Reprint from
INTERNATIONAL AUDIOLOGY - AUDIOLOGIE INTERNATIONALE
Vol. VI - No. 3 - December 1967 - pp. 431—435

THE MEASUREMENT OF THE EFFECTIVENESS WITH WHICH HARD-OF-HEARING INDIVIDUALS DISCRIMINATE SPEECH

Keith K. Neely

International Audiology - Audiologie Internationale
Vol. VI - No. 3 - December 1967, pp. 431-435

ERRATA

1. Page 432, line 9. "(1965)" should read "(1955)"
2. Page 432, line 21. "The scores" should read "The levels, signal-to-noise ratios, and intelligibility scores"
3. Page 432, line 37. "scores" should read "50% threshold levels"
4. Page 433, line 4. "89" should read "0.89"
5. Page 433, line 9. "Section" should be deleted.
6. Page 434, line 1. The first sentence should read: "The results support previous conclusions that an improvement could be made in assessing the effectiveness with which hard-of-hearing individuals hear speech in "everyday" conditions"

THE MEASUREMENT OF THE EFFECTIVENESS WITH WHICH HARD-OF-HEARING INDIVIDUALS DISCRIMINATE SPEECH*

by Keith K. Neely **, Downsview, Ontario, Canada

Valid and reliable measures are essential for assessing the ability of hard-of-hearing individuals to discriminate speech whether it be for purposes of compensation, pensions, job security or aural rehabilitation.

It is very difficult to determine the ability of the hard-of-hearing individual to discriminate speech under "everyday" conditions in which there may be noise, competing speakers and sound reflecting areas. The procedures employed for compensation purposes in the United States and Canada are outlined by Fox (1965). These include the use of various hearing impairment formulae based on pure-tone air-conduction hearing sensitivity levels, speech reception thresholds (SRT), speech discrimination scores (DS), whisper or conversational voice tests and medical evaluations. The tests are usually carried out under quiet conditions. Speech tests, presented under controlled noise-distortion conditions which simulate "everyday hearing" environments are apparently not used as the official basis for compensation.

Glorig (1958), Young and Gibbons (1962), Davis (1964) and Newby (1964) among others, have emphasized that hearing sensitivity data are not suitable for predicting discrimination of speech under "everyday" conditions. Harris (1963) pointed out that in many cases the use of SRT and DSs did not provide an assessment of acceptable accuracy of a hard-of-hearing person's communication ability. Thompson and Hoel (1962) have also indicated that hearing-sensitivity levels may not be used to accurately predict speech discrimination by individuals with sensorineural hearing losses. Sataloff and Varsallo (1965) have suggested that the major problem in the evaluation of the significance of occupational deafness is the lack of suitable tests while Simmons and Dixon (1964) point out that although hearing sensitivity tests may be a useful tool for diagnosis of auditory pathology their limitations must always be understood.

In the development of tests of impairment of speech discrimination there is experimental and clinical evidence that the use of "normal" hearing data is not satisfactory. Lightfoot, Carhart and Gaeth (1956) have reported that people with either conductive or sensorineural deafness do not suffer the same masking effects for a given effective level of masking noise as do normal-hearing individuals. Elliott (1963) found that speech-discrimination scores, using PB words, obtained from individuals with sensorineural losses are qualitatively different from those obtained from individuals with normal

* Defence Research Establishment Toronto Review Paper No. 642.

** Head, Sensory Capacities Section, Human Factors Wing, Defence Research Establishment Toronto, Downsview, Ontario, Canada hearing. In addition, Ross, et. al. (1963) report that with individuals who had sensorineural hearing losses the two ears did not always function equally in the discrimination of speech in noise. The ear which yields the better speech-discrimination score in quiet may not do so in noise.

Carhart (1965) points out that the existing speech discrimination tests are "imperfectly standardized and lack validation" and stresses the need of determining the efficiency of discrimination of speech with tests presented in noise environments which can be related to "everyday" environments. Silverman and Hirsch (1965) have suggested that different "kinds" of speech tests may have to be developed for use for different purposes, i.e., speech impairment evaluation, pathology diagnosis, and rehabilitation procedures. Harris (1960) has recommended that in order to correctly assess a hard-of-hearing individual's social incapacity the use of speech with a battery of distortions (noise, filtering, peak clipping, abnormal reverberation times, etc.) is required. Schultz (1964) suggests that different tests are needed for testing consonant discrimination and vowel discrimination.

Studies were initiated at the Defence Research Establishment Toronto to obtain more information concerning how the hard-of-hearing discriminate speech and the adequacy with which various formulae predict hearing impairment for speech. These studies complement and supplement work done by other investigators. The scores obtained using various speech tests, presented in quiet and in noise, were compared with SRTs, MCLs and DSs, and various formulae often used to asses hearing impairment for speech. The formulae included the **AMA** (Council on Physical Medicine, AMA, 1947), **AAOO** (Committee on Conservation of Hearing, AAOO, 1959), **two best frequencies** (Fletcher, 1950), **two worst frequencies** (Harris, Haines and Myers, 1956) and the **New York State** (Symons, 1957).

In the first of three preliminary studies 23 hard-of-hearing individuals took part. They were classed, after audiological and otological examinations, as having **mixed deafness.** They heard binaurally, in quiet, at four SPL, three types of speech material, i.e., multiple-choice intelligibility test words (Black, 1957 and Black and Haagen, 1963), CID W-22 PB words (Hirsh, et. al., 1952) and 3 digit numbers. Results indicated highly significant correlations ($p < 0.001$, range $r = 0.89$ to 0.96) between the 50% speech intelligibility threshold levels obtained with two of the speech tests (multiple-choice and PB words) and the scores of the hearing impairment formulae. Similar correlations (range $r = 0.78$ to 0.94) were found between the scores of the two speech tests and the hearing sensitivity levels from 250 to 2000 Hz. The correlations between the hearing impairment formulae scores and the hearing sensitivity levels below 4000 Hz ranged from 0.78 to 0.97. In 13 out of 15 instances there were highly significant correlations (range $r = 0.64$ to 0.98) between the 50% thresholds of speech intelligibility obtained using the three speech tests. The correlations between the scores of the various hearing impairment formulae were all over 0.93.

In the second study individuals with **predominantly high frequency** hearing losses, caused primarily by exposure to high-intensity impact- and continuous-type noises, were presented monaurally (76 ears) with multiple-choice test words, in white noise at sensation levels of 47 and 77 dB. The S/N levels were determined at which 50 per cent intelligibility scores were obtained.

None of the correlations between the S/N levels and the SRT, DS, MCL, and hearing impairment formulae scores were significant. It should be noted that the listeners had normal SRTs. In 31 out of 48 comparisons there were highly significant correlations (range r = 0.36 to 89) between the hearing impairment formulae scores and the hearing sensitivity levels. Highly significant negative correlations (r < — 0.39) were found between the hearing sensitivity levels above 2000 Hz and the DS scores. A highly significant correlation (r = 0.47) was found between the S/N levels obtained with the two noise conditions.

Section

In the third study individuals with **mixed deafness** were presented monaurally (99 ears) with multiple-choice test words under three listening conditions, i.e., (1) speech at MCL level in quiet, (2) speech at MCL and white noise 10 dB less (S/N = +10 dB), and (3) speech and white noise at MCL level (S/N = 0 dB). The speech intelligibility scores obtained under the three listening conditions were not correlated (r < — 0.11) with results obtained using the hearing-impairment formulae. This is in contrast with the results obtained in the first of our studies in which the levels for 50% intelligibility obtained when the speech was heard in quiet did correlate highly with the scores obtained with the hearing-impairment formulae. There was also no significant correlation (r < — 0.01) between the scores obtained under the three speech conditions and the hearing sensitivity levels from 250 to 2000 Hz. However, highly significant negative correlations (r > — 0.33) were found between the hearing sensitivity levels at 4000 Hz and the speech conditions scores in noise and a significant negative correlation (r = — 0.30) with the speech conditions scores in quiet. The hearing sensitivity levels at 8000 Hz had a significant negative correlation (r > — 0.27) with the speech conditions scores in noise. In 32 out of 36 comparisons the hearing sensitivity levels correlated highly significantly (range r = 0.33 to 0.94) with the hearing-impairment formulae scores. Highly significant correlations were found between the MCL and the hearing sensitivity levels (range r = 0.35 to 0.74) and the hearing impairment formulae (range r = 0.77 to 0.83). There was also a highly significant correlation (r > 0.59) between the speech intelligibility scores obtained under the three speech conditions.

Discussion

The results of this preliminary work indicate that pure-tone and speech threshold data should not be used to predict the amount of speech-discrimination impairment that an individual, with a mixed or sensorineural loss, will have. The accuracy of this conclusion is dependent upon the degree to which the multiple-choice words simulate "everyday" speech and the extent to which white noise presents similar masking effects on speech as "everyday" noise. While the multiple-choice test words and white noise used in these studies may not simulate all aspects of "everyday" conditions they are more realistic than pure tones heard under quiet conditions.

Conclusions

Preliminary studies have been made in which the results of speech tests in noise were compared with the scores determined using speech impairment formulae. The results support previous conclusions that hard-of-hearing individuals hear speech in "everyday" conditions. Our results also indicate that more emphasis of 4000 Hz hearing sensitivity levels in hearing impairment formulae may make them more accurate. Work must be continued into the development of more accurate speech tests for use in determining hearing impairment for speech under various acoustic conditions if the public, hard-of-hearing and/or taxpayer, is to be adequately served.

RÉSUMÉ

Des mesures valides et fidèles sont essentielles pour évaluer l'abilité avec laquelle les personnes dures d'oreille discernent la parole, que ce soit pour causes de compensation, de pension, de securité ou de réhabilitation aurale. Certains chercheurs ont déja souligné l'insuffissance des données acquises à l'aide de sons purs lorsque l'on veut prédire l'abilité à comprendre la parole sous des conditions ordinaires (de tous les jours). Les résultats obtenus dans des expériences préliminaires conduites aux Laboratoires appuyent certaines conclusions antérieures à savoir qu' il est possible d'améliorer l'abilité des personnes sourdes à discerner la parole sous des conditions ordinaires. Ces résultats semblent indiquer que si l'on accorde plus de poids aux niveaux de sensibilité Hertz 4000 les formules seraient peut-être plus justes. Si le public, sourd et/ou payeur de taxes, doit être justement servi il est nécessaire de continuer la recherche afin de construire des tests plus justes en vue de déterminer le degré de surdité sous diverses conditions acoustiques.

REFERENCES

1. American Academy of Ophthalmology and Otolaryngology, Committee on Conservation of Hearing. Guide for the evaluation of hearing impairment. **Trans. Am. Acad. of Ophthalm. and Otolaryng.,** 63, 1959, 236-238.
2. American Medical Association, Council on Physical Medicine. Tentative standard procedure for evaluating the percentage loss of hearing in medicolegal cases. J. Am. Med. Assoc., 133, February 8, 1947, 396-397.
3. Black, J. W. Multiple-choice speech intelligibility tests. **J. Sp. Hear. Dis.,** 22, 1957, 213-235.
4. Black, J. W. and Haagen, C. H. Multiple-choice intelligibility tests forms A and B. **J. Sp. Hear. Dis.,** 28, 1963, 77-86.
5. Carhart, R. Considerations in the measurement of speech discrimination. **USAF Sch. Aerospace Med., Brooks AFB, Texas, Review 3-65,** June 1965, 22 pp.
6. Davis, H. Audiometry. In H. Davis and S. R. Silverman **Hearing and Deafness** (Rev. Ed). Holt Rinehart and Winston, Toronto, 1964, Chap. 7.
7. Elliott, L. L. Prediction of speech discrimination scores from other test information. **J. Aud. Res.,** 3, January 1963, 35-45.
8. Fletcher, H. A method for calculating hearing loss for speech from an audiogram. **J. acoust. Soc. Am.,** 22, January 1950, 1-5.
9. Fox, M. S. Comparative provisions for occupational hearing loss. **Arch. Otolaryng.,** 81, March 1965, 257-260.
10. Glorig, A. **Noise and Your Ear.** Grune and Stratton, New York, 1958, Chap. 14.
11. Harris, J. D., Haines, H. L. and Myers, C. K. A new formula for using the audiogram to predict hearing loss for speech. **U.S. Medical Research Laboratory, New London, Connecticut, Report No. 273,** February 1956, 28 pp.
12. Harris, J. D. Combinations of distortion in speech. **Arch. Otolaryng.,** 72, August 1960, 227-232.
13. Harris, J. D. Research frontiers in audiology. In J. Jerger **Modern Developments in Audiology.** Academic Press, New York, 1963, Chap. 11.
14. Hirsh, I. J., Davis, H., Silverman, S. R., Reynolds, E. G., Eldert, E. and Benson, R. W. Development of materials for speech audiometry. **J. Sp. Hear. Dis.,** 17, September 1952, 321-337.

15. Lightfoot, C., Carhart, R. and Gaeth, J. H. Masking of impaired ears by noise. **J. Sp. Hear. Dis.,** 21, March 1956, 56-70.
16. Newby, H. A. **Audiology** (2nd Ed.) Appleton-Century-Crofts, New York, 1964, Chap. 6.
17. Ross, M., Huntington, D. A., Newby, H. A. and Nixon, R. F. Speech discrimination of hearing-impaired individuals in noise: Its relation to other audiometric parameters. **USAF Sch. Aerospace Med., Brooks AFB, Texas, Report No. 62-130,** April 1963, 25 pp.
18. Sataloff, J. and Varsallo, L. Medical audiology. **J. Laryngol. and Otol.,** 82, October 1965, 440-444.
19. Schultz, M. C. Suggested improvements in speech discrimination testing. **J. Aud. Res.,** 4, January 1964, 1-14.
20. Silverman, S. R. and Hirsh, I. J. Problems related to the use of speech in clinical audiometry. **Ann. Otol. Rhin. Laryngol.,** LXIV, December 1955, 1234-1244.
21. Simmons, F. B. and Dixon, R. F. On the importance of the question: What do you hear? **Arch. Otolaryng.,** 80, August, 1964, 167-169.
22. Symons, N. S. Legal aspects of the hearing loss problems. **Noise Control,** 3, March 1957, 49-56.
23. Thompson, G. and Hoel, R. 'Flat' sensorineural hearing loss and PB scores. **J. Sp. Hear. Dis.,** 3, August 1962, 284.
24. Young, M. A. and Gibbons, E. W. Speech discrimination scores and threshold measurements in a non-normal hearing population. **J. Aud. Res.,,** 2, January 1962, 21-33.