You regular readers of Page Ten probably recall that last month we had to interrupt **Robyn Cox**, PhD, and her inquiring friend in the middle of their discussion on verification procedures for the fitting of hearing aids. So far, Dr. Cox had learned that our "Joe the Audiologist" doesn't own a probe-mic system or a test box. He also seems to be a little confused regarding what is ***verification***, and what is ***fine-tuning***, and almost seems satisfied to forget about verification altogether.

Never being one to give up easily, Robyn has been explaining to him that there are some "low-tech" verification techniques that he can use—just until his probe-mic equipment arrives, of course. When we left them, she had just finished a detailed discussion of a couple of frequency-specific, low-tech procedures for verifying that aided soft sounds are audible. One method she presented was to dust off the old sound field-aided threshold approach, which, she showed us, provides closer to probe-mic results than you might think.

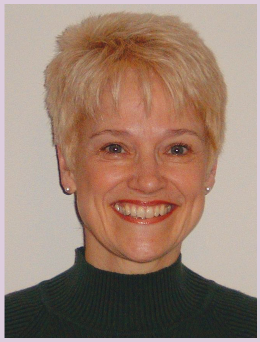
Unfortunately, Joe opted out of that approach, as he doesn't seem to own equipment to conduct sound field measures either. But with a timely counter punch, Dr. Cox came back with the Ling Six-Sound Test. She even presented data showing that this test can provide an estimate of audibility for soft sounds across the frequency range.

Although a month has passed, it appears that Joe is still waiting for his probe-mic equipment to arrive, so Robyn is continuing with her review of low-tech hearing aid verification alternatives. At the moment, they're talking about verification for conversation speech, so let's join them…

GUS MUELLER
Page Ten Editor

Verification and what to do until your probe-mic system arrives

By Robyn M. Cox **(The second of two parts)**


Robyn M. Cox

11 I'm beginning to see where you are going with all this. Let me guess, do you also have a low-tech approach to verifying appropriate amplification for conversational speech?

You bet I do. I'm on a roll now. First, you need to use one of the methods I mentioned earlier to verify and adjust amplification for soft speech across frequency, making sure you have optimized high-frequency gain for the patient. You can't do low-tech, frequency-specific verification for conversational speech, but if your frequency-specific soft speech is okay, conversational speech probably will be reasonable. So, your main challenge is to get the loudness of conversation adjusted correctly without compromising your adjustments for soft speech audibility. Ideally, you should do this part in a room that is similar to a typical living room.

First, you need to present some continuous speech. You might be tempted just to use your own voice for this, but it is more accurate and quite easy to do it by using a recorded speech passage, such as an audio book. Avoid anything that creates lots of excitement by using loud and soft voice levels. You also could purchase a CD designed for this type of testing from Bill Carver at Auditec of St. Louis, or a similar source.

I know you said you don't have sound field equipment, but for this testing you can use a fairly inexpensive portable CD player with loudspeakers. You'll want to do a quick calibration for where your patient soon will be sitting in front of the loudspeakers. Adjust the volume of the CD player so that the speech level is about 60 dB SPL, a…

12 Hold on a minute! How can I do that without a high-tech sound level meter? I thought you were giving me a low-tech approach?

Take it easy. It doesn't have to be rocket-science precise. At Radio Shack, you can buy a dandy little sound level meter that is inexpensive and quite adequate for this job, and others. Also, if you have an iPhone, you can download a $1 app that will turn it into a sound level meter.

13 I see. I can do that. Sorry I interrupted.

No problem. Anyway, if you spring for Radio Shack's $49.99 model, use the C-weighting scale and fast response. When you do this, you'll notice that the readout changes a bit every few seconds. Just do an eyeball average. Adjust the volume on your CD player until the speech level is about 60 dB SPL at the place where your patient will sit. This is similar to normal vocal effort.[8]

7. UNCOMFORTABLY LOUD

6. LOUD, BUT OK

5. COMFORTABLE, BUT SLIGHTLY LOUD

4. COMFORTABLE

3. COMFORTABLE, BUT SLIGHTLY SOFT

2. SOFT

1. VERY SOFT

Figure 5. *Chart of loudness categories.*

It is most convenient to do this calibration ahead of time and mark or tape the volume control on the CD player. Then you are ready to go when the patient comes in. Hand the patient a loudness chart (see Figure 5). You can download a big-print version from my web site if you like. Go to www.memphis.edu/ausp/harl and look under Clinical Applications–Contour test.

Let the patient wear the hearing aid and sit in the place that you calibrated. Play the speech and give the patient a chance to listen, then ask her to say which category best describes the loudness of the speech (no hints allowed). If she is an experienced hearing aid user, you want her to pick category 4 (comfortable). If she is new to hearing aid use, she should pick category 5 (comfortable, but slightly loud). If your patient doesn't choose the correct category, you should adjust the programming in the right direction to get their judgment closer to the goal.

Since you have already adjusted gain for soft (referred to as G50 in some software), you should now adjust the gain for higher levels to get conversational speech to the right loudness. Most software has a handle for this, labeled something like "loud gain" or G80. Use that one. This will adjust the compression ratio.

14 That sounds pretty easy and quick. Let's keep going. What can I do to verify that loud sounds are okay? I've read that this can be a big problem for hearing aid wearers.

It's true that sounds that are too loud have historically been a major cause of unsuccessful hearing aid fittings. This problem has become less serious since we started using WDRC processing in hearing aids,[9] but it has not gone away.[10] So, every patient should be checked for potential problems with loudness of environmental sounds.

To do this, you need to collect a few materials that will allow you to generate loud sounds of different types. We call ours the HONK (HARL Obnoxious Noise Kit). At present, we have two noisemakers in the HONK. The first is a 12-ounce metal coffee can with a plastic lid containing three $\frac{3}{4} \times 1\frac{1}{2}$-inch hex-head bolts and four 5/8-inch hex nuts. You hold the coffee can horizontally by the ends and shake it up and down. This makes a flat-spectrum, broadband noise of about 80 dB SPL with peaks about 100 dB SPL.

Our second noisemaker is a pair of 16-ounce glass jars (canning jars work well) and about two dozen small glass marbles. You hold the glass jars around the tops and pour the marbles back and forth between them in a stream. This makes a high-frequency noise with spectral peaks in the range of 5000 to 10,000 Hz, and a level around 100 dB SPL with peaks up to about 115 dB SPL.

The verification procedure is simple: Stand in front of the patient and activate the noisemaker for about 15 seconds. Ask the patient to choose the appropriate loudness level from the loudness chart. The goal is for him to pick 6 (loud, but OK). If he finds either of the noisemakers seriously uncomfortable, adjust the programming to reduce the MPO. You'll want to do this using the handle for MPO adjustment, not one of the handles you used earlier for speech.

We tested 36 subjects to find out how aided listeners rate these noisemakers (see Figure 6). The subjects wore modern hearing aids in two conditions. In one condition the hearing aid was adjusted and fine-tuned beginning with the NAL-NL1 prescription. In the other condition, the NAL-NL1 prescription was modified with a high-frequency gain roll-off starting about 2000 Hz (the low-pass LP condition). The bolts/coffee can noisemaker was a category 6 on average. The jar/glass marbles noisemaker was a bit less loud on average. If your patient rates either of these noises a category 7, you should adjust the MPO a couple of decibels at a time until the rating goes down to category 6.

15 I'm starting to like all this verification stuff! Are there other quick and easy checks I can make to improve the quality of my hearing aid fittings?

Indeed, there are a couple more, and these are also really important. As I said earlier, you should check to make sure that the directionality (DM) and noise-reduction (DNR) features of the hearing aid are working properly. Although there are other new processing algorithms, DM and DNR are the most highly touted advanced features of modern hearing

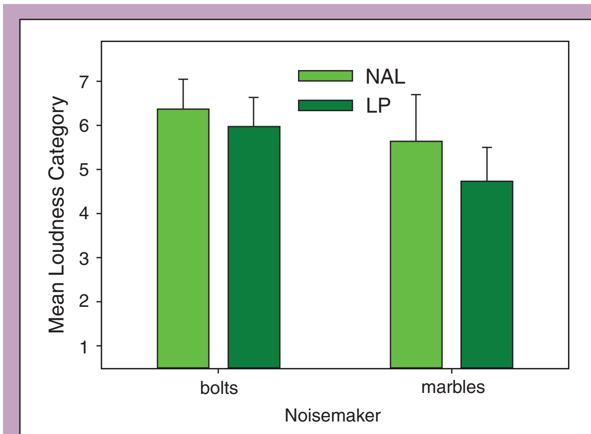


Figure 6. *Mean loudness ratings of two noisemakers by 36 subjects wearing two hearing aid prescriptions.*

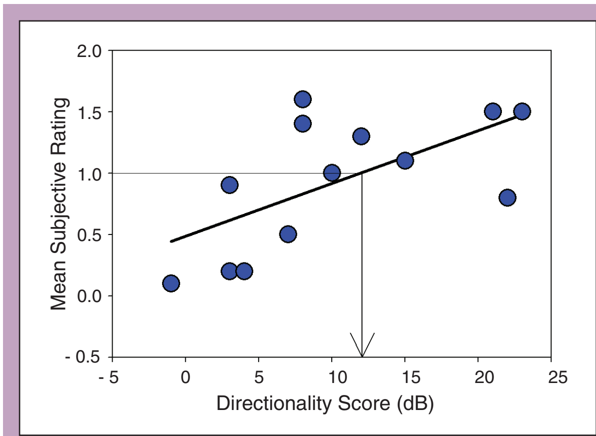


Figure 7. *Test box Directionality Scores and corresponding mean subjective ratings for 13 hearing aids.*

aids, and they are available on nearly all instruments, including entry level.

Based on our counseling, our patients have certain expectations about how these features will operate to help them manage their hearing problems. But, as I mentioned earlier (illustrated in Figure 1), hearing aids function very differently in how much directionality they provide. The same is true of DNR. It is our professional responsibility to make sure these features are behaving as we expect them to when we fit hearing aids on our patients.

16 But you were testing hearing aids in a test box, and I don't have one. What can I do?

Actually, it's not too hard to perform a simple check of directional function. It doesn't give you as much information as a test box or probe-mic measure, but you might be surprised by what you can find out. To do this check you need a CD that has a track with noise (white or pink or speech-shaped). Lots of speech test CDs have something like this. We use the speech-shaped noise on track 1 of the HARL Speech Intelligibility Tests CD (www.memphis.edu/ausp/harl).

First, program the hearing aid for your patient with the DM activated, and attach the hearing aid to a listening stethoset. Next, play your CD using the computer you use to program hearing aids. Just put the CD in the drive and play the noise track on *one* of the computer loudspeakers (the other loudspeaker should be muted or unplugged). Turn up the volume of the speaker until the noise is loud, but not uncomfortable. As you know, many of today's products have "automatic" directional technology, that is, they automatically go into the directional mode when the input signal meets certain requirements (based on intensity and spectral content). That is why it is important for you to use *loud noise* for this test.

To begin the test, hold the hearing aid about 6 inches from the loudspeaker, point the front of the aid at the loudspeaker, and listen through the stethoset. Then turn the hearing aid around so that the back of the hearing aid is toward the speaker. Can you hear a difference in the level of the noise? Based on the difference you can (or cannot) hear, assign a subjective rating as described in the list provided in Table 1. It seems reasonable to assert that hearing aid directionality should be at least "noticeable" in this test to be judged worthwhile.

17 That sounds too easy. Are you sure it works?

Good question. This little test might seem too simpleminded to tell you much, but it actually produces scores that are related to test box measures. We recently compared the test box directionality scores (measured as I described earlier) and the mean subjective ratings for 13 hearing aids[11] (see Figure 7). In this experiment, the DNR was turned off in each hearing aid. The ratings of directionality were provided by 10 practitioners who had some previous experience making these kinds of ratings.

There was a clear relationship between test box data and practitioner ratings: a higher Directionality Score tended to produce a higher subjective rating of the front-back difference. Further, we found that to attain a mean subjective rating of 1.0 ("noticeable"), the Directionality Score must be at least 12 dB. This would be equivalent to, for example, a front-back separation of at least 4 dB across the whole frequency range from 250 to 4000 Hz (there are other patterns that would also give a directionality score of 12 dB). Since a difference smaller than this is not noticeable to a normal-hearing practitioner, it is quite unlikely to be detectable by a hearing-impaired listener.

18 Table 1 includes a scoring category for "wired backward." Would you explain that?

When the DM is wired backward, you notice that the sound is actually louder when the back microphone is pointed toward the noise. This really does happen in a small proportion of cases. Even though it is a rare occurrence, you do not want to miss this problem because it will mean that the DM is actually working against your patient. Needless to say, your patient is not likely to be happy about it. The simple listening test I described above should protect your patient from this type of counter-productive experience.

19 Sounds good. Do you also have a way to do a listening assessment of the DNR function?

I'm glad you asked that. There *is* a way you can check the functioning of the noise-reduction feature on a hearing aid that

Table 1. *Subjective ratings for directional microphone function.*

Subjective rating	Description	Score
Wired backward	Louder when the back microphone faces noise	-1
Not noticeable	No difference regardless of microphone position	0
Noticeable	Front microphone louder than back microphone	1
Very noticeable	Front microphone much louder than back microphone	2

you've programmed for your patient. You need a CD with a noise track (it can be the same one you used for checking the DM functioning), and a speech track (a man or woman talking for about a minute). The recorded levels of the speech track and the noise track should be the same, or very close. For these we use tracks 1 and 2 on the HARL Speech Intelligibility Tests CD. Track 1 contains a speech-shaped noise and track 2 contains a 2-minute speech passage at about the same level as the noise.

Activate the DNR feature and attach the hearing aid to a listening stethoset. Play the CD on the computer you use to program hearing aids, just as you did to check the DM function. Begin by playing the speech track on *one* of the computer's loudspeakers (the other loudspeaker is muted or unplugged). Turn up the volume of the loudspeaker until the speech is loud, but not uncomfortable (you need loud signals so that the DNR will be activated for the noise). Hold the hearing aid about 6 inches from the loudspeaker, point the front of the hearing aid at the loudspeaker, and listen to the speech through the stethoset.

Now use Windows Media Player to switch to the track with noise. In a couple of seconds the noise will begin. Keep listening. The loudness of the noise will probably decrease as the hearing aid recognizes that it is receiving noise instead of speech and engages the DNR. The time needed for the loudness of the noise to lessen varies across hearing aids from just a second or two to half a minute or even more. Wait until the noise level seems to stabilize. Go back to the speech track and repeat the listening test, if you like.

Based on the loudness reduction you can (or cannot) hear when the noise comes on, assign a subjective rating as described in the list in Table 2. In a parallel to the DM test, it seems reasonable to assert that digital noise reduction should be at least "noticeable" in this test to be judged worthwhile.

At this point, you probably will not be surprised when I say that this subjective test produces scores that are related to test box measures. We recently compared the test box noise-reduction scores and mean subjective ratings for 13 hearing aids that were set to give maximum noise reduction with directionality minimized[11] (see Figure 8).

The test box Noise Reduction Scores were computed by measuring the amount of reduction for an 85-dB pink noise in each 1/3-octave band from 250 to 4000 Hz. These noise-reduction values were averaged within low frequencies (250-500 Hz), mid-frequencies (630-1600 Hz), and high frequencies (2000-4000 Hz), and then these three averages were summed. So, a bigger Noise Reduction Score means that the hearing aid DNR processing lowered noise by a greater number of decibels.

Again, there was a clear relationship between the test box data and subjective ratings by 10 experienced practitioners. A higher Noise Reduction Score tended to produce a higher

Table 2. *Subjective ratings for digital noise reduction function.*

Subjective rating	Description	Score
Not noticeable	No reduction in loudness noticed when switching to noise	0
Noticeable	Some reduction in loudness noticed when noise introduced	1
Very noticeable	Large reduction in loudness noticed when noise introduced	2

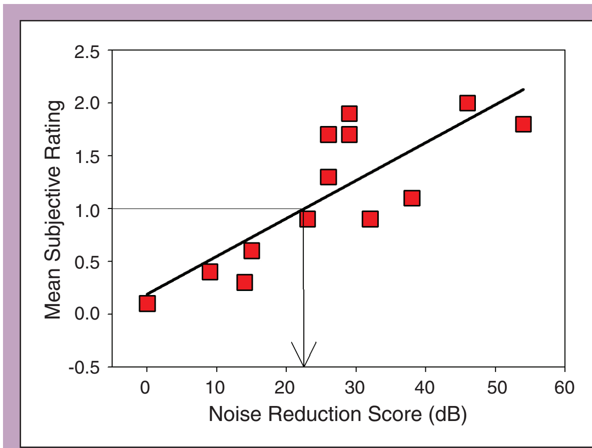


Figure 8. *Test box Noise Reduction Scores and corresponding mean subjective ratings for 13 hearing aids.*

subjective rating of the drop in loudness of the noise. Further, we found that to attain a mean subjective rating of 1.0 ("noticeable") the Noise Reduction Score must be about 24 dB. This would be equivalent to, for example, a noise level lowering of about 8 dB across the whole frequency range from 250 to 4000 Hz.

20 It's starting to sound as if I don't really need a probe-mic system at all, do I?

Whoa! Even though using these low-tech methods will make it more likely that your fittings will be successful, you can never optimize a fitting unless you actually measure what is happening in the patient's ear. When your probe-mic system arrives, you will be able to do so much more.

You can make sure that soft speech is as available as possible by comparing soft speech levels with thresholds across the whole frequency range. You can maximize sound quality by adjusting the programming so that conversational speech matches the prescription targets and has a nice, smooth response curve. You can see those problematic peaks in the MPO curve so you will know how to address certain types of loudness complaints. You can measure the amount of occlusion effect to assess whether the patient's difficulties with his own voice are being caused by that or something else. And, of course, you can make more precise measurements of the way the DM and DNR features are functioning for this patient.

In addition, there are times when you can help the patient better appreciate hearing problems and amplification by discussing and demonstrating the results of ear canal sound measures.

When your probe-mic system arrives, you'll wonder how you ever fitted hearing aids without it. But you'll probably find that you still use some of the techniques I've discussed (such as the HONK) as a valuable *supplement* to your probe-mic findings.

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