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SPEECH AUDIOMETRY*

By THEO E. WALSH (St. Louis, Mo., U.S.A.)

IN spite of the many articles in recent years on the subject of speech audiometry, it seems that otologists in general are not fully aware of its value in diagnosis and prognosis. The reasons for otologists' lack of enthusiasm for the newer testing procedures are probably two-fold. First, the otologist is apt to be unfamiliar with the audiologists' terminology, e.g. "discrimination score", "articulation function", "social adequacy index", etc.; second, he is appalled by the thought of the cost of apparatus required for doing speech testing. It is perhaps unfortunate that in most papers dealing with speech audiometry, diagrams have been published of apparatus that appears complicated and expensive. However, it must be remembered that the authors of these papers were reporting investigative work, and elaborate apparatus was necessary for their purpose. Perfectly adequate speech audiometry can be done with relatively simple apparatus in the otologist's office, as has been pointed out by Work (1949). It is a mistake for otologists to think that elaborate expensive equipment is essential for speech audiometry. Speech audiometers, records, etc., are now available commercially at a cost of approximately $400—£130.

Speech audiometry differs from the pure tone audiogram only in two main aspects: 1. The test material used is speech rather than pure tones. 2. The hearing is measured not only at threshold but at supra-threshold intensities. A third and an important difference between the two methods is that in pure tone audiometry the examiner relies on the patient to tell

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him whether or not the signal is heard; in speech audiometry he *knows* whether or not the signal is repeated correctly.

Let us review the principles of speech audiometry briefly. For the purpose of this paper, let us confine our testing to each ear separately. When speech is delivered to the ear of a normal listener at gradually increasing intensities, he can hear and repeat correctly more of the speech as the intensity increases, until all of the test material is heard and repeated correctly. If the listener's responses are plotted, a curve, as in Fig. 1, is obtained. This is called the "Articulation Function". The shape of this curve will vary to some extent with the test material used. For instance, sentences with contextual clues, numbers and disyllabic words are easier than isolated monosyllabic words or nonsense syllables. The curve for easier material is obviously steeper than for that which is difficult. The threshold of intelligibility is defined as that intensity at which the subject hears and repeats correctly 50 per cent. of the test material. It is important when reporting the results of speech tests to indicate what test materials were used and the conditions under which the test was performed. For example, normal threshold for the disyllabic word lists is 22 db. re ·0002 dyne/cm.^{2} while for the monosyllabic word lists is 33 db. (See Fig. 1.)

The "Discrimination Score" of a listener is the percentage of material correctly heard at an intensity above which no further improvement occurs.

It has been our experience that the threshold can most reliably be obtained by using recorded lists of spondee words, which are delivered to the ear first at an intensity at which all the words are heard and then with the intensity reduced in four decibel steps until the patient no longer repeats correctly any of the words. That intensity at which he repeats correctly 50 per cent. of the words is his "Threshold of hearing for Speech". Note the increased validity of the test over the pure tone audiogram. Here we test the patient's ability to hear speech, with speech, and do not translate his threshold for pure-tones into his threshold for speech.

For the discrimination score the phonetically balanced (P.B.) word lists originally assembled at the Psycho-acoustic Laboratory at Harvard is the material we find most useful. Those lists consist of fifty monosyllabic words, each list being designed to contain the phonemes of English in proportion to their relative occurrence in conversational speech. They are phonetically balanced, they are familiar words and they depend on slight differences for their difficulty. For example to differentiate between "thin" and "fin" or "pit" and "pith" requires a high degree of discrimination. The P.B. lists are administered to the patient at least 35 decibels, sometimes 40 or 50 decibels above his threshold for speech. For test-retest reliability it is important that recorded speech rather than "live voice" be used as the test material.

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Speech Audiometry

It is obvious that a patient with normal cochlear function but with a conductive loss of hearing, will hear and repeat correctly all the words on a P.B. list if these words are delivered to him at a sufficient intensity to overcome the conductive deafness. His articulation function, therefore, will be parallel to that of the normal but shifted to the right by the number of decibels of threshold loss (Fig. 1, Curve B). On the other hand, the patient with impaired cochlear function, i.e. with a perceptive deafness, will hear correctly only a certain percentage of the words, however loudly they may be administered. The perceptive deafness curve, therefore, will flatten out at a level below the maximum of 100 per cent. as in Fig. 1,

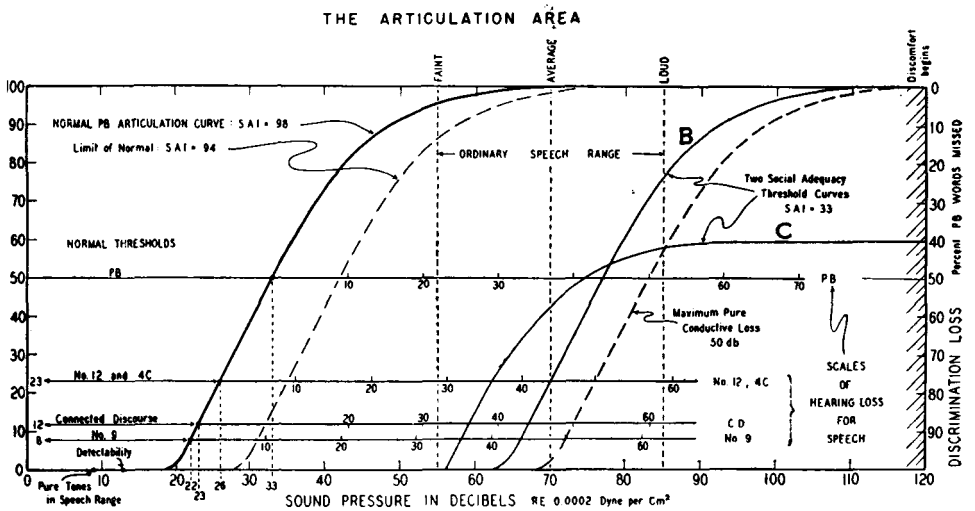


FIG. 1.

Curve C. Varying degrees of perceptive deafness will give a greater or lesser discrimination score.

The Social Adequacy Index of Hearing

To appreciate the handicap of the hard of hearing individual, it is necessary to know how much he hears not only at threshold but in the supra-threshold conditions of everyday life. In other words, how much he hears of faint speech—of normal conversation or of loud speech. The intensity of normal conversation has been determined to be about 70 db. re ·0002 dyne/cm.² and that of "faint" and "loud" speech approximately 15 db. less and more respectively. We have suggested that the average percentage of P.B. words heard at these levels of "faint", "normal" and "loud" speech is the Social Adequacy Index of hearing (S.A.I.). This index is comparable in hearing to the I.Q. in education.

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The S.A.I. is determined by averaging the discrimination scores at which the articulation function crosses the three vertical lines drawn at 55, 70 and 85 db. re ·0002 dyne/cm. in Fig. 1. We assume that the shape of the articulation function is the same for all types of hearing loss but that it is displaced either to the right in pure conduction deafness or to the right and downward in mixed and perceptive deafness. Thus the S.A.I. can be determined in any case in which the threshold and discrimination scores are known. Davis (1948) has made a Table of S.A.I. Scores for all combinations of threshold and discrimination scores (Fig. 2). The Threshold of Social Adequacy is S.A.I. 33 (Silverman *et al.*, 1948).

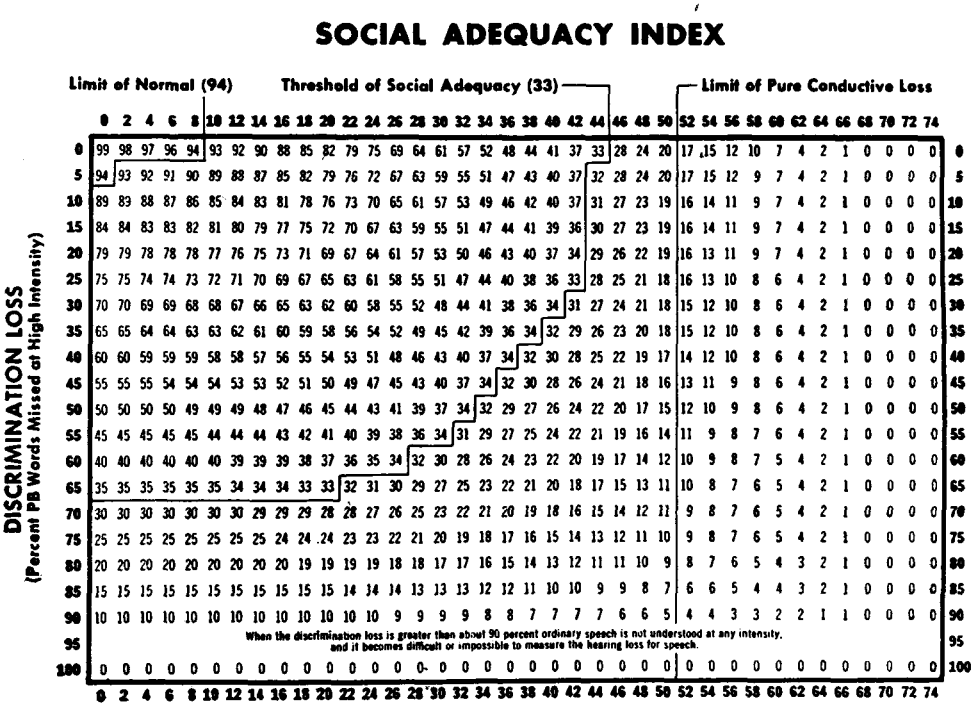


FIG. 2.

Speech Audiometry and Fenestration

The surgeon who performs the fenestration operation for clinical otosclerosis has difficulty in predicting the outcome in those cases in which there is apparent nerve involvement. The patient with a normal bone conduction audiogram and an air conduction loss at threshold for pure tones of from 40 to 60 decibels can usually be advised that he has a good chance for success from fenestration. It becomes more difficult to predict the outcome of the operation when the pure tone bone audiogram exhibits

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a loss of 20-30 db., i.e. in cases of mixed deafness. Speech audiometry and the S.A.I. make possible a prediction of whether the operation is worth while or not, but it must be based on the surgeon's previous experience. In our cases the *average* improvement at threshold from fenestration is 27 decibels. The maximum gain possible is 40 decibels.* As an example, a patient with a 60 db. threshold loss but with 95 per cent. discrimination has an S.A.I. of 7. He can expect a gain from fenestration of 27 db. at threshold and can therefore expect an S.A.I. of 53. If he obtains the maximum gain possible his S.A.I. will be 79. Either result will be very satisfactory. On the other hand, a patient with a 60 db. threshold loss and only 45 per cent. discrimination can hope for an S.A.I. of only 35 or at best of no more than 50. In the former instance chance of success makes the operation worth while; in the latter case the chances are so poor that a hearing aid should be advised. It is apparent that a far more realistic prediction of the possible results from fenestration can be made on the basis of speech audiometry than by reliance on the bone conduction audiogram and the correction for the "Carhart Notch" (Shambaugh, 1952).

Speech Audiometry and Perceptive Deafness

The otologist, who relies on pure tone audiometry, has difficulty in knowing how a hearing aid will help a patient with perceptive deafness. Too often a nerve-deaf person is "fitted" with a hearing aid only to find it "makes him nervous" and he refuses to wear it. Such a patient is often accused of being "obstinate" in refusing to learn to use the aid, whereas, in reality, an examination of his hearing at supra-threshold intensities demonstrates why he cannot benefit from it.

Patients whose pure tone audiograms and speech tests are shown in Fig. 3 will serve to illustrate the point. R.A., a woman 24 years of age, complained of considerable difficulty in hearing, particularly at social gatherings. She found a conversation with one person in a quiet room was not too difficult, but that when there were several people talking or if the environment was noisy she understood nothing of what was said.

J.H., a man 23 years of age employed in a government office, had similar difficulty but found that if people spoke loudly enough he could understand most of what was said. He also complained of great difficulty in a noisy environment.

The pure tone audiograms of both patients are strikingly similar. Only the air conduction curve is illustrated; the bone thresholds were the same as the air thresholds and were omitted from the chart for clarity.

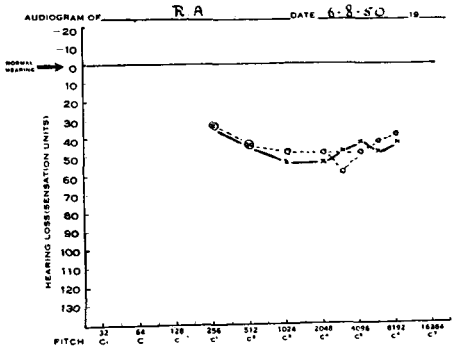
Speech audiometry revealed that R.A. can hear ordinary conversation with her left ear but at best only understands 24 per cent. of what she

* Assuming the limit of conduction deafness is 60 db. and the residual loss after fenestration—due to the disruption of the ossicular chain—is 20 db.

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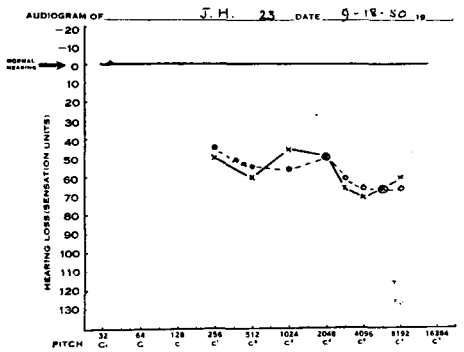
hears. A hearing aid in her case would only cause the sounds she already hears to be much louder but no more understandable.

J.H. on the other hand has difficulty in hearing ordinary conversation but can understand at best 74 per cent. of what is said provided it is loud enough to be heard. An aid that would improve his threshold for hearing would materially help him. He would not have to ask people to speak loudly nor to repeat.



	Right	Left
#9	44	48
P.B.	56% at 110 60% at 110	74% at 110 60% at 110
S.A.I.	25	20

Fig. 3 (i).



	Right	Left
#9	49	37
P.B.	10% at 100	24% at 100
S.A.I.	8	17

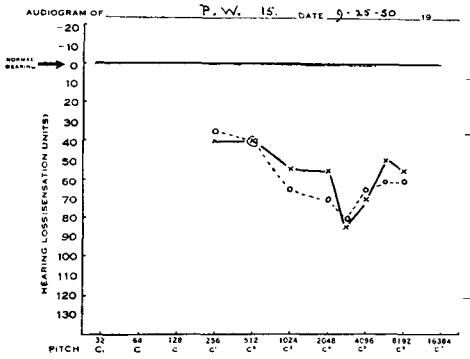
Fig. 3 (ii).

Another example is P.W., a girl 15 years of age whose pure tone audiogram and speech tests are shown in Fig. 4. Although at best she understands only 46 per cent. of the words she hears, an aid in the right ear would make the words easier to hear. She does well with an aid. On the contrary R.M., a man 46 years old whose audiogram and speech tests are shown in Fig. 5, would find an aid useless. His threshold loss for speech is only 29 db. in the better ear, and an aid would not help him understand more than the 32 per cent. which he already hears.

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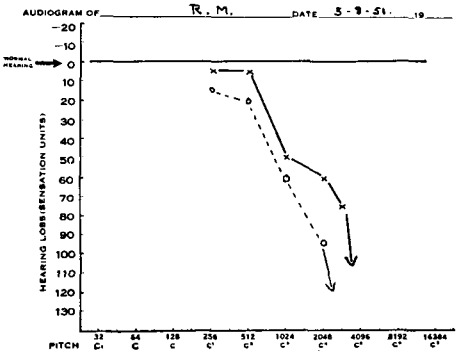
Speech Audiometry

Speech audiometry affords the otologist an appreciation of his patient's difficulties. It must be emphasized that in a case such as that of R.A. the patient must not be dismissed with the remark that there is nothing that can be done for her. She should be advised that, to date, there is no known therapy that will cure her deafness, that "treatments" by injection of



	Right	Left
#9	59	62
P.B.	46% at 110 38% at 116	30% at 104 40% at 100
S.A.I.	8	4

Fig. 4.



	Right	Left
#9	29	40
P.B.	32% at 110 30% at 90 12% at 70	8% at 110 30% at 100 32% at 80

Fig. 5.

vitamins, etc., and by irradiation will serve only to lighten her purse. On the other hand she should be encouraged to learn and to become adept at lip reading and in the interpretation of any auditory clues. In other words, as Day (1950) has put it, she must "learn to hear with her eyes and with her brain".

Speech Audiometry in Diagnosis

The deafness of Ménière's disease (endolymphatic hydrops) is an end organ deafness. Dix, Hallpike and Hood (1948) have pointed out that the recruitment phenomenon is present in Ménière's disease and is absent or

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incomplete in lesions of the nerve medial to the cochlea. Eby and Williams (1951) confirmed these findings and stated that speech intelligibility of individuals with end organ lesions reaches a maximum and then declines with further increases of intensity while, in individuals with nerve fibre degeneration, speech becomes more and more intelligible with increased intensity of sound until the limit of the audiometric scale is reached.

We also found that in Ménière's disease recruitment or over-recruitment was present in almost every case. With speech tests we found that the discrimination score was universally low. Of 49 ears in which a diagnosis of Ménière's disease was made, 86 per cent. had a discrimination score of less than 50 per cent. and in no case was the discrimination score better than 80 per cent. (see table). This loss of discrimination was in

TABLE

DISCRIMINATION SCORES IN 49 EARS WITH MÉNIÈRE'S DISEASE

Discrimination	No.	%
0 -10%	14	29
11%-20%	9	19
21%-30%	5	10
31%-40%	10	20
41%-50%	4	8
51%-60%	3	6
61%-70%	2	4
71%-80%	2	4
	49	100

contrast, in many cases, to a relatively moderate loss of hearing for speech at threshold. It would seem that a poor discrimination score with a *relatively* small threshold loss for speech is indicative of an end organ lesion.

Summary

1. Speech audiometry is within the means of the average practising otologist. The appropriate apparatus is not prohibitive in cost, nor is the method excessively time-consuming.

2. Speech audiometry affords the otologist an understanding of his patient's ability to hear speech not only at threshold but at the supra-threshold intensities of everyday life.

3. Speech audiometry is more satisfactory than the pure tone audiogram as a means of predicting the possible results of the fenestration operation and in determining when a hearing aid will be of value.

4. Speech audiometry affords an added test in making a differential diagnosis in cases of Ménière's disease and in lesions of the VIIIth nerve proximal to the cochlea.

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Speech Audiometry

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