ELECTROACOUSTIC EVALUATION OF THE RESOUND UNITE™ MINI MICROPHONE WITH OTOMETRICS AURICAL HIT

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Abstract

With ReSound's 2.4 GHz wireless technology and the ReSound Unite™ Mini Microphone wireless accessory, clinicians are presented with a great option to meet patients' assistive listening needs. The Unite Mini Microphone provides the signal-to-noise ratio (SNR) advantages of traditional FM systems without the need for additional hardware worn at ear level, as the receiver is integrated in the hearing instrument. The integrated receiver also negates the need for separate programming outside of the hearing instrument fitting software. Verification of the assistive technology is possible through Otometrics AURICAL HIT (hearing instrument test chamber), which includes a special test designed for this purpose. This paper describes the protocol for measuring transparency, SNR advantage and maximum output of the Unite Mini Microphone using AURICAL HIT.

Improving the signal-to-noise ratio (SNR) of a speaker's voice is the primary goal for hearing assistive technology (HAT) using a remote microphone (American Academy of Audiology (AAA), 2011). This technology, which includes FM systems, is widely used by the adult and pediatric populations, to overcome obstacles to speech audibility and intelligibility, including background noise, distance and reverberation. With any of these systems, the signal is transmitted by a device positioned close to the speaker's mouth to the hearing aids, via a dedicated receiver or through a receiver integrated in the hearing instrument. In typical use, the wireless (remote) and local (hearing instrument) microphones are active simultaneously. This allows for increased SNR benefits as well as audibility for the hearing instrument user's own speech and other environmental sounds.

To ensure proper functional status of this assistive technology, verification guidelines have been published (American Speech-Language and Hearing Association (ASHA), 2002; AAA, 2011). The verification process is especially important when fitting hearing assistive technology for pediatric patients, as children may not be able to give any subjective feedback regarding the performance and SNR benefits provided by the wireless system.

These verification procedures were initially developed for FM systems. However, they can also be applied for hearing instruments with integrated wireless 2.4 GHz technology (Mulla & Archbold, 2012). With this technology, the hearing instruments themselves act as the FM receivers. Adjustments made within the fitting software and using the volume control on the ReSound Unite Mini Microphone itself allows for fine tuning of the response for optimal benefit.

The ASHA guidelines recommend monitoring performance through a variety of measures at least once a year for adults and children older than 5 years of age, and every 3-6 months for children younger than 5 years (2002). To realistically verify the benefit of this assistive wireless technology, responses from the hearing instrument (HI) are compared with responses from the hearing instrument and hearing assistive technology together (HI+HAT).

Two aspects of performance are important to verify electroacoustically: transparency and SNR advantage. The transparency measurement evaluates if the local and wireless microphones provide equal outputs from the hearing instrument when presented with the same 65 dB SPL input stimulus. A calibrated speech signal such as the International Speech Test Signal (ISTS) is recommended. The AAA guidelines state that the transparency must be within an average of +/- 2 dB for .75, 1 and 2 kHz (2011).

Once transparency has been verified, SNR advantage can be measured. The SNR advantage is the increase in the signal level by the wireless technology, as compared to the level provided by the hearing instrument alone. It is calculated by subtracting the output of the

HI from output of the HI+HAT. SNR advantage is used to fine tune the wireless system so that an input of 80 dB SPL to the wireless microphone at a distance of 15-20 cm provides a 10 dB higher output than a 65 dB SPL input at a distance of 1 to 2 m to the hearing instrument microphone (AAA, 2011).

Furthermore, Schafer et al. (2007) recommend an additional measurement to confirm similar maximum output (OSPL 90) between the HI and the HI+HAT. This measure ensures the hearing instrument user's uncomfortable loudness levels are not exceeded and that the dynamic range is not adversely affected by the compression characteristics of the HI and wireless accessory.

Although FM systems provide increased SNR benefit to the patient, they have drawbacks outside of their financial cost. With FM systems, an ear-level or body-worn receiver is necessary for routing the signal to the patient's hearing instruments. For children especially, this can create problems due to increased size of the hearing aid with the ear-level receiver, as well as the inconvenience of having a third device to wear. In addition, FM system transmissions are susceptible to privacy concerns.

ReSound Unite™ Mini Microphone

With ReSound's introduction of 2.4 GHz wireless transmission in hearing instruments, a new solution for SNR improvements is available. The ReSound Unite™ Mini Microphone is a small personal portable streaming device for transmitting sound and/or external audio sources directly to the user's hearing instruments (Figure 1). It can be affixed to the speaker's clothing in the same manner as an FM transmitter, to pick up the signal where it is strongest and clearest. The signal is then transmitted directly to the hearing instruments via ReSound's proprietary 2.4 GHz digital wireless technology, without the need for a separate body-worn or ear-level receiver.

Figure 1. The ReSound Unite™ Mini Microphone wireless accessory.

The ReSound Unite™ Mini Microphone features an on/off switch and a volume control for the microphone input. It is easily paired to the hearing instruments via the ReSound® Aventa 3 fitting software, or manually outside of the fitting software. The status of the device, including the battery level, is indicated by a multi-color LED, making monitoring of its functionality easier for teachers and caregivers. In addition, an unlimited number of hearing aid users can be connected to one Unite Mini Microphone, making it especially applicable for classroom settings.

The ReSound Unite Mini Microphone can be used in any situation where a SNR improvement is desired, and provides up to 7 meters of wireless connection between the speaker and the hearing instrument user. Its line-in functionality allows for direct streaming from an audio source, such as an MP3 player, to the hearing instruments. The hearing instrument user can receive the streamed sound alone or in combination with the hearing instrument microphone input.

As with FM systems, electroacoustic verification of the ReSound Unite™ Mini Microphone is optimal to ensure proper functionality and SNR benefit. This can be accomplished through test box equipment such as the Otometrics AURICAL HIT.

AURICAL HIT

AURICAL HIT is a test chamber that facilitates measurement of hearing instruments and wireless accessories. The new OnePosition Method alleviates positioning issues and improves accuracy and quality of results. The integrated coupler and microphone are connected in a designated slot that ensures a correct height of the hearing instrument for any style of instrument and for any measurement. A gooseneck reference microphone allows for easy, secure positioning.

AURICAL HIT's external accessory module acts as an extension of the test chamber, allowing for external coupler measurements. The position of the coupler with the hearing instrument and Mini Microphone can be easily exchanged to accommodate all steps of the verification process.

A step-by-step guide to obtaining ReSound Unite™ Mini Microphone measurements with AURICAL HIT

The following is a detailed guide to measuring transparency, SNR advantage and max output of the Unite Mini Microphone. To begin, assemble the following:

- AURICAL HIT
- ReSound Unite™ Mini Microphone
- ReSound wireless hearing instrument paired with the Unite Mini Microphone
- Coupler assembly (adapter, coupler cavity and coupler microphone), placed in external accessory module
- Coupler cable between the external accessory module and AURICAL HIT
- Insulating pad under external accessory module (optional)

Step 1: Reference measurements

- Measure the hearing instrument output in omnidirectional mode with a 65 dB SPL ISTS input.
- Attach the hearing instrument to the coupler in AURICAL HIT.
- Position the reference microphone as close to the hearing instrument microphone as possible, without touching the front microphone of the hearing instrument (Figure 2).

Figure 2: Positioning of the hearing instrument and reference microphone in AURICAL HIT.

- In the OTOsuite software Test Selector menu, choose the special test “FM Reference Sequence - HI in AURICAL HIT” on the PMM tab. This launches the FreeStyle test screen.
- Close the cover of AURICAL HIT and click the “Sequence” button in the Control Panel to measure curves 1 and 3. These curves will be identical because measurement settings are unchanged within the sequence (Figure 3).

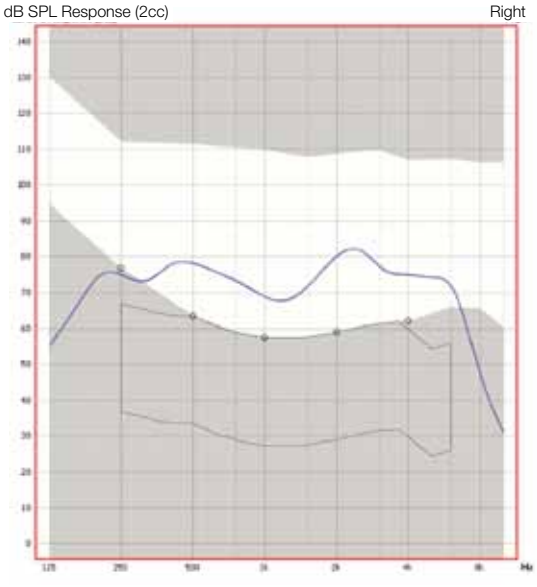

Figure 3: Output of the hearing instrument for a 65 dB ISTS signal (reference curves). The two identical curves appear as a single purple curve.

Step 2: Transparency and SNR advantage measurements

- Raise the elevation plate in AURICAL HIT and position the ReSound Unite™ Mini Microphone on the elevation plate.
- Place the reference microphone over the microphone inlet of the Unite Mini Microphone (Figure 4).

Figure 4: Positioning of the Mini Microphone in AURICAL HIT.

- Connect the coupler cable from the external accessory module to AURICAL HIT.
- Place the hearing instrument and coupler setup in the first coupler hole of the external accessory

module (Figure 5). The external accessory module may be placed on an insulating pad to prevent any deleterious effects of noise and vibration.

Figure 5: Positioning of the hearing instrument outside AURICAL HIT in the external accessory module. The Mini Microphone is positioned on the elevation plate in AURICAL HIT.

- In the OTOsuite Test Selector menu, select the special test “FM Transparency & Advantage Sequence - HI outside AURICAL HIT” on the PMM tab.
- Close the cover of HIT and click the “Sequence” button in the Control Panel to measure curves 2 and 4. An ISTS input is presented to the Unite Mini Microphone at 65 dB SPL for the transparency measurement, and the result is shown by the orange curve. For the SNR Advantage measurement, an 80 dB SPL ISTS input is presented, and the result is displayed in HIT by the green curve (Figure 6).

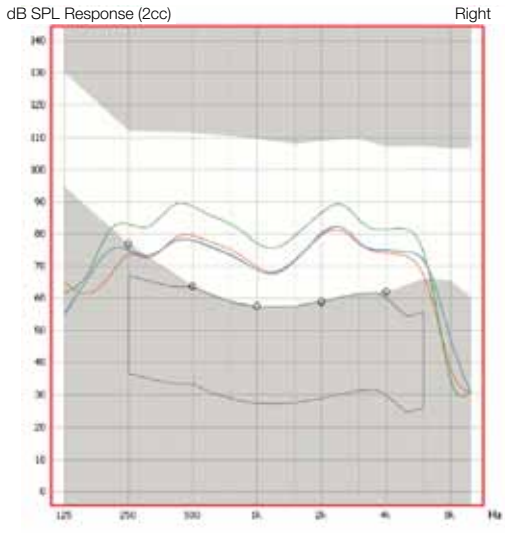

Figure 6: Output of the hearing instrument in streaming mode. The hearing instrument is placed outside AURICAL HIT. The orange curve represents the transparency measure and the green curve indicates the SNR advantage. The purple curve is the output of the hearing instrument for a 65 dB ISTS signal (the reference curves).

By viewing the FreeStyle tabular data (Table 1, curves 1 and 2), transparency results can be verified for acceptability. In this example, the results show differences between the Unite Mini Microphone and the HI output of 2 dB for .75 KHz, 1 dB for 1 KHz and 0 dB for 2 KHz, with a resulting average difference (for all input frequencies) of 0 dB. In this example, the Mini Microphone performance falls within the AAA tolerances (+/-2 dB) for acceptable transparency.

The tabular data for the SNR advantage sequence (Table 1, curves 3 and 4) shows differences of 9 dB at .75 KHz, 8 dB at 1 KHz and 7 dB at 2 KHz. According to Shafer et al (2007), a 3 dB tolerance of the 10 dB target result is acceptable for FM advantage measures in most cases; in this example, the SNR advantage is verified.

Modifications: Maximum Power Output measurements

AURICAL HIT can also be used to measure maximum output levels between the HI alone and the HI + Unite Mini Microphone system.

- Modify the “FM Reference Sequence” to include measurement curve 5, and the “Transparency & Advantage Sequence” to include measurement curve 6.
- Set the stimulus to a 90 dB Maximum Power Output (MPO).
- Results of this max output (OSPL 90) test are shown in Figure 7 as the pink and yellow curves.

The tabular data (Table 1, curves 5 and 6) shows differences of 0 dB at .75 KHz, 1 dB at 1 KHz and 0 dB at 2 KHz. This confirms the maximum output is similar for the HI alone and the HI with the Unite Mini Microphone. In addition, this measurement helps to ensure the listener’s uncomfortable loudness levels (designated as the upper gray area of Figure 7) are not exceeded with high input levels. Furthermore, this indicates that the presence of the Unite Mini Microphone is unlikely to adversely affect the dynamic range of speech cues.

FreeStyle Table Right (* 2cc Measurement)										
Right	250	500	750	1k	1.5k	2k	3k	4k	6k	RMS
Curve 1*	75	78	73	69	72	80	78	75	71	88
Curve 2*	74	79	75	70	73	80	77	74	66	88
F2B 1	2	-1	-1	-1	0	0	0	1	5	
Curve 3*	75	78	74	69	72	80	78	75	71	88
Curve 4*	83	89	83	77	80	87	84	81	72	96
F2B 2	9	5	4	5	4	6	6	7	12	
Curve 5*	96	97	94	89	92	99	96	89	84	
Curve 6*	95	97	94	90	92	99	96	89	85	
F2B 3										
HTL (SPL)	77	64		58		59		62		
UCL (SPL)										

Table 1: Tabular data for all measurements. Differences between values for curves 1 and 2 illustrate transparency. Differences between curves 3 and 4 demonstrate SNR advantage. Differences between curves 5 and 6 indicate similarity of maximum output for the HI alone and the HI + Unite Mini Microphone.

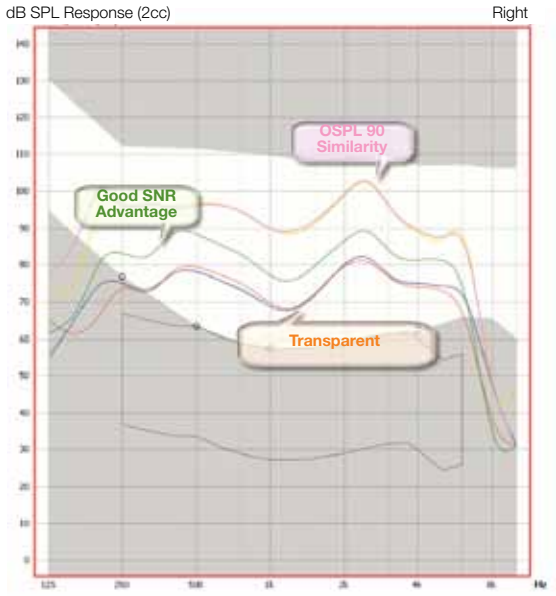

Figure 7: Output of the hearing instrument, showing the transparency, SNR advantage, and OSPL 90 curves

Conclusions and discussion

As demonstrated with AURICAL HIT, it is possible to utilize existing verification procedures for FM systems to quickly verify performance of hearing instruments with integrated wireless 2.4GHz technology such as the ReSound Unite™ Mini Microphone. In the above examples, acceptable transparency, SNR advantage and max output measures were achieved without the need for further adjustments.

In the case that the desired transparency is not initially acceptable, adjustment of the microphone volume on the Unite Mini Microphone will serve as an easy way of fine tuning to achieve transparency. The Unite Mini Microphone volume control also provides the ability to accomplish a favorable SNR advantage. If an acceptable SNR advantage is not achieved by simply adjusting the volume control on the Unite Mini Microphone, adjustments can be made to the gain or MPO settings of the Unite Mini Microphone and/or the hearing instrument within the Aventa 3 fitting software. If similarity is not observed for the OSPL 90 measurements, adjustments can also be made to MPO settings and compression characteristics in the fitting software.

The electroacoustic verification of transparency, SNR advantage, and maximum output similarity is important, but does not fully verify nor validate the fitting (ASHA, 2002; AAA, 2011). Behavioral procedures including sound field aided speech recognition should be done to further verify the wireless accessory fitting. Validation tools such as self-assessment questionnaires, observation surveys and evaluations such as the Ling Six Sound Test can assess the additional benefit the patient receives from wireless hearing assistive technology such as the ReSound Unite™ Mini Microphone.

References

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