A New Method of Hearing Aid Evaluation

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The hearing aid evaluation can be an integral part of the total rehabilitation of the hearing-impaired individual. We report a new method of hearing aid evaluation directed to this goal. This new method uses synthetic sentences and speech competition in varying "message-to-competition ratios (MCR)" to evaluate patient performance with hearing aids. We present two cases to illustrate the use of this technique.

INTRODUCTION

The hearing aid evaluation is an important clinical procedure directed to the goal of auditory rehabilitation of the hearing-impaired patient. It is often the only direct rehabilitative measure the audiologist employs in the management of the hearing handicapped individual.

Ideally, the hearing aid evaluation should be a part of an integral rehabilitative process. As such, it should not only "select" the best hearing aid for a patient, but should also aid in judging prognosis for successful hearing aid use, and in determining realistic expectations from amplification. Furthermore, it should provide the basis for meaningful patient counseling.

In an effort to meet these goals, we have designed the following method of hearing aid evaluation. The specific aims of this method are 1) to determine the most suitable hearing aid arrangement for the individual, 2) to define differences among hearing aid arrangements in real life listening conditions, 3) to provide information on realistic expectations of

hearing aid use for patient counseling, and 4) to make accountable rehabilitative recommendations to patients.

METHOD

The patient is seated in the test chamber equidistant between two loudspeakers. Figure 1 shows this seating arrangement. The loudspeaker directly in front of the patient delivers the primary message. The loudspeaker directly behind the patient delivers the secondary message.

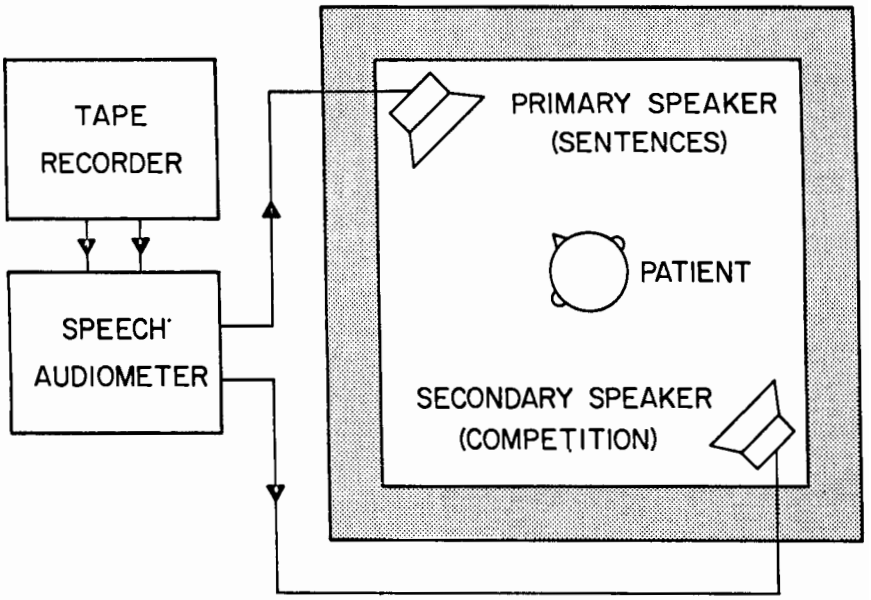


Figure 1: Seating arrangement in the test chamber for hearing aid evaluations performed with the sentence identification materials.

The primary message is a sequence of ten synthetic sentences (Speaks & Jerger, 1965). These sentences are approximations to real English sentences, based on the transitional probabilities linking adjacent words. Table I lists the ten sentences of the primary message set. The secondary message is continuous discourse in the form of a biographical story. This continuous discourse provides speech competition during the presentation of each test sentence.

The primary sentence and the secondary competition are recorded on dual channel magnetic tape by the same male talker. Channel one contains the primary sentences. They are recorded at ten-second intervals. The same ten-sentence list is recorded in ten successively randomized

Table I: The ten synthetic sentences forming the primary message set.

1. Small boat with a picture has become
2. Built the government with the force almost
3. Go change you car color is red
4. Forward march said the boy had a
5. March around without a care in your
6. That neighbor who said business is better
7. Battle cry and be better than ever
8. Down by the time is real enough
9. Agree with him only to find out
10. Women view men with green paper should

blocks. These taped materials are played via a speech audiometer through the two loudspeakers in the test chamber.

The intensity of the primary sentences is set to 60 dB SPL. This intensity is never varied during the evaluation procedure. The secondary speech competition, however, is varied between 40 dB SPL and 80 dB SPL. At each secondary level, all ten primary sentences are presented. Throughout the evaluation procedure, the patient holds before him a large card listing the ten primary sentences. He is instructed to call out the number of each sentence as it is presented.

Each combination of intensity levels defines a "message-to-competition ratio (MCR)." A positive or negative value is assigned based on the relationship of the secondary speech competition to the primary sentences. For example, when the primary sentences are at 60 dB SPL and the secondary speech competition is at 40 DB SPL, the MCR is +20dB. When the primary sentences are at 60 dB SPL and the secondary speech competition is at 80 dB SPL, the MCR is -20 dB. Each MCR condition corresponds to a real-life listening condition. Table II lists the MCR conditions and their corresponding real-life analogs.

The patient is practiced unaided with the primary sentences at a comfortable loudness level. The actual test procedure begins at a +20 MCR condition. The level of the primary sentences is set to 60 dB SPL and the level of the speech competition is set to 40 dB SPL. The level of the speech competition is then varied to produce a different MCR condition. The patient's performance is tested, unaided, under the various MCR conditions.

Performance with a given hearing aid arrangement is then evaluated

Table II: The various MCR conditions and their real-life listening situation analogs.

MCR in dB	LISTENING SITUATION
+20	Very easy
+10	Easy
0	Average
-10	Difficult
-20	Very difficult

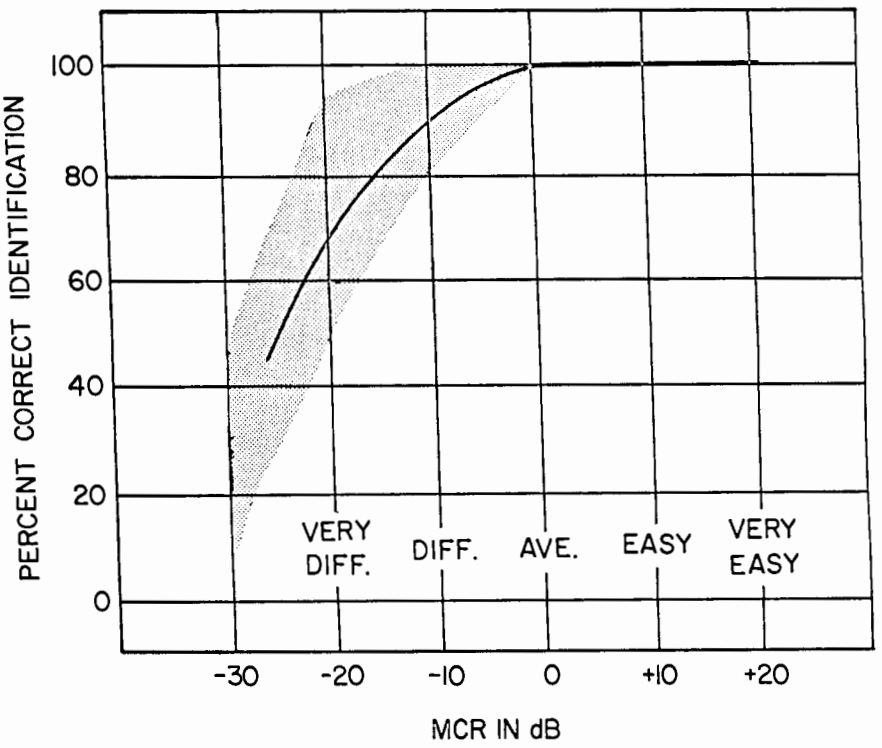
under the same varying MCR conditions. While the continuous discourse (speech competition) is presented at 60 dB SPL, the audiologist adjusts the acoustic gain of the hearing aid to a comfortable loudness level for the patient. This gain setting remains constant during the subsequent testing.

At the completion of the evaluation procedure, the patient's unaided performance is re-tested under several MCR conditions. This allows the clinician to evaluate the "practice effect" in comparing unaided to aided performance.

The patient's unaided and aided scores at each MCR are plotted graphically in relation to the performance of normal listeners in the same condition. Figure 2a shows this graph. The abscissa represents the varying MCR condition from -20dB (very difficult) to +20 dB (very easy); the ordinate shows performance in percent. The patient's performance is described as his "SSI score." The shaded area of the graph represents the expected performance range of normal listeners. Figure 2b shows a hypothetical hearing aid evaluation plotted on this summary form. The solid triangles represent the patient's unaided performance and indicate that he was unable to identify any sentences in any listening condition. The open circles represent the patient's performance with a hearing aid. The difference between this patient's unaided and aided performance is considered his "aided improvement," and is easily visualized on this graph. Similarly, the difference between his aided performance and normal performance is considered the patient's "residual deficit." Both concepts, "aided improvement" and "residual deficit," are helpful in counselling the patient successfully.

ILLUSTRATIVE CASES

We present the following cases to illustrate our clinical experience with this new method.



Fibure 2a: Hearing aid evaluation summary form for recording patient performance with SSI materials. The shaded area represents the performance range of normal listeners.

Case one is a 76 year old retired male with a moderate sensori-neural loss in his right ear, and a profound loss in the left ear. His PB score was good (84%) in his right ear, but could not be measured in his left ear. This patient had worn a body-borne hearing aid for a number of years. Although he was satisfied with this arrangement, he wanted to know whether an ear-level hearing aid arrangement would improve his communication ability. His audiogram and hearing aid evaluation summary form are shown in Figure 3.

Without a hearing aid, this patient was unable to identify any of the primary sentences in the very-easy listening condition (+20 MCR). With his own body-borne hearing aid, his SSI score was 100% in the easy and average listening conditions (+10 MCR and 0 MCR); 60% in the difficult listening condition (-20 MCR). His SSI score did not improve with the other arrangements tested, a directional microphone ear-level IROS aid, and a left-to-right BiCROS.

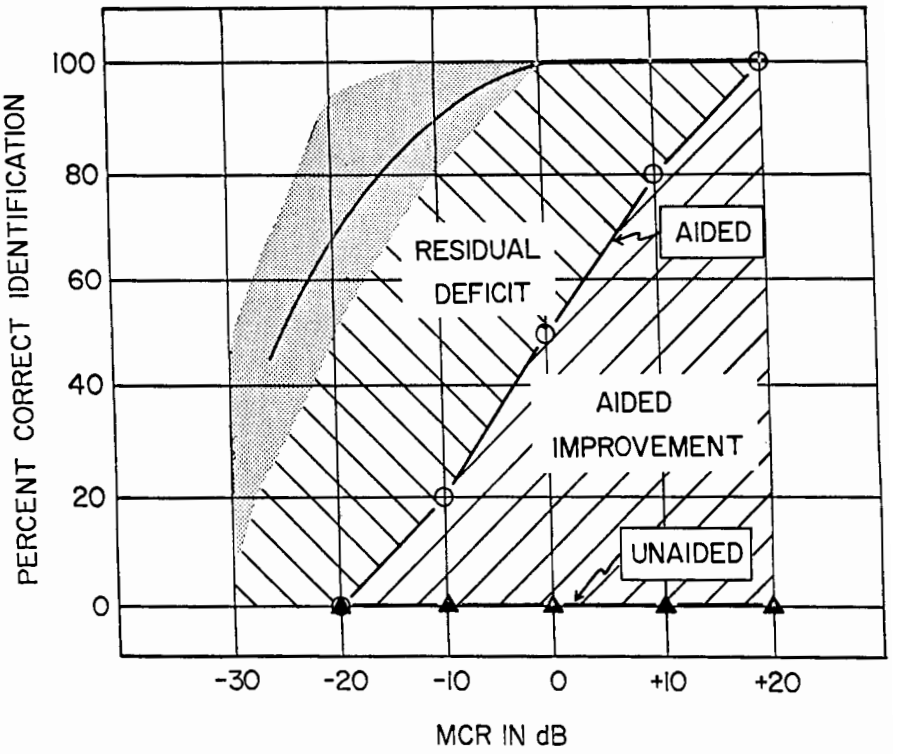


Figure 2b: Hypothetical hearing aid evaluation summary showing concepts of "Aided improvement" and "Residual deficit."

This case illustrates how the SSI procedure successfully evaluated the patient's performance with various hearing aid arrangements. Each arrangement tested was a distinct configuration of amplification. These various configurations were compared in four listening conditions by the same test protocol. The graphic comparison of the arrangements tested quickly revealed how much aided improvement he experienced in each listening condition, which arrangement afforded him the most aided improvement, and how much residual deficit still remained. Clearly, his own body-borne hearing aid was as good as, or better than, the other arrangements tested.

Case two is an 11 year old female with a moderate, bilateral apparently congenital hearing loss. Her PB-K score was good bilaterally (80%). Her hearing loss was identified at age three years, and she had worn a body-borne hearing aid with a Y-cord since that time. Her audiogram and hearing aid evaluation summary form are shown in figure 4.

Unaided, this patient could not identify any primary sentences in the

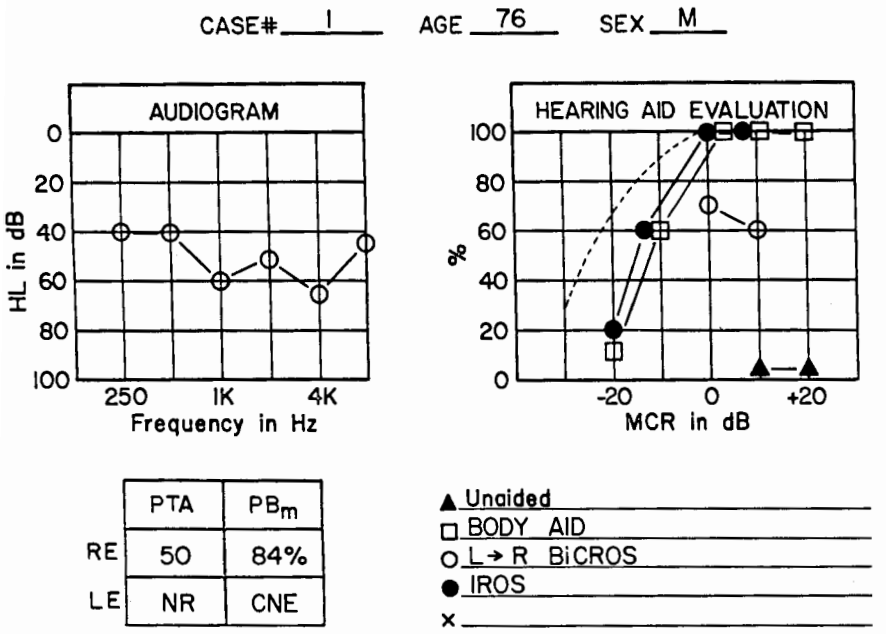


Figure 3: Audiogram and hearing aid evaluation summary form for case one, a 76 year old male with a moderate sensori-neural loss in the right ear, and a profound loss in the left ear.

very-easy listening condition (+20 MCR). With her own body-borne hearing aid, her SSI score was 80% in the easy listening condition (+10 MCR), 40% in the average listening condition (0 MCR), and 0% in the difficult listening condition (-10 MCR). With a standard binaural IROS arrangement, her score improved 20% to 30% in the easy and average listening conditions (+10 MCR and 0 MCR). Binaural IROS hearing aids with a directional microphone feature, moreover, improved her performance even further. With this arrangement, her SSI score was 100% in the average listening condition (0 MCR) and 80% in the difficult listening condition (-10 MCR). We recommended the binaural IROS arrangement with the directional microphone.

This case shows how our test procedure can successfully evaluate the audiologist's most challenging patient, the child. Ideally, a hearing aid evaluation for a child should not only identify the most suitable hearing aid arrangement, it should also initiate meaningful discussion with the parents on hearing handicap and hearing aid use. This evaluation allowed us to quickly determine the most suitable hearing aid arrangement for the child. It also allowed the parents to observe their child's performance under listening conditions they could understand. This contribu-

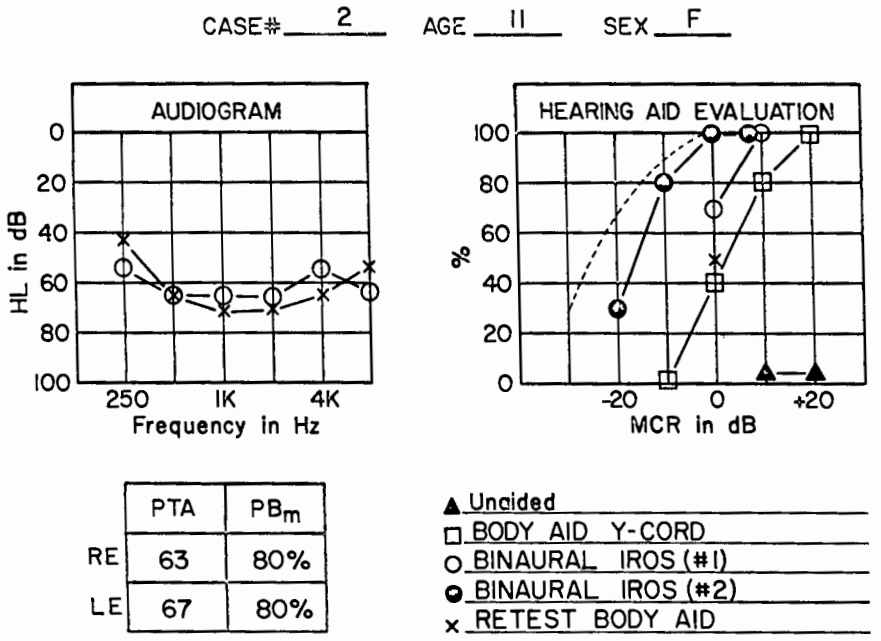


Figure 4: Audiogram and hearing aid evaluation summary form for case two, an 11 year old female with a moderate, bilateral sensori-neural loss.

ted to a thorough discussion of the child's hearing handicap and a consideration of realistic expectations from hearing aid use.

DISCUSSION

We believe that this new method of hearing aid evaluation can play a significant part in the auditory rehabilitation of the hearing impaired patient. It not only helps determine the best hearing aid for the patient, but also aids in judging prognosis for successful hearing aid use and in determining realistic expectations from amplification.

We further believe that this technique has several advantages over other methods of hearing aid evaluation. First, by varying the difficulty of the listening task, we can clearly define differences among hearing aid arrangements. The five potential test conditions of this new method provide a complete range of listening difficulty, from "very easy" to "very difficult." Differences among arrangements may be evident in some, but not all listening conditions. Second, by quantifying patient performance relative to normal listeners' performance, we can more realistically counsel patients on expectations of hearing aid use. The test conditions of

varying listening difficulty provide a meaningful framework for interpreting test results to patients. Third, the procedure can be used to evaluate patients with almost any degree of hearing impairment. For patients with very severe hearing losses, we might consider improvement in the very easy and easy listening conditions (+20 and +10 MCR) sufficient for recommending a hearing aid, whereas for patients with minimal hearing loss, we might not recommend an aid unless improvement could be demonstrated in difficult and very difficult listening conditions (-10 and -20 MCR).

Our experience leads us to the conclusion that this new method of hearing aid evaluation is an important part of rehabilitative audiology. It not only validly evaluates hearing impaired patients and their performance with amplification, it also differentiates performance with various hearing aid arrangements and allows us to make more accountable hearing aid recommendations.

REFERENCES

SPEAKS, C., and JERGER, J.: (1965) Method for the measurement of speech identification. *J. Speech Hearing Res.* 8:185-194.