



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

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ABSTRACT

If there is sound in the ear canal, you can measure it with a probe microphone in the ear. The following are a few examples of how you might use your real-ear probe microphone measures beyond verifying hearing aid fittings, signal processing, and function of features. A process to simulate hearing loss to **educate** and support family members and patients is described.

KEYWORDS: occlusion effect, earmold, voice audibility, feedback, hearing protection, simulated hearing loss

ASSESSING THE OCCLUSION EFFECT

The occlusion effect can be defined as the perception of one's own voice sounding louder, hollow, and/or unnatural after a hearing aid fitting. It is due to the increase in low-frequency sound pressure produced in the ear canal by the hearing aid wearer's own voice or any other signal transmitted by bone conduction caused by closing the ear canal with an earmold or closed dome. The occlusion effect can be a typical complaint of hearing aid users, especially among new users. Occlusion is generally caused by the hearing aid shell or earmold which is closing the ear canal.

In clinical practice, it is possible to add or create a larger vent or fit an open hearing aid on a patient if appropriate to alleviate the occlusion effect. Objective measures (i.e., measuring occlusion effect using the probe microphone system) can tell you the effectiveness of those clinical procedures. Measuring the occlusion effect also can be used as a counseling tool for patients who experience difficulty adapting to the occlusion effect.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, hearing aid with earmold or closed dome, probe tubes.

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Unleashing to Power of Test Box and Real-Ear Probe Microphone Measurement; Guest Editor, Lori Zitelli, Au.D.

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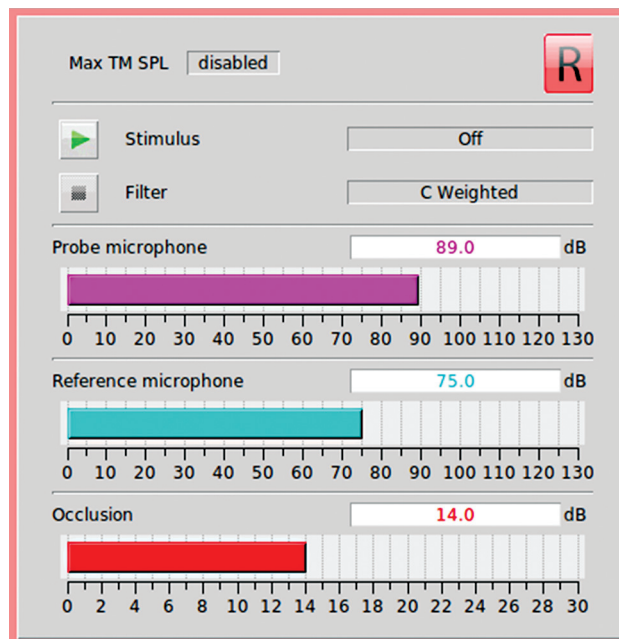


Figure 1 Occlusion test results with an occluded ear.

Activity 1

1. Set up the equipment using instructions from Chapter 4.
2. Insert the probe tubes into your patient's ears and have them face the speaker. See Chapter 5 (Activity 1) for microphone placement. Insert the hearing aid(s) into the ears, as well. Ensure that hearing aid(s) are turned off or muted.
3. Right-click and select **Occlusion** under On-ear measures.
4. Click **the green arrow** and follow instructions on screen. (You will ask the patient to say "eeee" in a conversational voice.) Click the Stop button to capture the recording (Figure 1).
5. The screen will display the difference between the probe and reference microphones, resulting in the occlusion in decibels. In this example, when the patient vocalized "eeee," the signal was 89 dB at the probe microphone in the ear canal and 75 dB at the reference microphone. When these two measurements are subtracted, they result in the occlusion which was calculated to be 14 dB. Because there was occlusion, the result is a positive number. Yellow and red results indicate that the fitting is not open (i.e., there is occlusion).

6. Look now at another measurement that was taken with an open ear (Figure 2).
7. In this second example, when the patient vocalized "eeee," the signal was 73 dB at the probe microphone in the ear canal and 77 dB at the reference microphone. When these two measurements are subtracted, they result in the occlusion which was calculated to be -4 dB. A negative number in a green color indicates that there is no occlusion (i.e., the fitting is open). If a change is made (e.g., using a larger vent, changing to a more open dome), this can be remeasured, and you should see a difference in the results as we do between Figures 1 and 2.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, hearing aid with earmold or closed dome, probe tubes.

Activity 2

1. Using a closed dome (hearing aid muted or off), measure the occlusion effect as described in Activity 1, steps 1 to 4.

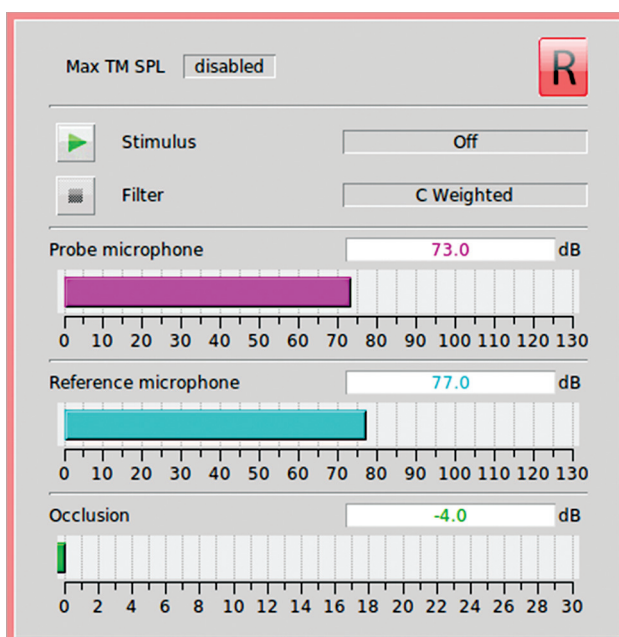


Figure 2 Occlusion test results with an open ear.

2. Using a more open dome (hearing aid off), measure the occlusion effect again (Activity 1, steps 1–4).
3. Describe your first measurement (closed dome) in terms of occlusion effect.
4. What changed when you replaced the closed dome with an open dome in terms of occlusion?
5. What could be an adverse effect of changing to an open dome for a patient?
6. How might you use this measurement to counsel a patient about occlusion?

YOUR SPEECH-LANGUAGE PATHOLOGY COLLEAGUE IS CONCERNED THAT THE CHILD WITH WHOM SHE IS WORKING IS NOT HEARING HER OWN VOICE WHEN WEARING HER HEARING AIDS

Introduction

The test described in Activity 3 can help you support the work of your speech-language pa-

thology colleagues. Knowing whether a child can hear specific sounds will support their work in speech and language development. It would be important to know if a child cannot hear specific sounds they are trying to produce. Improving speech and articulation is dependent on self-monitoring. You may want to have the child use the ling sounds¹ (ah, ee, oo, mm, s, sh) to make these audibility judgments. This test describes the use of a probe microphone as a sound level meter (SLM) with the child's own voice as the input signal. It measures how loud the patient's voice is in their own ear when using a hearing aid compared to the patient's thresholds to see if they are or are not hearing themselves well.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, hearing aid text box system, hearing aid, probe tubes, insert earphones.

Activity 3

1. Set up the equipment using the instructions in Chapters 1 and 4.

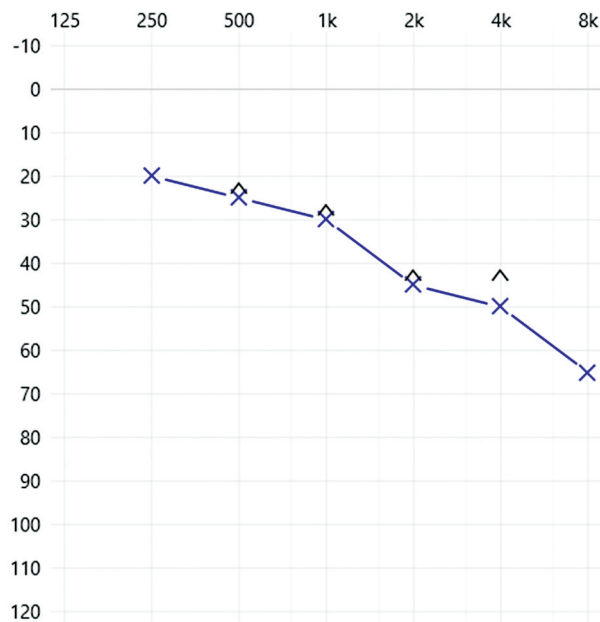


Figure 3 Audiogram for Activity 3.

- Right-click and select **Speechmap** under On-ear measures.
- Select **Audiometry**, choose **None** under Targets, and select **Measure RECD**. We are not fitting to target for this activity, so we are essentially asking the Verifit to ignore this component of the Speechmapping screen by selecting no targets. Use the audiometric data in Figure 3 for this activity.
- Measure WRECD using instructions from Activity 3 in Chapter 4 and Activity 1 in Chapter 5 to convert dB HL thresholds to dB sound pressure level (SPL) thresholds.
- Place the probe tube in the ear (see Chapter 5, Activity 1, for probe tube placement).
- Place the hearing aid in the ear.
- Click the **green arrow** above Test 1 and select **speech-live**. This turns probe microphone into a SLM. Do not click the **red circle** to capture the measurement; instead, watch how the curve changes while the child vocalizes different sounds.
- Ask the child to say the ling sounds (ah, ee, oo, mm, s, sh; Figures 4-6).
- Watch the screen during each sound to see if the speech signal reaches audibility (lou-

der than the hearing thresholds). All the examples provided above in Figures 4 to 6 would be audible for this particular patient. The hearing aid fitting should be providing good support for speech and language development.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, hearing aid text box system, hearing aid, probe tubes, insert earphones.

Activity 4

- Follow steps 1 to 8 in Activity 3, using the audiometric data in Table 1.
- Using the ling sounds (oo, ee, ah, mm, s, sh) data, check voice audibility across the speech bandwidth. In the table below, indicate whether each sound is audible (Table 2).
- If a sound is not audible, what could you do to make the sound audible given the constraints of the hearing loss?

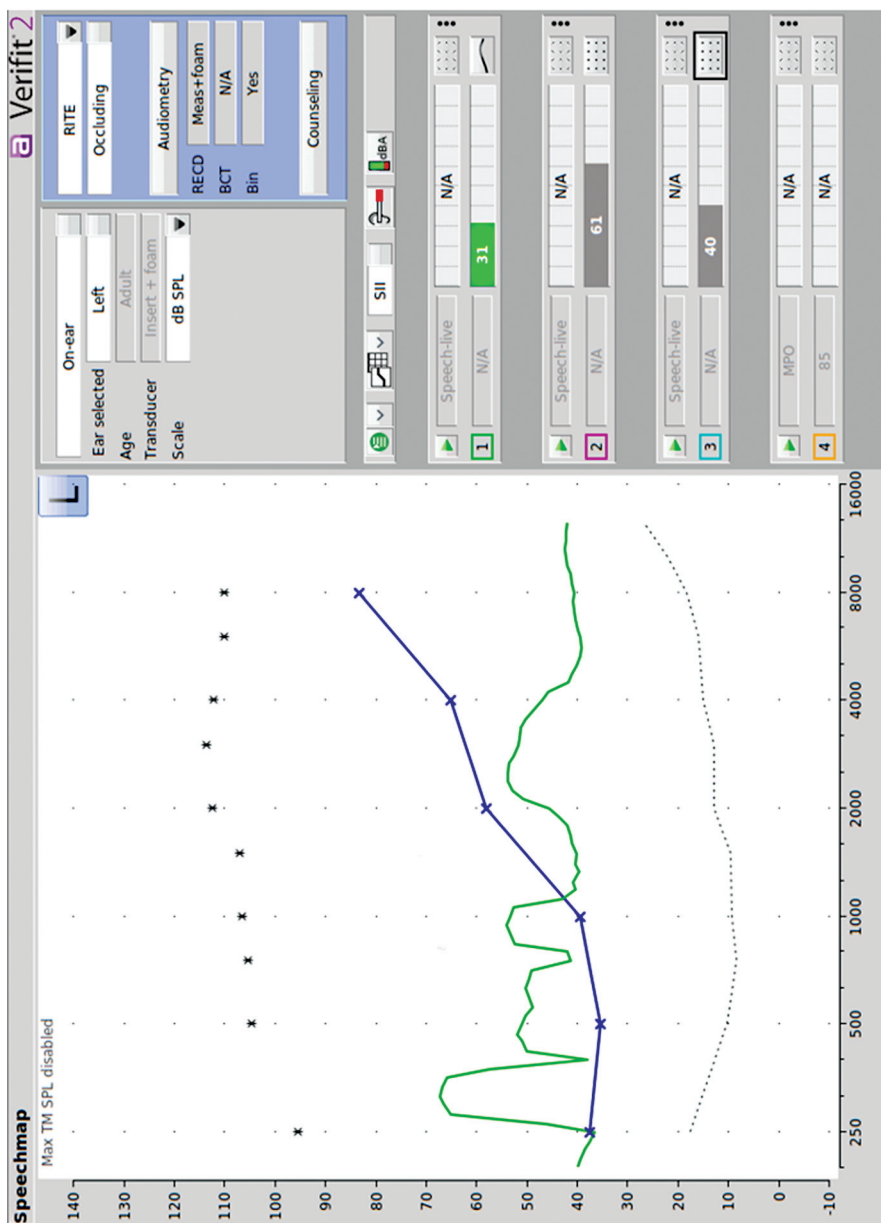


Figure 4 Real-ear sound pressure level (SPL) recorded during “oo” vocalization.

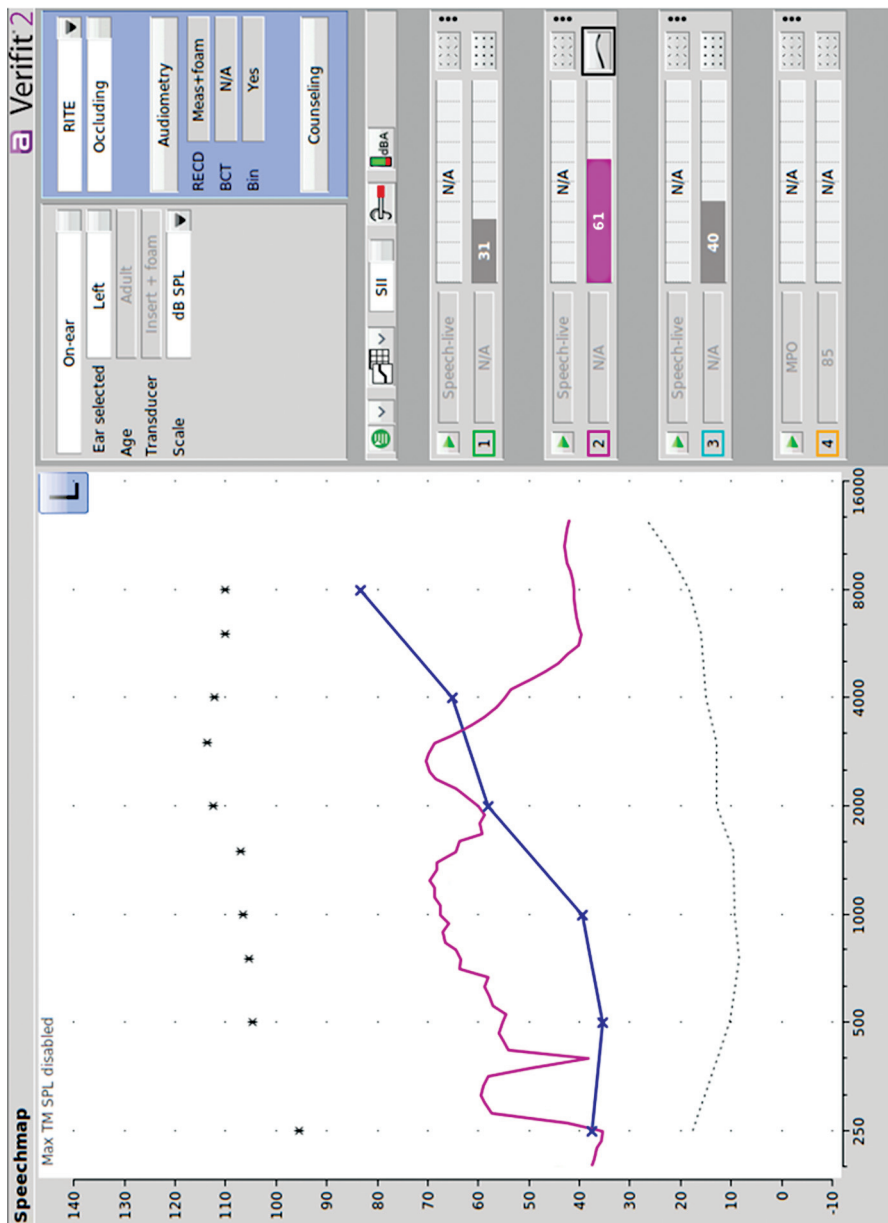


Figure 5 Rearear sound pressure level (SPL) recorded during "ah" vocalization.

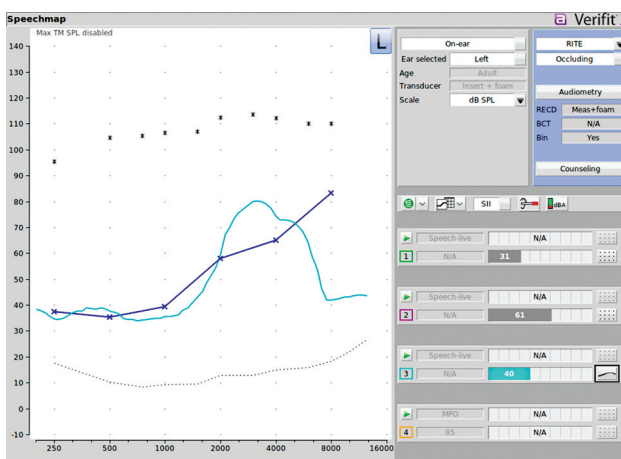


Figure 6 Real-ear sound pressure level (SPL) recorded during “sh” vocalization.

Table 1 Audiometric data for Activity 4

250	500	1,000	2,000	4,000	6,000
20	30	35	50	55	50

Table 2 Interpreting your measurements from Activity 4

Ling sound	Oo	Ee	ah	Mm	S	Sh
Audible?						
Solution if not audible						

MY PATIENT HAS FEEDBACK AND I DON’T WANT TO REDUCE ANY MORE GAIN THAN IS ABSOLUTELY NECESSARY

Introduction

Feedback occurs when amplified sound leaks out of the ear canal and reaches the microphone of the hearing aid; this amplified sound is then re-amplified. Modern hearing aids have automatic feedback tests that result in the hearing aid decreasing gain in certain regions and implementing various strategies to decrease the chance of feedback. Some of these automatic programs are very aggressive and quite a bit of gain may be reduced. In addition, you may run one of these automatic programs and find that there is still feedback in specific situations (e.g., when chewing or smiling). Using the probe microphone as a SLM allows you to identify the exact frequency that is causing

the feedback. If you are working with a hearing aid with many channels, you will be able to reduce gain at that specific frequency to alleviate the feedback without reducing overall gain and compromising audibility.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, hearing aid, probe tubes.

Activity 5

1. Set up the equipment using instructions in Chapter 4.
2. Right-click and select **Speechmap** under On-ear measures. There is no need to enter the audiogram, measure RECD, or select targets because you are not comparing these results to the individual’s hearing or measuring audibility (note that you will be required to enter one audiometric data point to move past this screen).

3. Insert the hearing aid and ensure that it is turned on. For this activity, use a receiver-in-canal hearing aid with a small open dome (Figure 7) to increase the likelihood of feedback. The probe microphone is not in the ear canal for this measurement.
4. Hold the probe microphone outside of the ear canal near the hearing aid. You may need

Helpful hint: This technique can be useful for audiologists with hearing loss that may prevent them from hearing feedback. During the hearing aid fitting, they could implement this testing to verify that neither hearing aid is feeding back.

to put your hand near the hearing aid to make it feed back for this activity. With a real patient, they may smile or chew or complete whatever action was creating the feedback.

5. Click the **green arrow** above Test 1 and choose **speech-live**. This allows the probe microphone to function like a SLM with any input from the environment.
6. If the hearing aid has feedback, the sound will be represented as a square wave on the graph (Figure 8). This allows you to identify

the exact frequency that is triggering the feedback. A slight reduction in gain at this frequency should resolve the problem.

Materials needed for this activity: For these activities, you will need data from Activity 5.

Activity 6

1. Using the measurement of feedback in Activity 5, answer the following questions.
2. What frequency did you identify as causing the feedback?
3. What are two possible solutions to reduce the chance of experiencing this feedback?

IS THE HEARING PROTECTION THAT I HAVE PROVIDED TO MY PATIENT DECREASING SOUND AS EXPECTED?

Introduction

Hearing protection is used to protect people from sound damaging their hearing in loud situations. Hearing protection can be non-custom, such as foam plugs or non-custom musician's earplugs that the user simply inserts into



Figure 7 Receiver-in-canal with open dome.

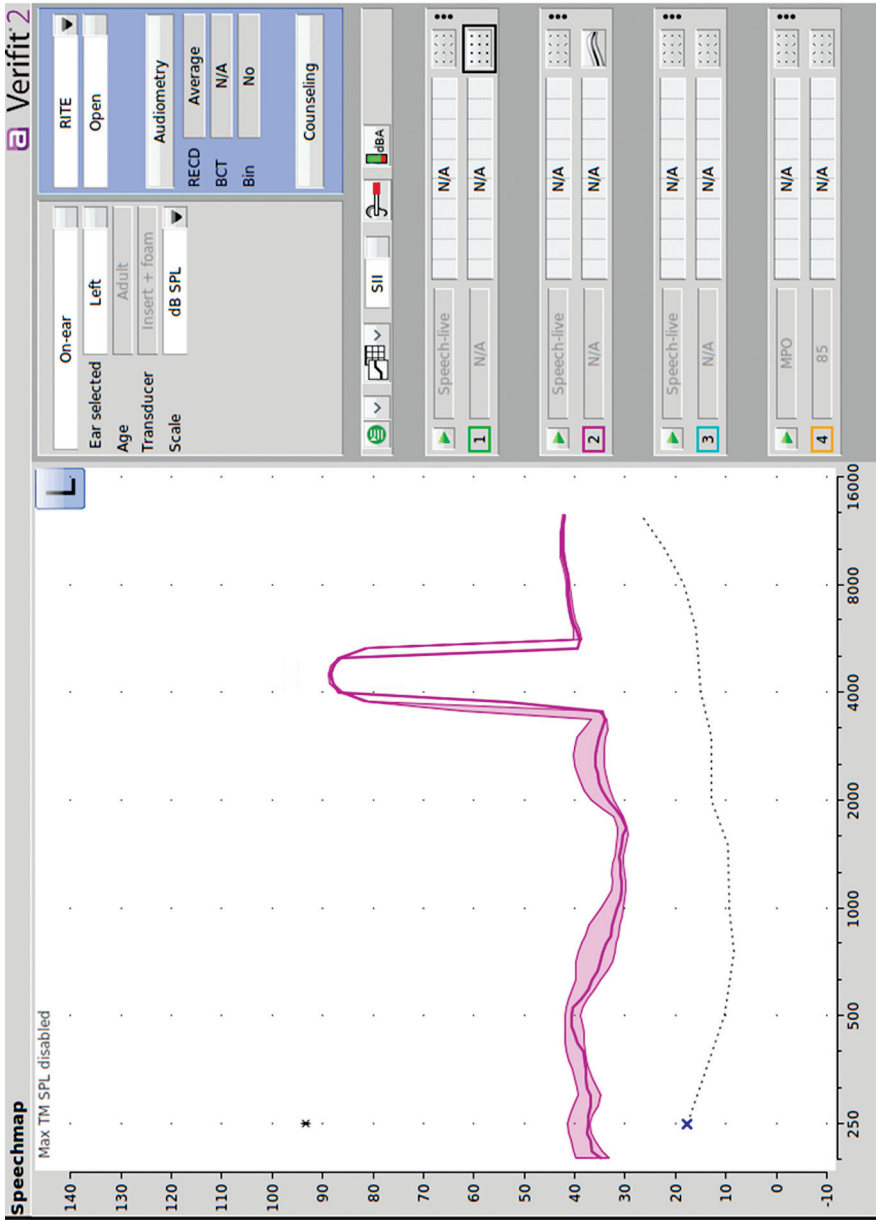


Figure 8 Measurement of feedback centered around 4,400 Hz.

their ear canal. Hearing protection also can be in the form of customized earplugs that look like a regular earmold. To verify the impact of the hearing protection, follow the protocol below.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, probe tubes, earplug.

Activity 7

1. Set up the equipment using instructions in Chapter 4.
2. Right-click and select **Insertion gain** from the On-ear menu. While you can select your instrument type, enter thresholds, and select targets, these pieces of information are not relevant to the task at hand and may be skipped for this activity. Select **Measure** for the real ear unaided response (REUR) option.
3. Position the patient in front of the speaker and insert a probe microphone into their ear. See Activity 1 in Chapter 5 for probe tube placement.
4. Click the **green arrow** directly below the REUR text (this is the bottom measurement on the screen). Select **Pink noise** at a moderate level (e.g., **60 dB**). Press the **red circle** to record the curve (Figure 9).
5. Insert the earplug into the ear, leaving the probe tube in place. If the earplug is customized, it should fit tightly. If you need to, use lubricant for easier insertion.
6. Click the **green arrow** directly below REIG/AR1. Select the same stimulus used in Step 3 and press the **red circle** to record the curve (Figure 10).
7. Earplugs which are not designated as musician's earplugs will not attenuate all frequencies equally and, although the response should indicate a lower intensity level, the shape of the frequency response is not expected to match the REUR curve (i.e., some frequencies will be attenuated more than others) (Figure 10). If measuring the response from musician's earplugs, the REOR curve is expected to be the same shape as the REUR curve, but it should appear lower on

the graph (indicating high fidelity with an overall lower intensity level).

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, probe tubes, earplug.

Activity 8

1. Following the process in Activity 7 (steps 1–6), measure the attenuation of an earplug.
2. Describe the differences you see between the REUR and REOR curves.

IS MY CHILD LISTENING TO THEIR EARBUDS TOO LOUDLY?

Introduction

It is common practice to listen through a headset (e.g., AirPods or other earbuds) to music being streamed from your cell phone or another personal listening device. Many people listen to their personal devices during a variety of activities, such as walking, exercising, commuting, or relaxing. In some cases, the volume may be turned up so high that everyone surrounding the individual can hear the music or other sounds to which they are listening. The following test can be used with a patient to determine if their typical volume setting on their personal music player streamed to their headset is set at a safe intensity level. This information can assist in counseling people about responsible listening.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, headset, device streaming music, probe tubes.

Activity 9

1. Set up the equipment using instructions in Chapter 4.
2. Right-click and select **Speechmap** under On-ear measures.
3. Select **ITE** for instrument, **occluding** coupling, and click the **Audiometry** button. There is no need to enter the audiogram, measure RECD, or select targets because you are not comparing these results to the individual's

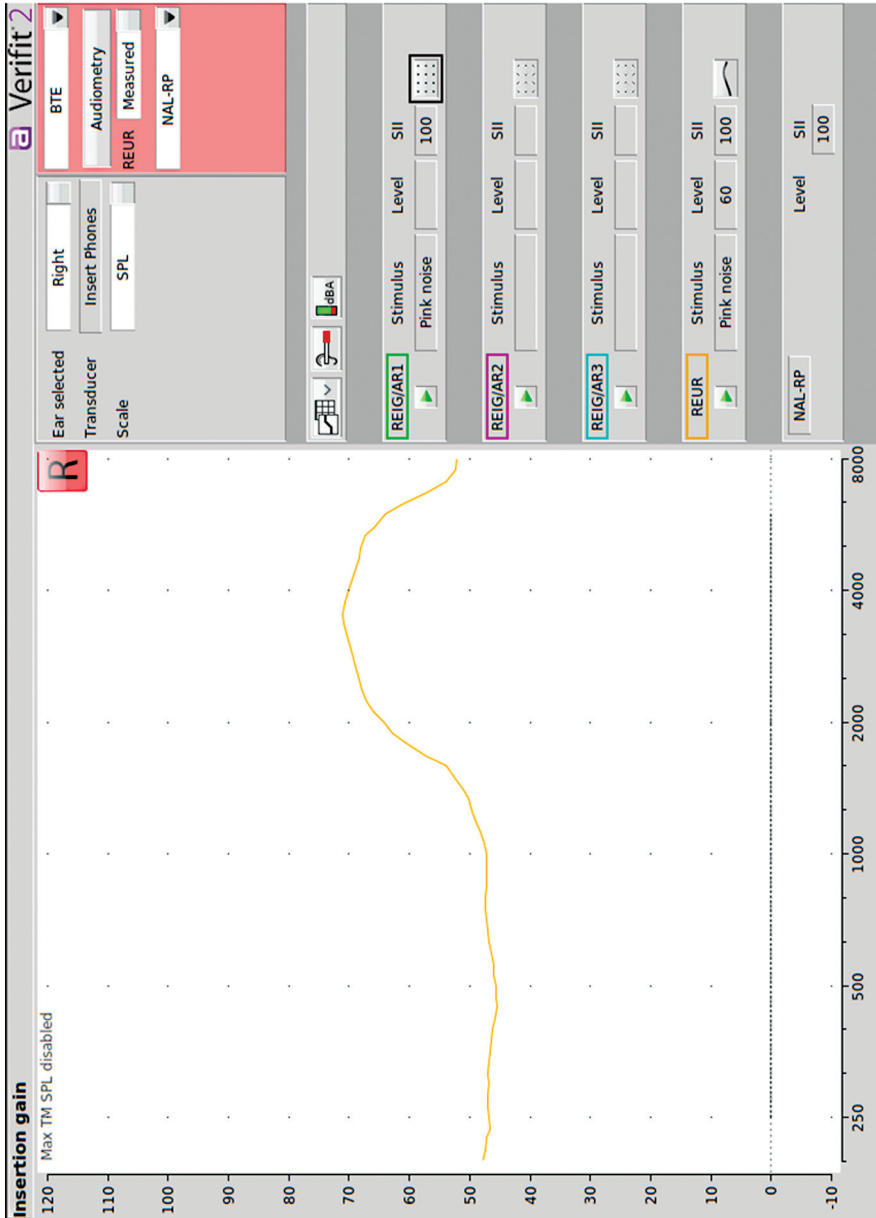


Figure 9 Real-ear unaided response.

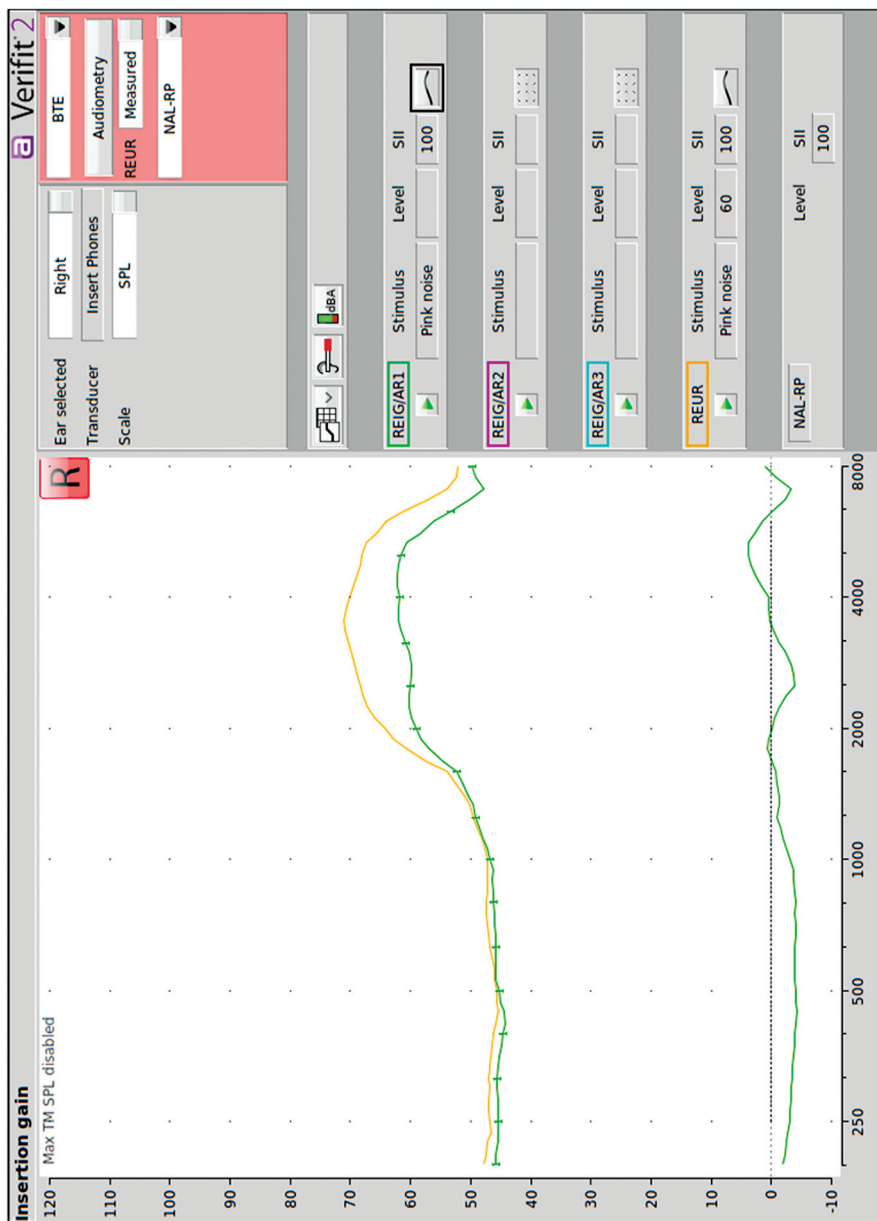


Figure 10 Real-ear occluded response (REOR) with non-custom, non-musician’s earplug.

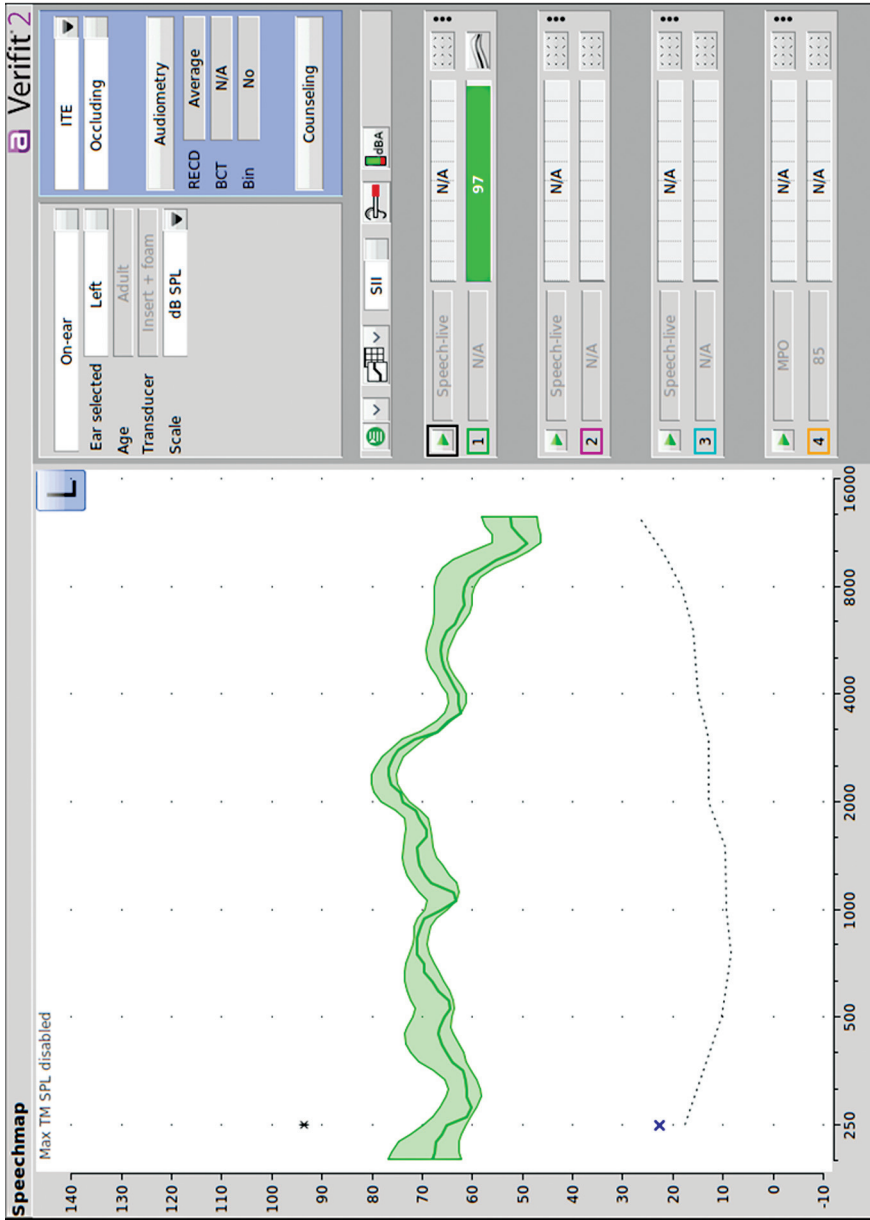


Figure 11 SPL at the eardrum when listening to music at a typical volume level through a personal listening device.

Table 3 What volume setting produces 85 dB SPL?

Exposure level	Volume setting on your device	Time to reach 100% noise dose ²
85 dB SPL		8 h
88 dB SPL		4 h
91 dB SPL		2 h
94 dB SPL		1 h
97 dB SPL		30 min
100 dB SPL		15 min

hearing or measuring audibility (note that you will be required to enter one audiometric data point in order to move past this screen).

4. Insert the probe tube into the ear canal and place the earbud in the ear. See Activity 1 in Chapter 5 for probe tube placement.
5. Click the **green arrow** above Test 1 and select **speech live** so that the probe microphone functions as a SLM able to measure signals in the environment.
6. Turn on the device, play music (streaming to the earbud or headset), and set it at the patient's typical everyday volume setting.
7. Click the **red circle** to record the response and click the **pause button** to capture a specific moment (Figure 11).
8. Figure 11 shows the dB SPL at the eardrum. Safe listening levels are below 85 dB SPL for no more than 40 hours per week. If the level exceeds 85 dB SPL, it is important to counsel the patient on excessive noise exposure and hearing protection as a function of how long they listen to these levels.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, headset, device streaming music, probe tubes.

Activity 10

1. Use the worksheet in Table 3 to determine the safe volume settings for your personal listening device. Volume setting should be described as a number (if provided) or number of "steps" above or below the default level that is produced when the device is turned on.
2. Follow Steps 1 to 5 in Activity 9 to make measurements. Set your device at your normal listening level. Record the volume setting next to the level that was measured. If

over 85 dB SPL, manipulate the volume setting until you measure 85 dB SPL and record the volume setting in Table 3.

Note that the above times are based on an average population. Some people may experience hearing loss at lower levels and at shorter exposure times than others. These are general guidelines.²

I'VE ALWAYS WONDERED HOW MY FAMILY MEMBER HEARS THROUGH THEIR HEARING LOSS

Introduction

Much of our time is focused on the patient and their hearing needs, but it is often helpful to make sure family members understand the impact of hearing loss. The Verifit 2 can simulate hearing losses to support your family education efforts using the sensory loss simulator feature. Using this capability, you can allow support persons to "listen" through the ears of their loved ones.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system, your patient's WRECD, and audiogram.

Activity 11

1. Set up the equipment using instructions in Chapter 4.
2. Right-click and select **Speechmap** under On-ear measures. You can ignore the instrument and coupling menus this time.
3. Click on the **Audiometry** button. You do not need targets for this activity. However, you will want to enter or measure the patient's WRECD in order to create accurate SPL thresholds. Enter the patient's HL

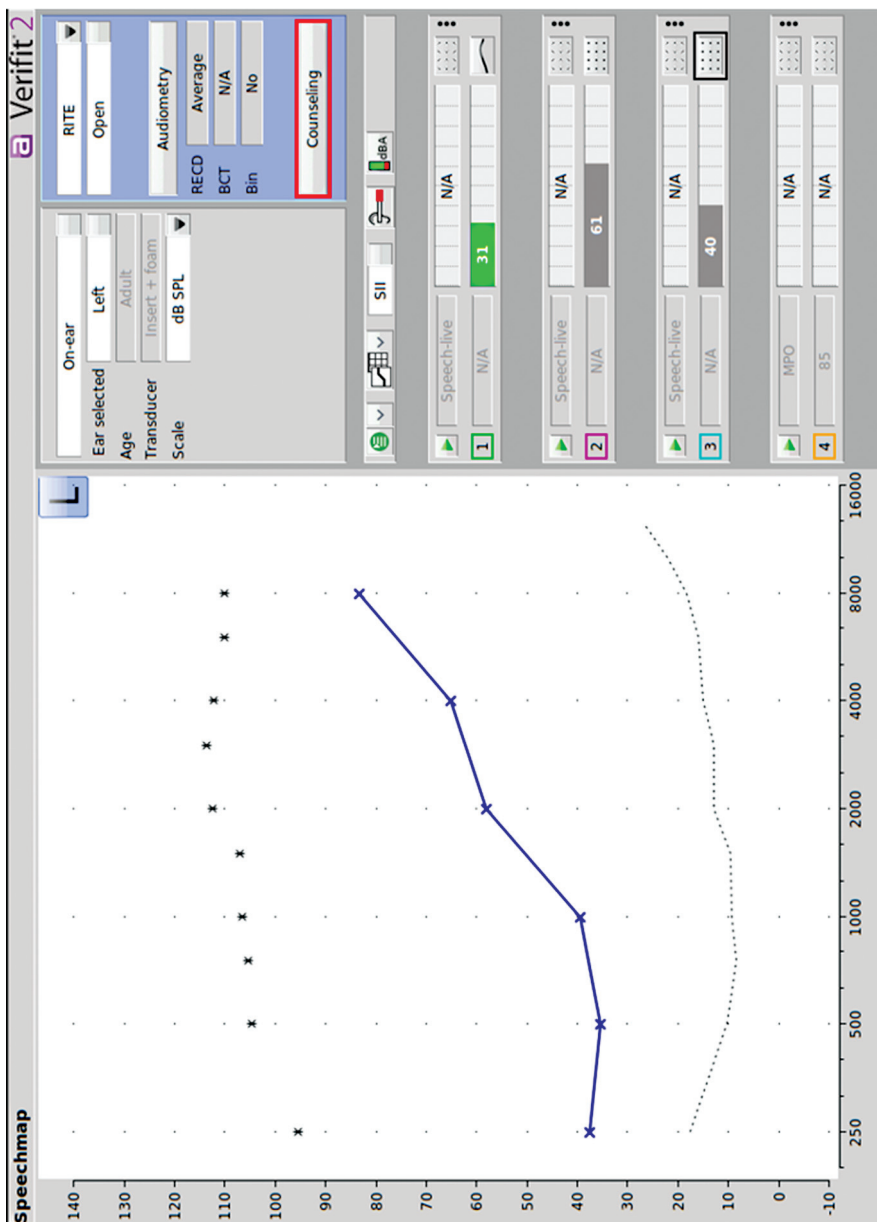


Figure 12 Select the counseling option.

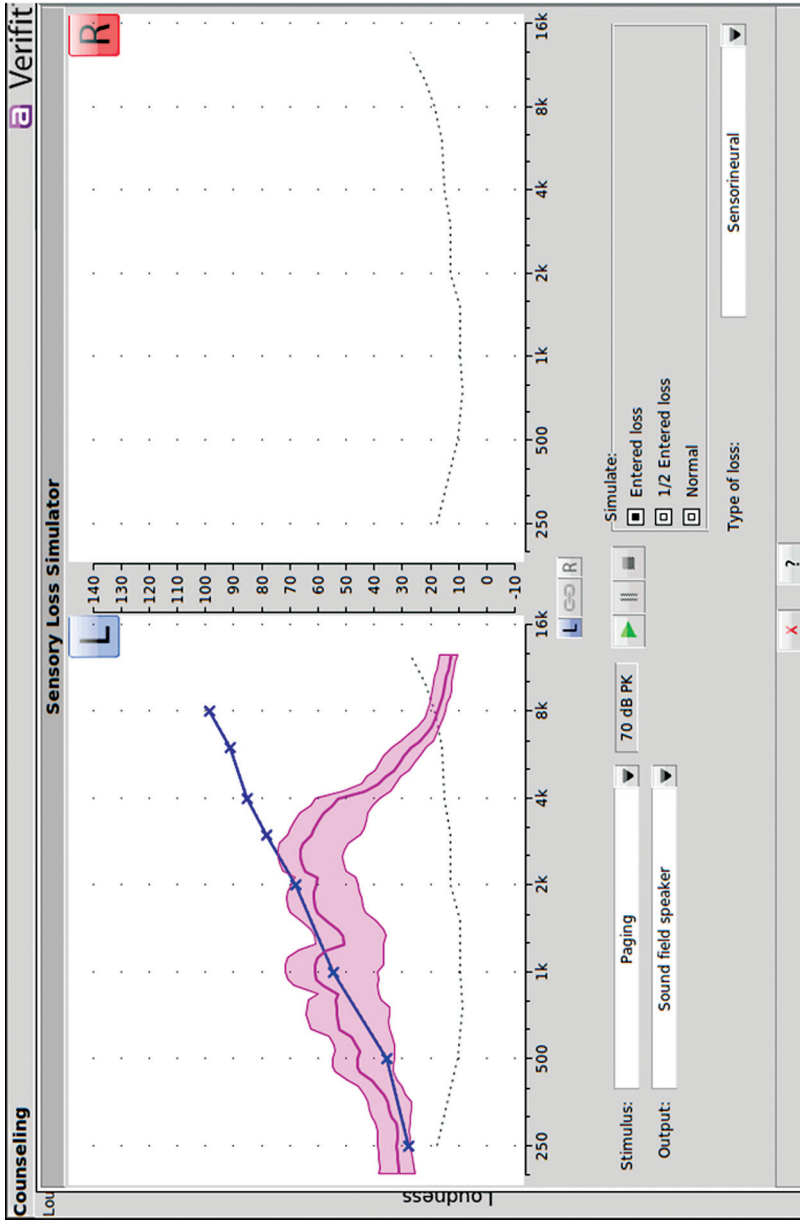


Figure 13 Sensory loss simulator. In this example, the paging stimulus is largely inaudible to this patient, and they would not be expected to understand the announcement under these conditions.

- threshold values on the Audiometric entry screen.
4. Measure WRECD using instructions from Activity 3 in Chapter 4 and Activity 1 in Chapter 5.
 5. Click the **Counseling** button (Figure 12). In this screen, there are a variety of different tools that can be used for counseling purposes—for both your patients and their loved ones.
 6. Click **Loss simulator** (Figure 13). This allows you to play different everyday sounds (e.g., birds, telephone, talkers at an average level, talkers at a loud level). Choose the selected stimulus and indicate how you prefer the output to be produced (through the speaker or through connected headphones). Simulate the entered hearing loss to let the patient's loved one experience listening through the hearing loss. Choose the type of loss (sensorineural or conductive) the patient has.
 7. Press the **green arrow** to start the simulation. It will run until you pause or stop it (Figure 13). While the simulation is playing, you can make changes to the stimulus, choose 1/2 of the entered loss, or choose to listen through normal thresholds.
 8. Click the **pause button** to stop the demonstration and freeze the stimulus output on the screen. When you are ready to stop the demonstration, click the **stop button**.

Materials needed for this activity: For these activities, you will need a real-ear probe microphone system and Audiogram.

Activity 12

1. Enter a hearing loss (you choose the hearing loss for this activity) into the Sensory Loss Simulator and play a typical sound.
 2. How would you describe what you hear?
3. How do you think this demonstration might impact a family member of a person with hearing loss?

CONCLUSION

This chapter has introduced you to some measurements and functionality of the Real-Ear Probe Microphone System that you may not have considered. Keep in mind if a device amplifies or attenuates sound; you can measure output and change from one condition to another. The audiologist should position themselves as the expert and educational resource for all things related to sound. As you work with the test box and real-ear probe microphone measures you may consider new ways you can market your services to the community. Audiologists should be positioned as the health care professionals who use evidence-based practices to provide the best possible care. The tools and procedures described in this set of articles are the underpinning to evidence-based practice when it comes to returning audibility, setting signal processing and features to enhance hearing, and protecting hearing. Make sure to let your patient know what you are doing and why—this can be very compelling and supports adherence to recommendations that the patient understands are based on science.

CONFLICT OF INTEREST

None declared.

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