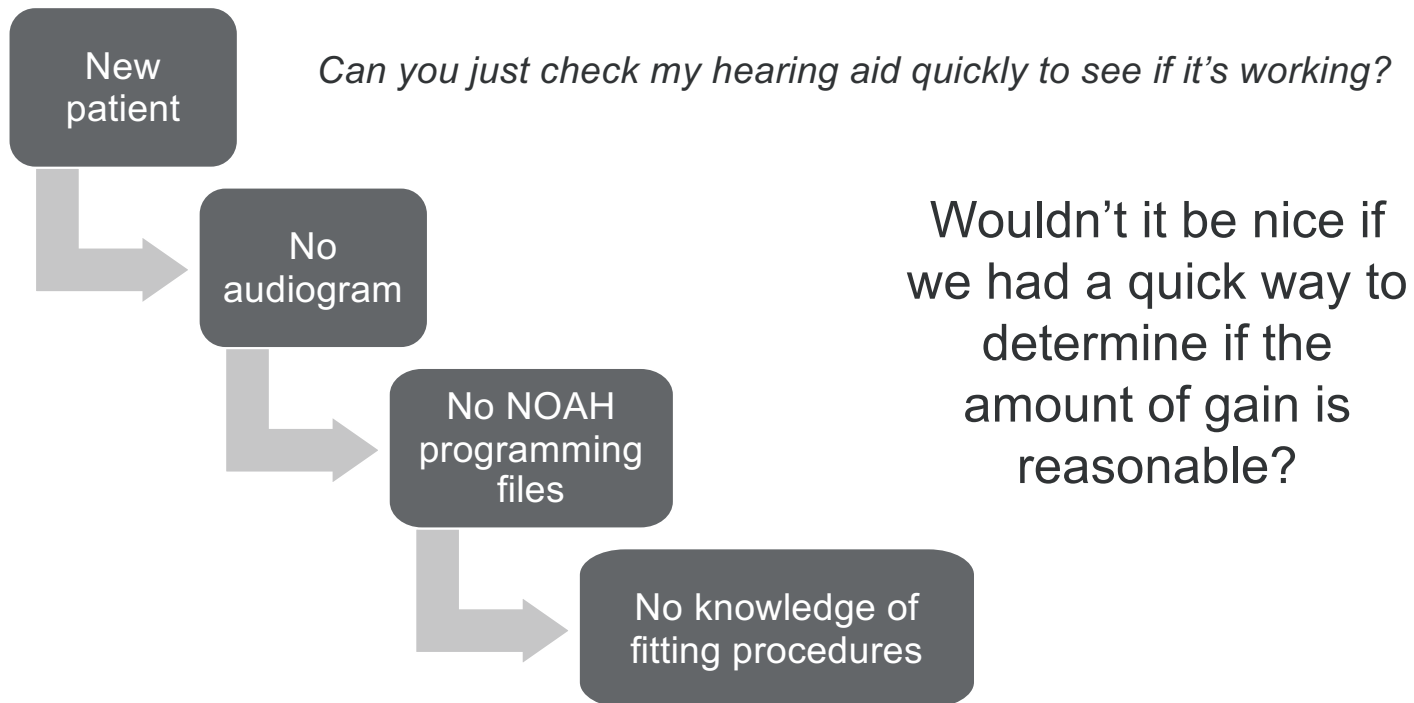
Part 3:

Examples

Tips



Many patients find their way to our clinic after purchasing hearing aid(s) elsewhere...

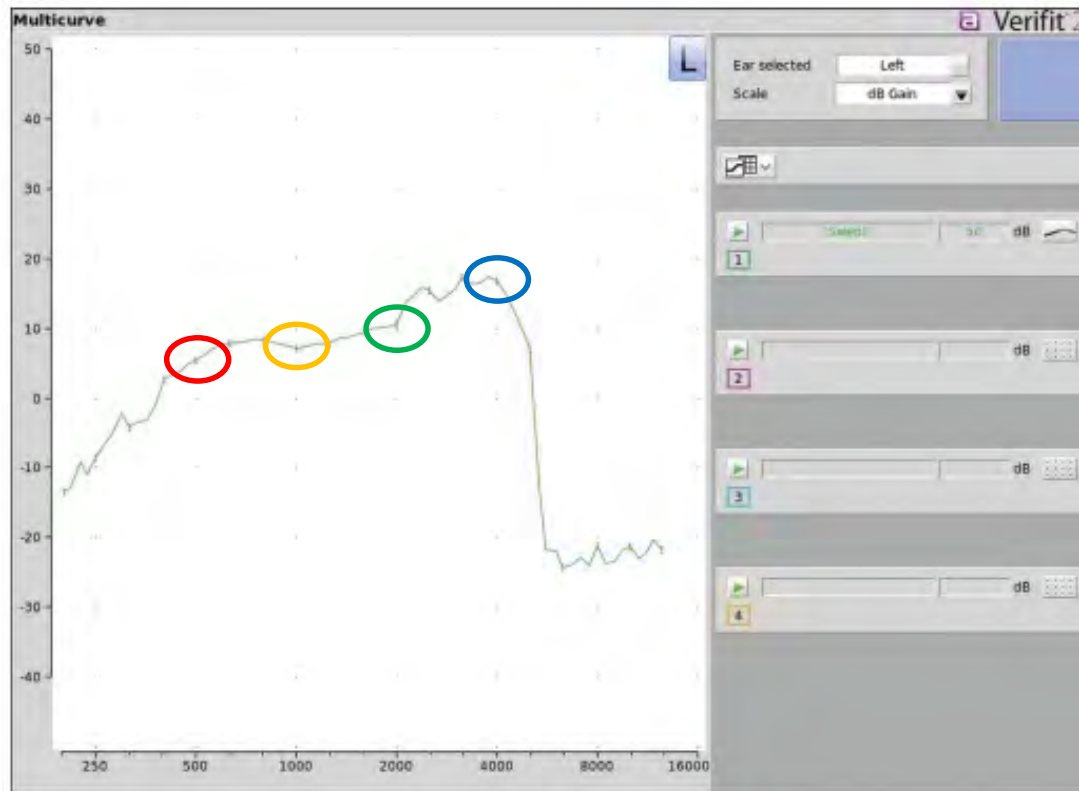




*“Is the hearing aid programmed with the appropriate gain for **moderate input levels** when compared to your patient’s hearing loss?”*

- 1/2 (DSL) and 1/3 (NAL) gain rules
- Given a 60 dB HL air conduction threshold at 1000 Hz...
 - 1/2 gain rule?
 - 1/3 gain rule?



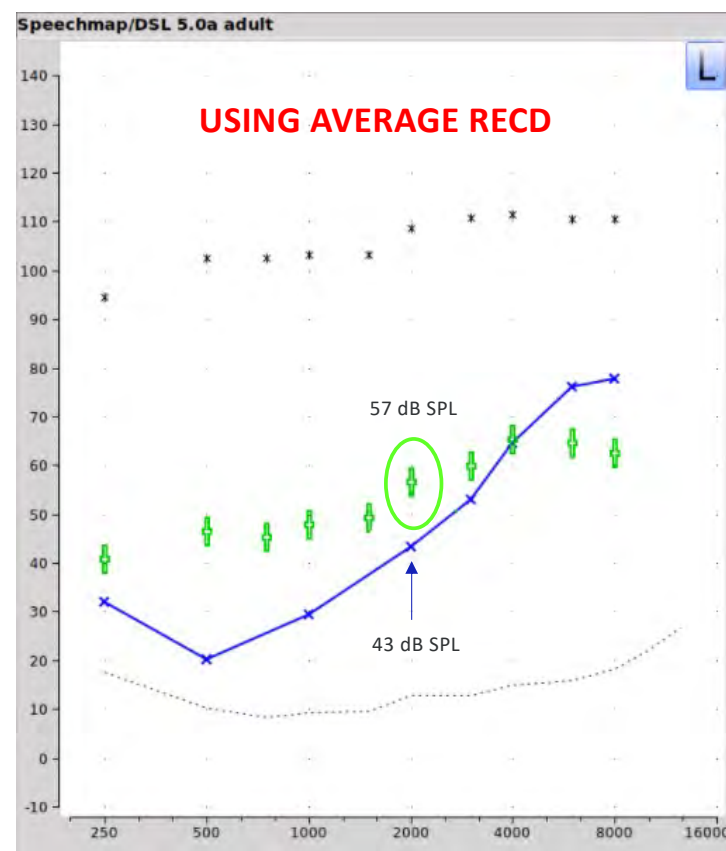
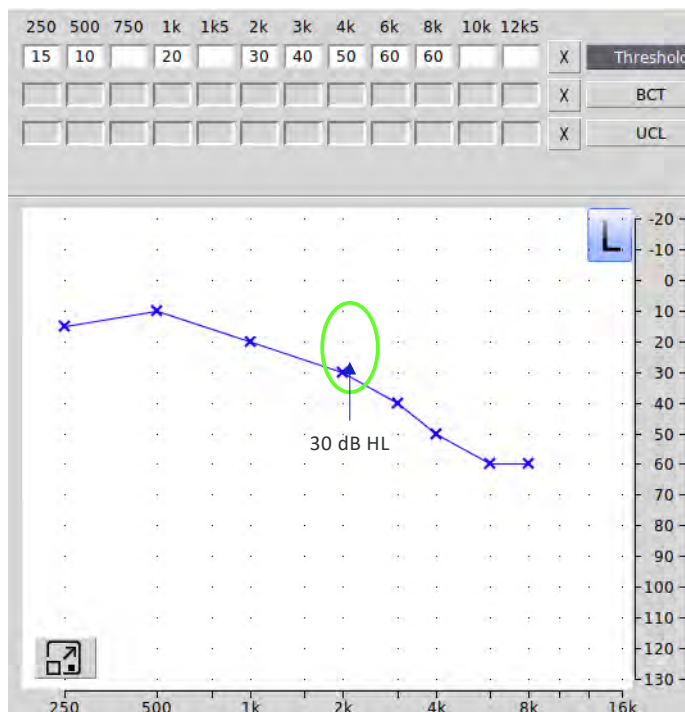


NOTE: THIS IS NOT A SUBSTITUTE
FOR REAL EAR PROBE
MICROPHONE MEASUREMENTS!

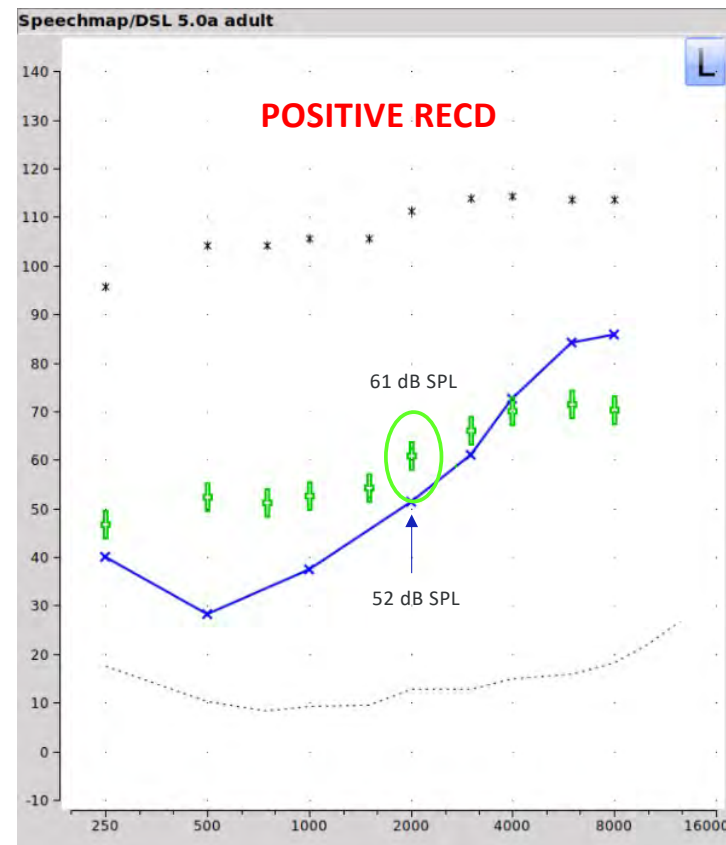
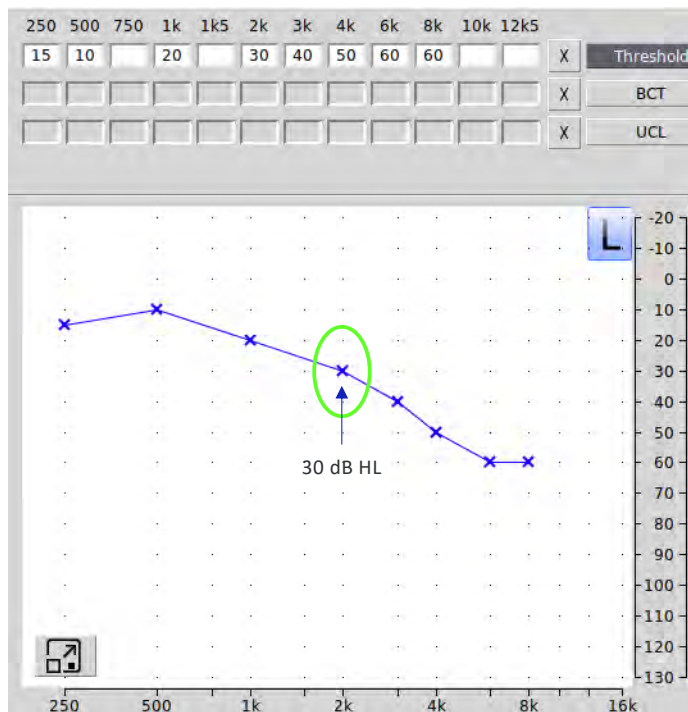
Table 4 Complete the following chart based on your hearing aid measurements

Frequency	Pt thresholds (left ear)	HA gain	1/3 Gain rule	1/2 Gain rule	Appropriate?
500 Hz	30 dB HL	5 dB	10	15	NO
1,000 Hz	45 dB HL	7 dB	15	23	NO
2,000 Hz	65 dB HL	10 dB	22	33	NO
4,000 Hz	70 dB HL	16 dB	23	35	NO

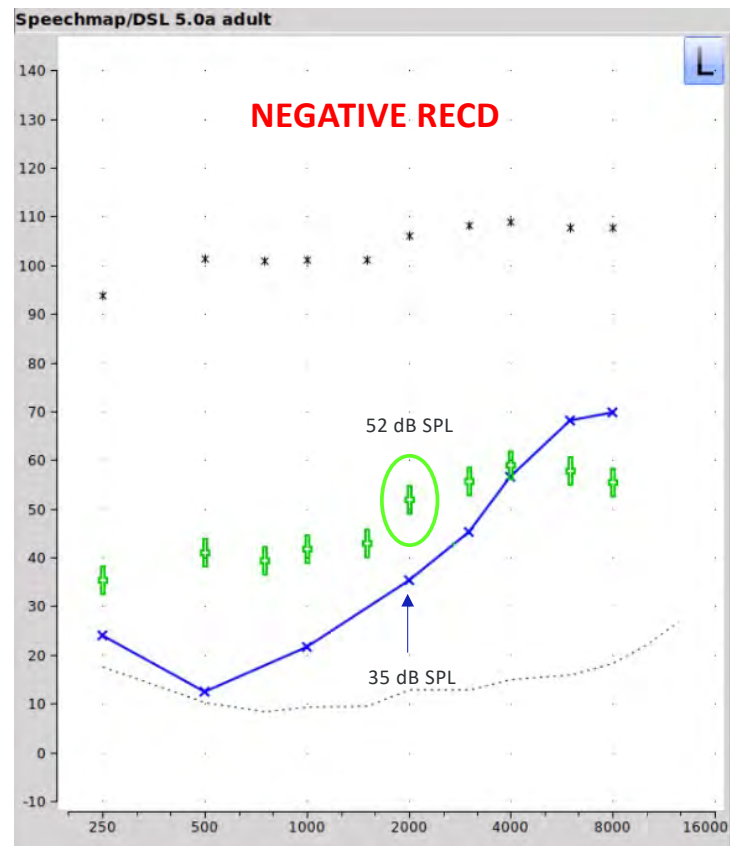
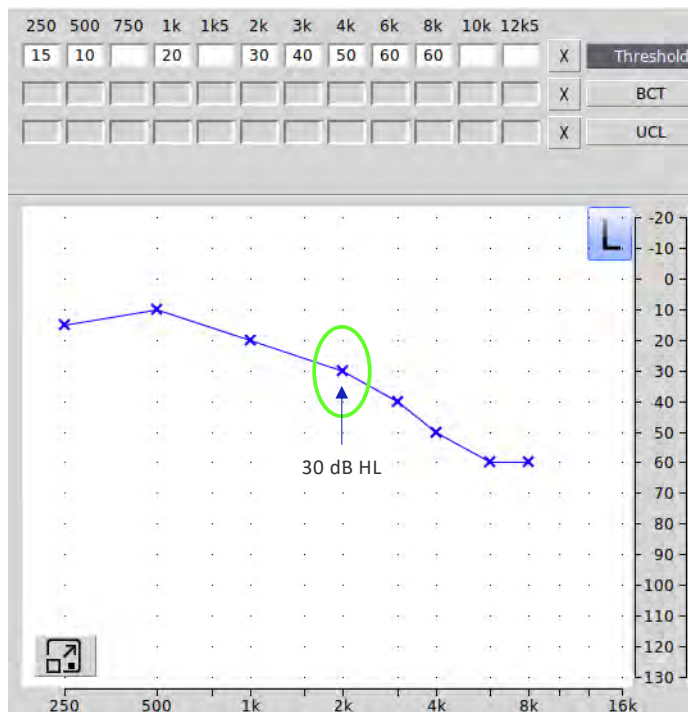
RECD is a powerful tool...
but only if we use it.



What if we had someone with a smaller ear?



What if we had someone with a larger ear?



Most patients are not average and your fitting is not customized unless you apply measured RECD.

	dB SPL output	If we had used average RECD, this patient would have been...	because...
A person with average RECD would need _____ at 2000 Hz...	57 dB SPL	FIT APPROPRIATELY	They needed 57 dB SPL. <i>They got 57 dB SPL.</i>
The person with the smaller ear needed _____ at 2000 Hz...	61 dB SPL	UNDERFIT	They needed 61 dB SPL. <i>They got 57 dB SPL.</i>
The person with the larger ear needed _____ at 2000 Hz...	52 dB SPL	OVERFIT	They needed 52 dB SPL. <i>They got 57 dB SPL.</i>



Maximize your level of customization by applying measured RECD to your Real-Ear Aided Response measurements

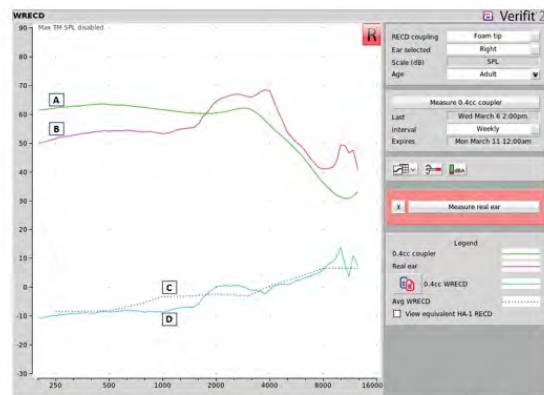


Figure 5 This graph illustrates a patient's WRECD. (A) The 0.4-cc coupler response (output); (B) the real-ear response (output); (C) the average expected WRECD from an average ear; (D) the individual's measured WRECD.

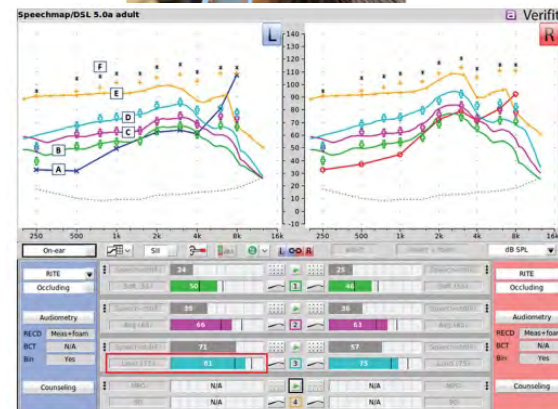


Figure 13 Speechmapping or REAR. (A) Thresholds; (B) soft input (55 dB SPL); (C) moderate input (65 dB SPL); (D) loud input (75 dB SPL); (E) MPO; (F) estimated UCLs.



Jorgensen L, Barrett R, Jedlicka D, Messersmith J, Pratt S. Real-ear-to-coupler difference: Physical and perceptual differences.
Am J Audiol 2022;31 (04):1088–1097

SII can be an efficient way to determine if you've returned audibility appropriately.

- Speech intelligibility index (SII) = percentage of input signal that is audible



Figure 12 Probe tube and RITE in an ear.

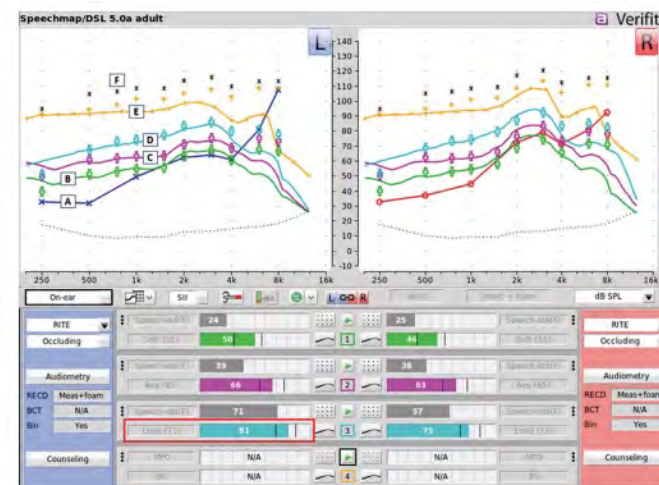


Figure 13 Speechmapping or REAR. (A) Thresholds; (B) soft input (55 dB SPL); (C) moderate input (65 dB SPL); (D) loud input (75 dB SPL); (E) MPO; (F) estimated UCLs.

American National Standards Institute / Acoustical Society of America. (1997). Methods for Calculation of the Speech Intelligibility Index. (ANSI/ ASA S3.5–1997).
 Dao A, Folkeard P, Baker S, Pumford J, Scollie S. Fit-to-targets and aided speech intelligibility index values for hearing aids fitted to the DSL v5-adult prescription. *J Am Acad Audiol* 2021;32(02):90–98

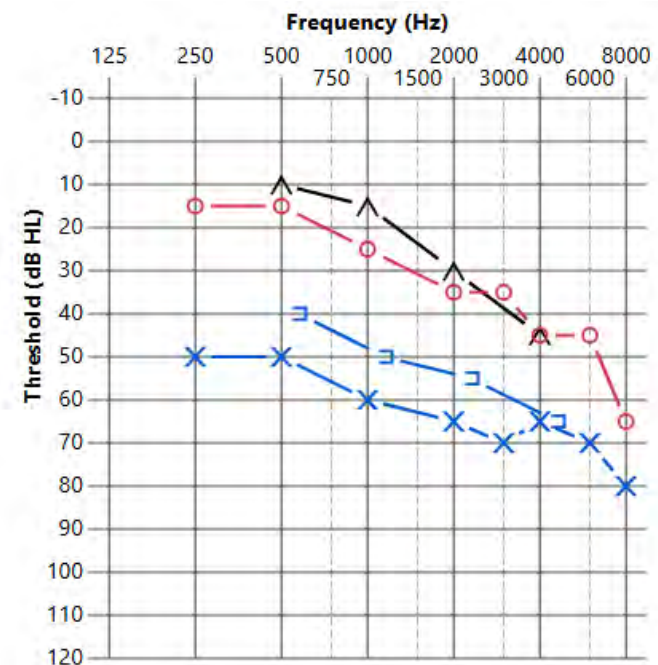
Meet Judy: 69 y/o female

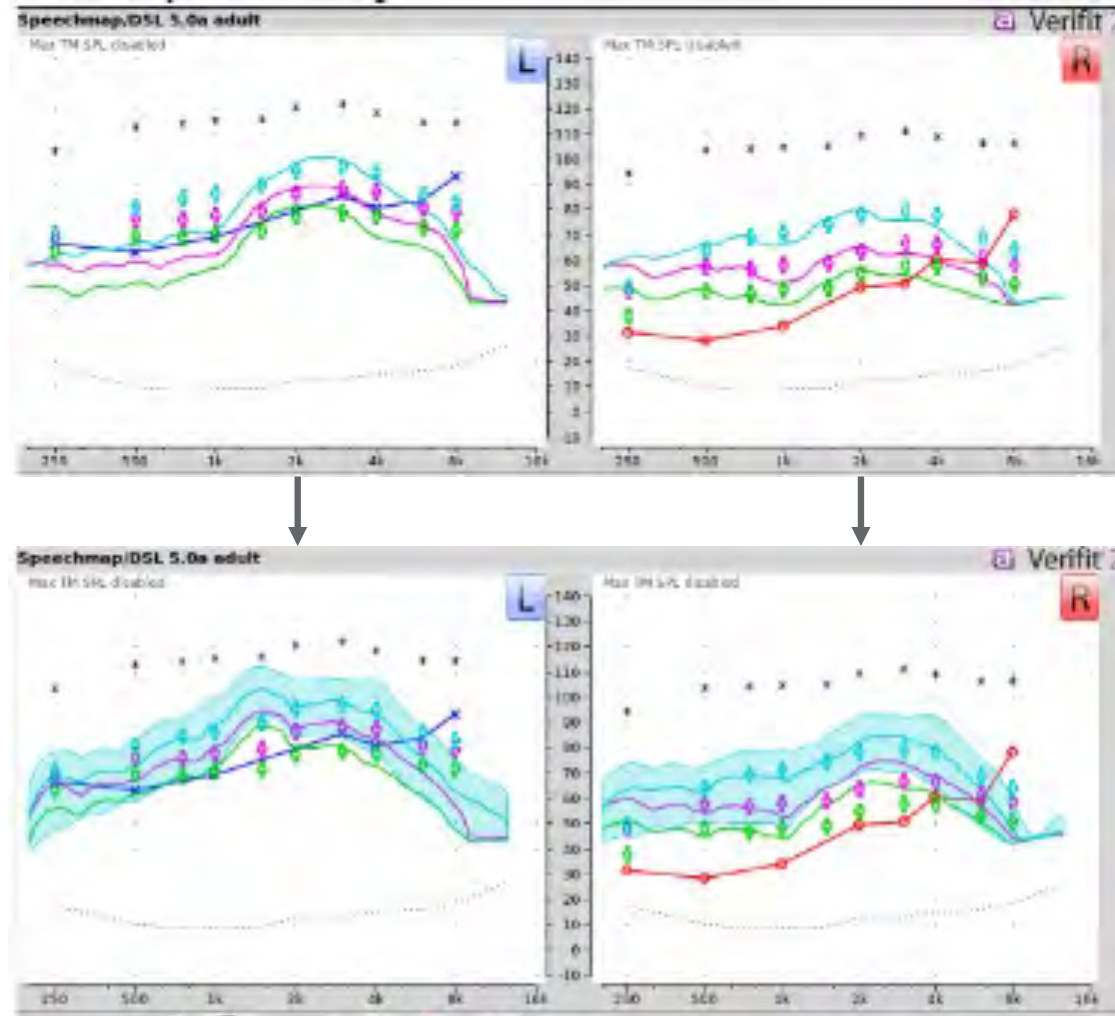
- Oticon RICs (purchased 3 years ago from outside clinic)
- Listening needs
- COSI

Hearing thresholds are stable from audiogram on 6/2/25

Word Recognition

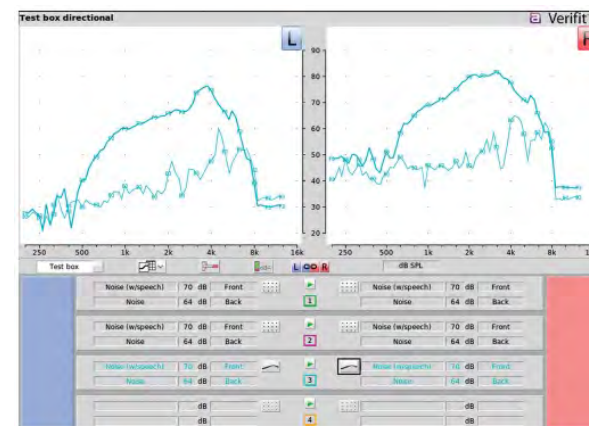
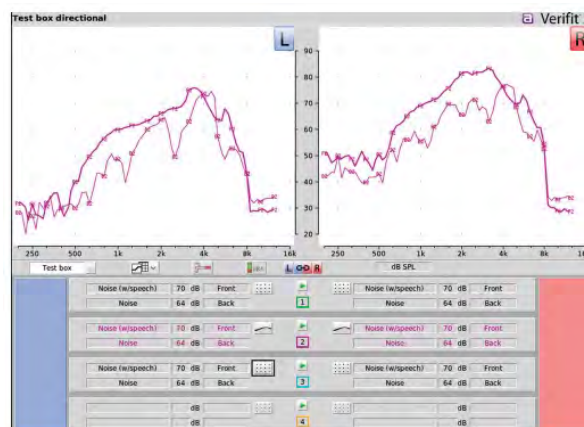
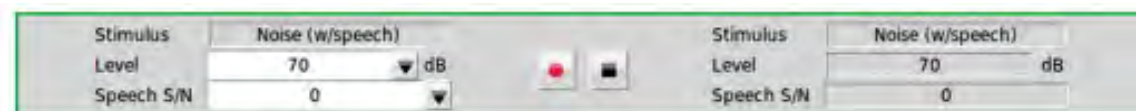
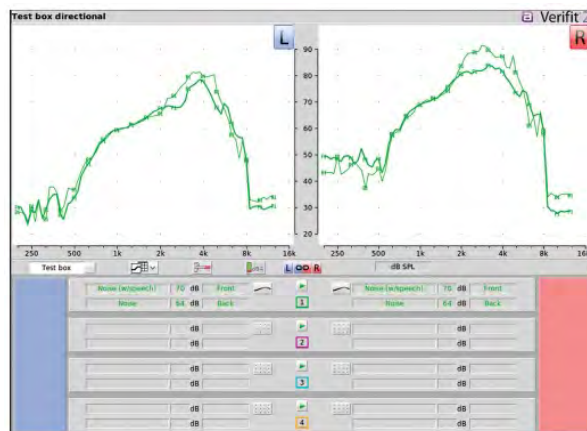
Word recognition in quiet at elevated levels was 100% in the right ear and 80% in the left ear.



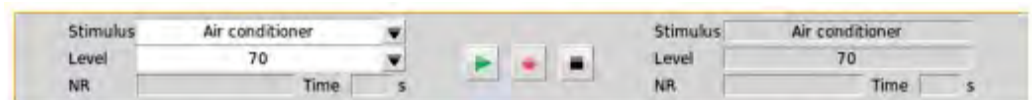
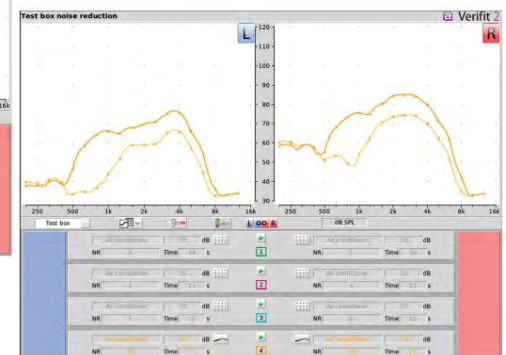
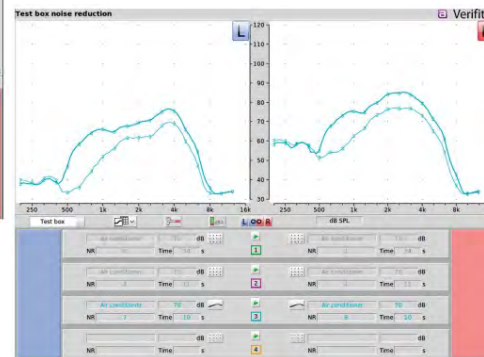
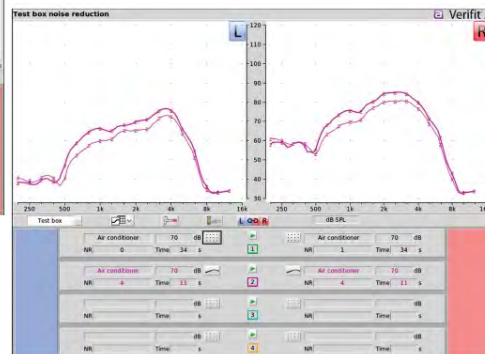
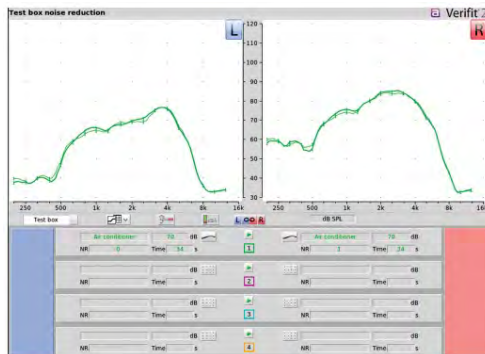




You can verify features on-ear or in the testbox (e.g., d-mics).

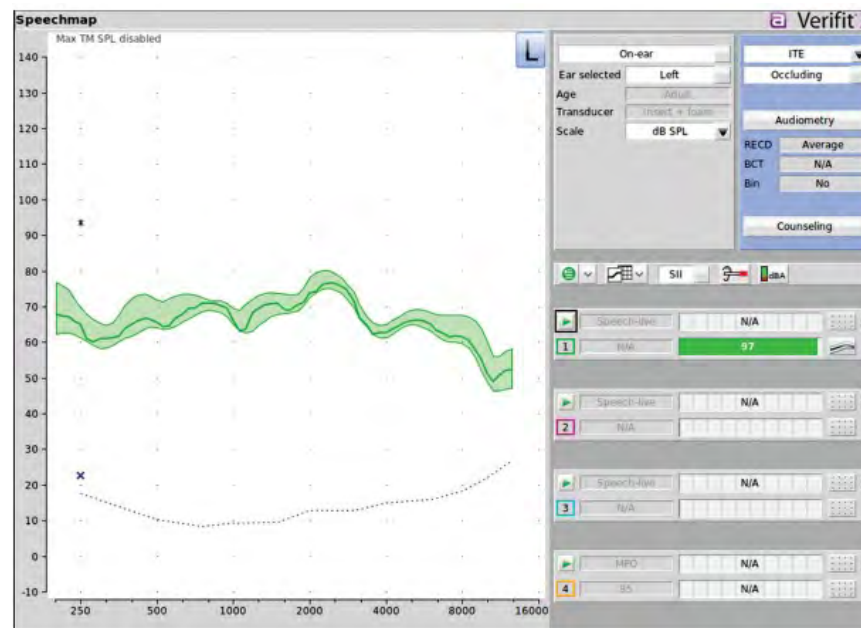


You can verify features on-ear or in the testbox (e.g., noise reduction).



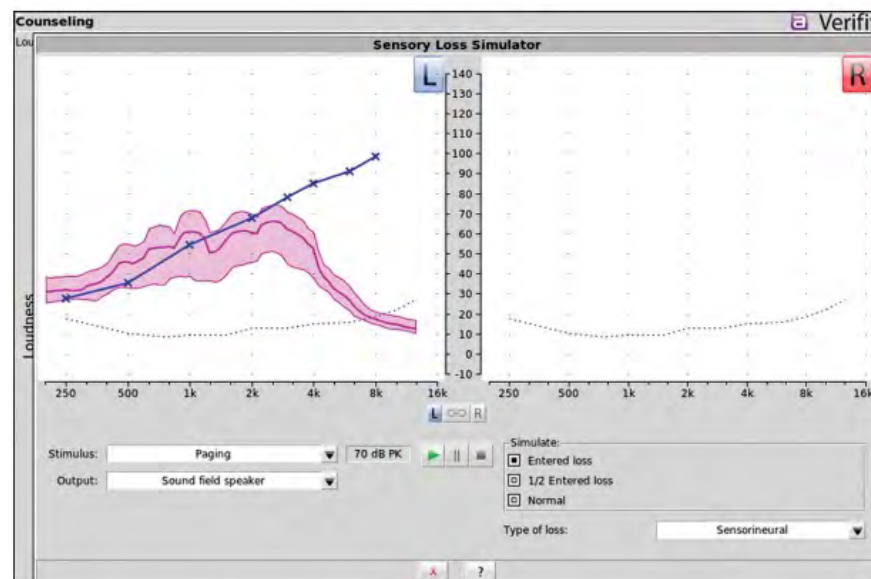
Real-ear measurements can be an excellent counseling tool.

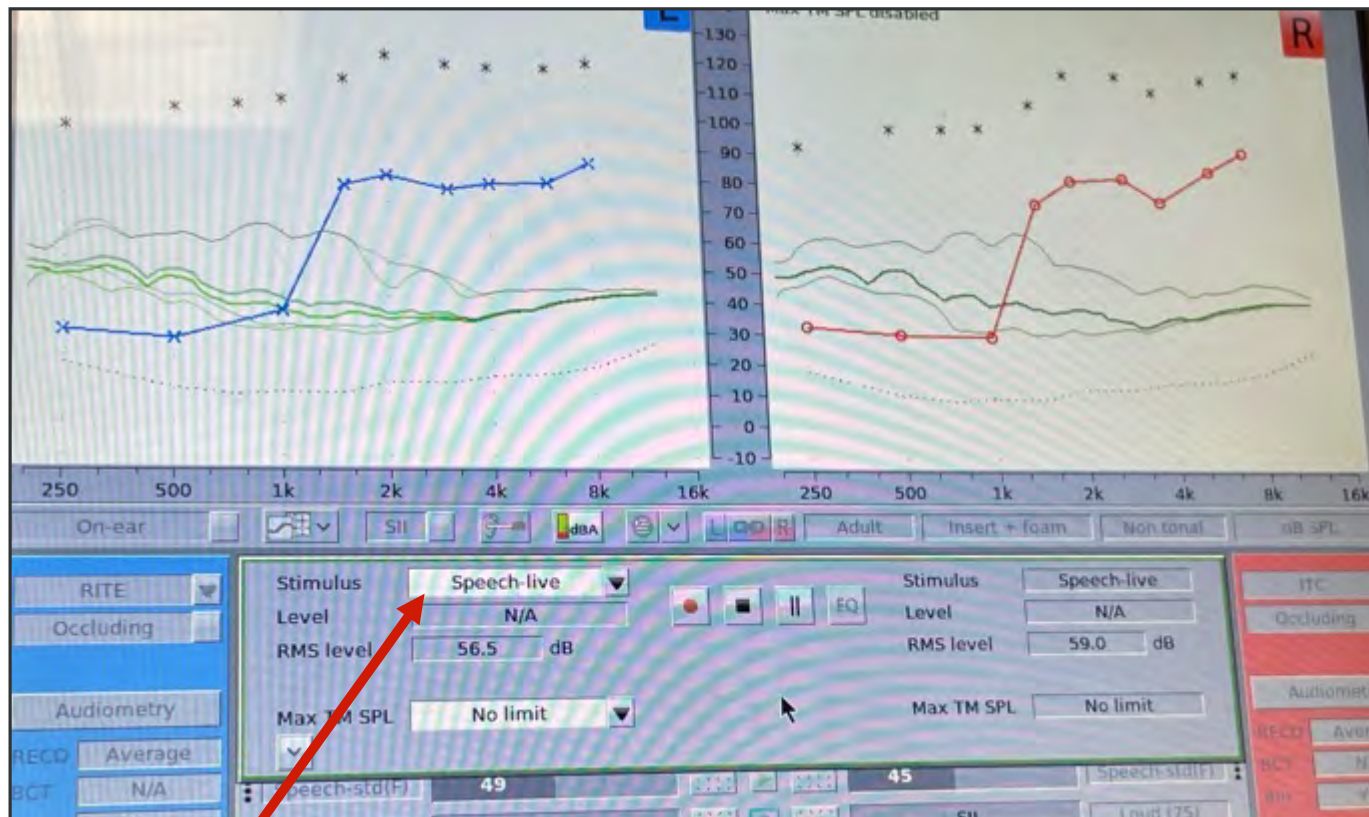
- “Is my child listening to their earbuds too loudly?”



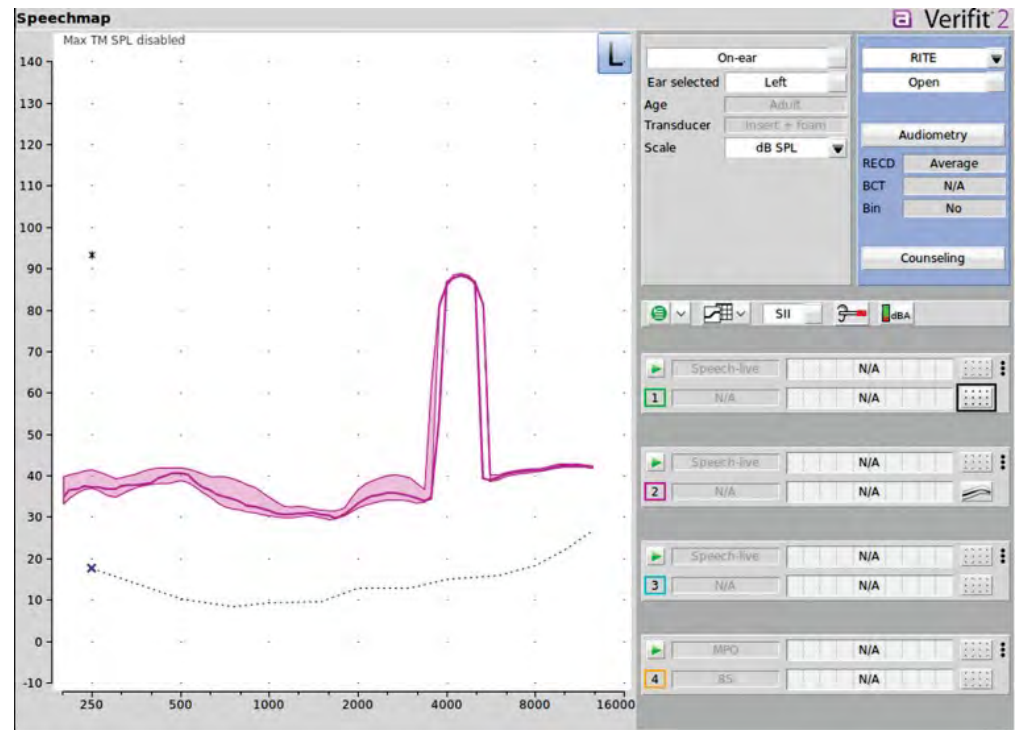
Real-ear measurements can be an excellent counseling tool.

- “My wife got really mad at me because I missed the announcement at the airport and went to the wrong gate.”





Feedback



Take Home Messages

- Our ability to customize and precisely program devices for our patients sets us apart from other pathways to care, but only if we use the tools available to us
- We hope these resources support you.
 - Reminder that this workbook is Open Access (many thanks to the Eye & Ear Foundation of Pittsburgh)!



<https://www.thieme-connect.com/products/ejournals/issue/10.1055/s-014-59739>





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