

Some instructions to readers on using the *Journal's* real-world audio CD

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The April 1998 issue of *The Hearing Journal* contained an audio CD that supplemented two articles published in the *Journal* in April and May. Bands 1 through 26 of the CD relate to the April 1998 article, "Real-world performance of an ITE directional microphone,"¹ while Bands 27 through 37 accompany the May article, "The case of the missing dots."²

The purpose of the following brief article is to guide the reader in using this CD for demonstration purposes as well as in clinical and research applications.

DEMONSTRATIONS

Bands 1–11

The first 11 bands of the CD are A-B comparisons of omnidirectional and directional microphones in various environments including: clinic test booth, outdoors, restaurants, parties, and reverberant rooms. Bands 1 through 11 were included to demonstrate the range of benefit that can be achieved with advanced directional microphones in real-world environments.

The presentation order of Bands 1–11 was intentionally chosen to illustrate that the highest benefit is obtained in relatively low-reverberation environments (examples: Band 2 anechoic, Band 3 clinic test booth, Bands 4 and 5 Bourbon Street). The next highest degree of benefit is obtained in medium-reverberation environments (examples: Band 6 Lou Malnati's restaurant, Band 7 Elizabethan Restaurant, Band 9 Mardi Gras Museum cocktail party, Band 10 Etymotic Research [ER] classroom party). The least benefit is obtained in a high-reverberation environment (example: Band 11 ER reverberation chamber).

CLINIC TESTS

Bands 12–17

These bands are complete pairs of directional-microphone and omni-microphone blocks of SIN™ test IEEE sentences, and are some of the actual blocks used to obtain the data reported in the "Real-world" article (April 1998). To avoid learning effects in the use of Bands 12–17, recordings with different sentences were chosen for each band on the CD. Bands 12 and 13 were recorded in the Mardi Gras Museum party, 14 and 15 in Lou Malnati's restaurant, 16 and 17 in the ER classroom party. In each case, the even-numbered bands contain directional recordings; the odd, omni.

Each band contains one block of 20 recorded sentences, five each at four different signal-to-noise ratios (SNRs)—nominally +15 dB, +10 dB, +5 dB, and 0 dB—recorded simultaneously through omni and directional microphones housed in binaural in-the-ear (ITE) hearing aid shells.

To use these materials, set the audiometer input level

controls for 0-dB VU on both inputs using the calibration tone or the speech-spectrum noise on Band 24 of the CD. Present the recordings binaurally through earphones at 70 dB HL (or at Loud but OK if the hearing loss exceeds 50 dB HL at any frequency below 4000 Hz). Each omni-microphone list begins with five sentences presented at nominally +15 dB SNR, the next five at nominally +10 dB SNR, and so on.³ (The directional-microphone recordings generally have a better SNR at each level.) Five key words are scored (one point for each word correct) in each sentence, for a total of 25 words per SNR (sentence lists are located in Appendix A of the CD insert). Half credit is given for partially correct words.

At each SNR, the number of words correct is multiplied by 4 to obtain the percent-correct score. The percent-correct scores then are plotted graphically to interpolate the SNR required for 50% correct.

Figure 1 shows the percent-correct scores obtained at each SNR by a hearing-impaired listener in omni and directional conditions. From the figure it can be determined by inspection that the SNR required for 50% correct in the omnidirectional condition was approximately 11 dB: A horizontal line drawn at 50% intersects the omni curve above the 11-dB-SNR point on the x-axis.

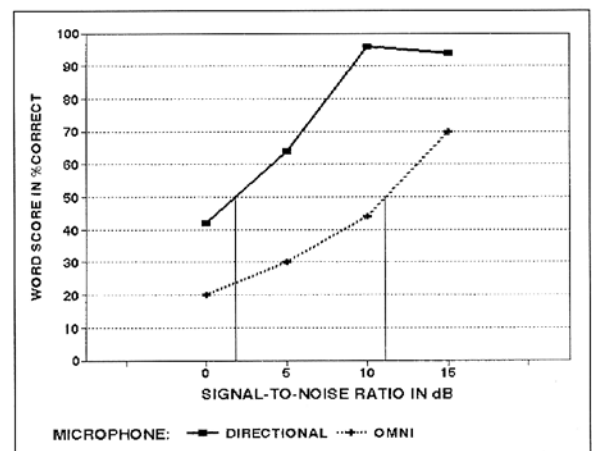


Figure 1. One subject's scores with directional and omni microphones, illustrating the method for estimating SNR in dB for 50% correct score.

Similarly, the SNR required for 50% in the directional condition was 2 dB. Thus, in this example, the directional microphone improved by 9 dB the SNR at which the subject could understand 50% of the words.

HISTORICAL DEMONSTRATIONS

Bands 18–23

These bands were included for their historical reference value. The recordings consist of A-B-A comparisons of omni and directional microphones in various settings and represent the state-of-the-art performance of BTE directional microphones in the late 1970s and early 1980s. Bands 18 through 22 may be compared with Bands 2 through 11 to give the listener an idea of how far we've progressed in directional microphone design in two decades. Band 23 illustrates the excellent matching of frequency responses between the omni and directional microphones in the 1980 recordings.

RESEARCH-ORIENTED TESTS

Bands 24–36

These bands were generated during research for "The case of the missing dots" article (May 1998). These materials permit an estimation of the number of missing dots through a variety of approaches explained below.

Band 24 contains the 0-dB VU calibration tone and a segment of 0-dB VU speech-spectrum noise. The latter is useful when calibrating sound field presentations. Note: By long-standing tradition in the U.S., taught to countless audiologists by Carhart, Olsen, Tillman, and others, the 0-dB VU calibration tone is set equal to the frequent peaks of speech.⁴

Bands 25 and 26 contain normal SIN test blocks but with the speech recorded on Channel 1 and the four-talker babble on Channel 2. This makes it possible to test a person who cannot achieve a 50% correct score even at +15 dB SNR. After 0-dB VU has been calibrated on both channels, Channel 1 is set for the desired presentation level, say 80 dB HL, and Channel 2 is set lower by the number of dB increase above 15 dB SNR desired. For example, Ch1=80 dB and Ch2=70 dB will provide 25 dB SNR for the first five sentences, 20 dB for the next five, etc. It is important to remember that both chan-

nels of the audiometer must be directed to the same (test) ear.

Bands 27 through 30 are low-pass and high-pass filtered versions of the SIN test (two blocks each), which have been brick-wall filtered (100 dB/octave) at 1600 Hz in order to remove approximately half of the speech cues. Only the low-frequency cues are left on Bands 27 and 28; only the high-frequency cues are left on Bands 29 and 30. These filtered-speech tests were used to double-check our estimates of the improved SNR required if half the dots were removed (see Figures 4 and 5 of "The case of the missing dots"). Use of the low-pass and high-pass SIN test recordings found on Bands 27–30 allows one to estimate where the missing dots are in terms of frequency, i.e., 1600 Hz.

Bands 31 through 36 are split-band materials generated to refine our estimate of the missing dots location. Two blocks are recorded at starting SNRs of 2 dB (Bands 31, 32), 7 dB (Bands 33, 34), and 12 dB (Bands 35, 36). In each band, only the high-frequency SNR varies. For example, on Bands 31 and 32, the first five sentences have both low-band and high-band SNRs of +2 dB. In the next three five-sen-

"Five key words are scored in each sentence, for a total of 25 words per SNR."

tence sets, the low-band SNR remains unchanged at +2 dB, but the high-band SNR increases progressively to +7 dB, +12 dB, and +17 dB.

Note: In previous blocks, the SNR progressed from highest to lowest, which makes it easy for the subject to identify the target talker's voice. In Blocks 31–36, the high-frequency SNR starts out at its *worst* (lowest) and progressively improves. An easier time for the test subject may result if the presentation order is reversed manually (by noting and cueing to the times on the CD corresponding to each set of five sentences).

To use these materials, first determine the subject's full-band SNR with one of the standard SIN⁵ test blocks (#3, 4, 5, and 6 are equivalent). Next choose a split-band block with a lower SNR. For exam-

ple, if the SNR for 50% correct on a full-band test is +9 dB, then the +7 dB blocks (33, 34) and the +2 dB blocks (31, 32) should both provide scores below 50%. What we call the "teeter-totter" method is then used: If degrading the low-frequency SNR by 4 dB requires increasing the high-frequency SNR by 4 dB, the "teeter-totter" is balanced. In many cases, however, more high-frequency dots will be required, indicating a larger loss of high-frequency than low-frequency dots. The following example should make the ideas clearer.

Assuming the full-band SNR is 9 dB, choose the 7-dB block of sentences (Band 33 or 34), whose first set of five sentences has low- and high-frequency SNRs of 7 dB, 2 dB below that required for 50% correct. Based on the Count-the-Dots Articulation Index, we can calculate that a 2-dB loss in low-frequency SNR corresponds to $50 \times 2/30 = 3.3$ dots; the same 2-dB loss in the high-frequency band removes another 3.3 dots, for a total deficit of 6.6 dots. Moving the high-frequency SNR from 7 dB to 11 dB, however, should uncover 6.6 extra dots. If all blocks were exactly equivalent and all of the subject's missing dots were distributed evenly across frequency, the result should bring the subject's score back up to 50% correct. The teeter-totter would be balanced.

If an increase in SNR to *more* than 11 dB is required in this example, this indicates that more high-frequency dots than low-frequency dots are missing. The amount of increase gives an estimate of the ratio of high-frequency dots to low-frequency dots that are missing. For example, if a 13-dB high-frequency SNR is required to restore a 50% correct score when the low-frequency SNR is dropped to 7 dB, this means a 4-dB increase in high-frequency SNR is required to balance a 2-dB reduction in low-frequency SNR. Apparently twice as many high-frequency dots are missing.

Band 37

The final band of the CD is a block recorded from the original SIN test. This block is included to demonstrate the SIN test, but it is not one of the equivalent blocks (#3, 4, 5, and 6), and should only be used as a screening tool to determine the approximate SNR deficit for an indi-

vidual patient. The scoring method to determine the SNR for 50% correct is described in this application note in the text for bands 12 through 17. Note: Contrary to the liner notes, Band 37 was *not* equalized for ER-3A earphones. (HJ)

ACKNOWLEDGMENTS

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REFERENCES AND NOTES

1. Killion MC, Schulein R, Christensen L, et al.: Real-world performance of an ITE directional microphone. *Hear J* 1998;51(4): 24–38.
2. Killion MC, Christensen LA: The case of the missing

dots: AI and SNR loss. *Hear J* 1998;51(5):32–47.

3. Note that the actual SNR for any one sentence often varied from the nominal value in the live real-world recordings, including the Mardi Gras Museum and Lou Malnati's restaurant recordings. An analysis of the recorded SNRs convinced the authors that the differences between omni and directional microphone SNRs for 50% correct word scores were adequately represented by assuming nominal SNR values. The SNRs in the ER Classroom recordings were more carefully controlled by a special recording technique, as described elsewhere.¹ Pleasantly enough, the better-controlled experiment gave similar results to the real-world recordings. Note that in the use of these bands, no changes in audiometer settings are necessary: The SNR changes were generated by changing talker effort.
4. For careful research, several VU-meter peaks in each sentence are noted (which can be done within 0.1-0.2 dB with practice) and averaged. Then the average from several sentences sampled throughout the test mater-

ial is used for the final calibration value. Comparison with the rms method commonly used in Europe (and by those using computers rather than meters for measurements) indicates a difference of 7 dB may occur. In particular, single-talker sentences having an rms value of 58 dB SPL would be read as 65 dB SPL by those equipped with meters. The practical significance is that continuous noise or many-talker babble will have about the same rms and VU meter readings, while a single-talker target will read 7 dB lower on an rms determination. Thus SNRs determined with rms measurements may show a value of -5 dB when meter-based measurements show a value of +2 dB SNR.

5. The SIN Test™ is available from Auditec of St. Louis, (314) 781-8890.

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SUPPLEMENTAL INSTRUCTIONS FOR SIN WORKSHEETS

Two helpful worksheets for scoring the Speech-In-Noise (SIN) Test are printed on the back of this article. The two graphs are identical except that the top graph includes mean data for listeners with normal hearing at all four signal-to-noise ratios (SNR) at presentation levels of 40 and 70 dB HL.

As a review, the SIN test is designed to determine the SNR required to repeat 50% of words-in-sentences presented in background noise. To administer the test, five sentences are presented at each of four SNRs (+15, +10, +5, and 0 dB). In each of the five sentences, five key words are scored for a total of 25 scored words at each SNR. Half credit is given for partially correct words. The percent correct is then determined for each SNR.

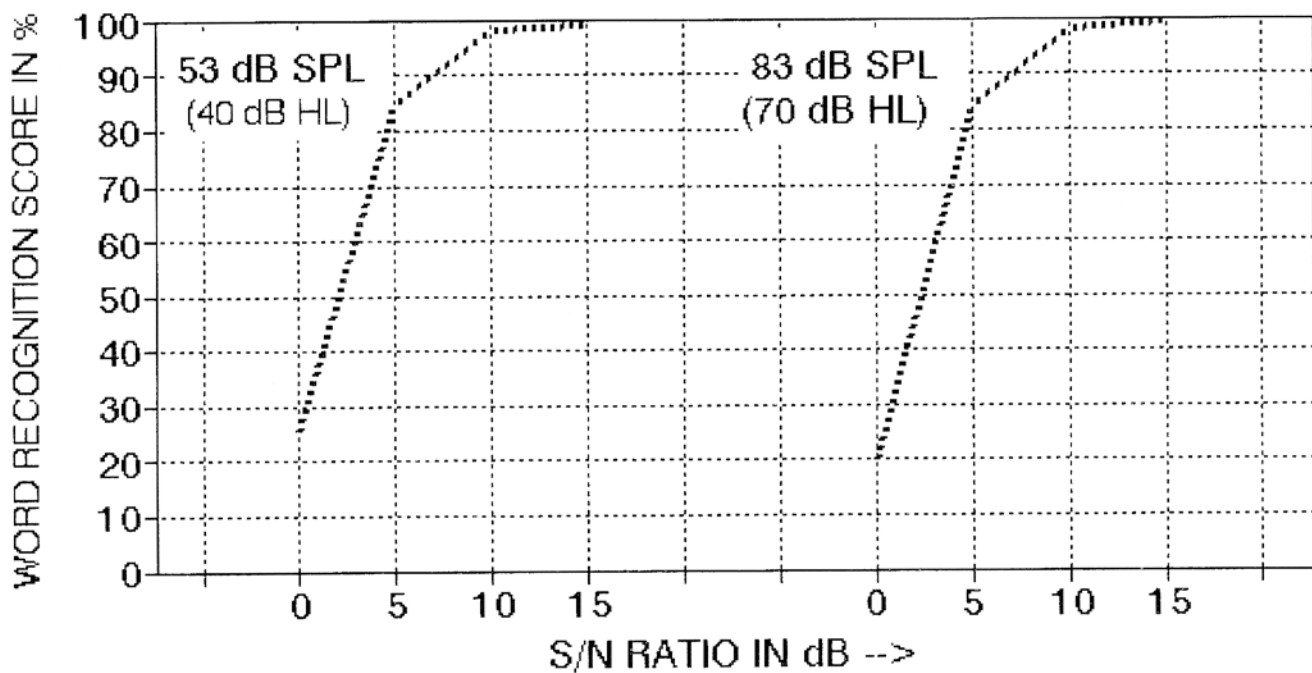
To determine the SNR for 50% correct score, plot a curve on the graph representing the patient's percent correct at each of the four SNRs. Then interpolate the 50% correct SNR by following the 50% horizontal line to the patient's curve. At the point the curve is intersected, draw a vertical line to the SNR axis. This point is the SNR required to obtain a 50% correct score (see Figure 1 of the article for an example).

The worksheets on the next page are designed to be reproduced and used by clinicians when administering the SIN test.

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SIN TEST NORMATIVE DATA

8 NORMAL Ss, BLOCKS 3,4,5,6,8



SIN TEST: BLANK GRAPH

