

HEARING-AID EVALUATION: AN EXAMINATION OF TWO PROCEDURES

Georgie Nance, M.A.

Audiologist, Audiology & Speech Pathology Service

G. Donald Causey, Ph. D.

Chief, Central Audiology & Speech Pathology Program

Veterans Administration Hospital

50 Irving Street, N.W.

Washington, D.C. 20422

Carhart (1950) stated that the problem of hearing-aid selection was currently the most controversial aspect of clinical audiology. Seventeen years later, according to an ASHA Report of A Conference on Hearing Aid Evaluation Procedures (1967), hearing-aid selection is still one of the most controversial aspects of clinical audiology.

There is a wide variety of opinion concerning the need for formal hearing-aid evaluations as described by Carhart (1946). In the selection of an aid to provide maximum benefit for the hearing-impaired individual, some audiologists feel that any hearing aid meeting certain specifications will satisfactorily benefit the patient. Others are of the opinion that variations in performance may be important to the individual and that each hearing aid must be evaluated under standardized or similar conditions to predict which hearing aid will be the most beneficial.

The present study was conducted to determine if a hearing aid chosen on the basis of a formal type of hearing-aid evaluation would perform more satisfactorily after a period of use than one arbitrarily selected.

PROCEDURES

The subjects consisted of 24 hearing-impaired veterans who were patients of the Audiology and Speech Pathology Service, VA Hospital, Washington, D.C. The average pure-tone loss for the better ear of the subjects was 50 dB International Standards Organization (ISO) or poorer. Three types of hearing impairment, predominantly conductive, predominantly sensori-neural, and mixed, were represented about equally among the subjects. All of the subjects had worn hearing aids for a minimum of 10 years. They were randomly divided into two equal groups, Groups A and B, to counter-balance the order of the experimental conditions.

The audiometric equipment was located in an IAC sound suite, Model 1205 ACT. The instrumentation included a Grason-Stadler Speech Audi-

ometer, Model 162; a Magnecord Tape Recorder, Model 748, and an Electro-voice SP 12 speaker in an Electro-voice Aristocrat enclosure.

The stimulus materials were the revised Consonant-Nucleus-Consonant (CNC) Monosyllabic Word Lists (Lehiste & Peterson, 1962) recorded by a male speaker considered to have general American speech. The tapes of each list included a 1000 Hz calibration tone recorded at the long term r.m.s. level of the speech signal. The lists were presented both in quiet and noise. A recording of cafeteria noise was used as a masking source for the noise task. This noise was chosen because of its broad band and transient characteristics.

One hearing-aid model from each of four manufacturers was selected for the study. These particular models were among those in the VA stock for Fiscal Year 1967. They were of the body type and in the strong power category. Each aid was adjusted according to manufacturers' specifications to yield a broad, full-range frequency response.

A Bruel and Kjaer test system was utilized to obtain a gain versus frequency response curve, harmonic distortion measurements, and signal-to-noise ratio for each hearing aid. All measurements were obtained with the volume control set to yield 6 dB less than maximum gain at 1000 Hz. Instruments which did not conform generally to the mean performance pattern of their particular model were not utilized in the study. The means reported in Table 1 indicate that the average performance of the aids utilized represented satisfactory physical characteristics. It was our purpose to have four well-performing instruments in each hearing-aid evaluation.

The initial testing procedure for each subject required that a formal hearing-aid evaluation be performed with four instruments representing the four different hearing-aid models. The order for testing the aids was systematically varied among the subjects. Each subject was seated in the examination room, and the experimenter mounted the first test aid on a baffle located on a horizontal plane with, and facing, the loud speaker.

TABLE 1.—Mean Gain, Signal/Noise Ratio, and Harmonic Distortion for Each Hearing-Aid Model ^a

Model	Mean gain in dB	Mean S/N ratio in dB	Mean harmonic distortion (percent)
I	53	55	5.9
II	61	51	6.2
III	53	60	5.4
IV	49	61	4.9

^a All measurements were obtained at a volume control setting 6 dB down from maximum gain at 1000 Hz.

While the volume setting of the aid under test was being adjusted to a comfort setting by the experimenter, running discourse was presented through the speaker at 70 dB sound pressure level (SPL). When a comfortable level for listening was indicated by the subject, this volume setting was used for all tests with that instrument. The same procedure was followed for all four aids.

Measurements of aided speech discrimination were obtained first in quiet and then in noise using a different CNC list for each test. The discrimination materials were presented at 70 dB SPL measured at the face of the hearing aid. A signal-to-noise ratio of +10 dB was used for the test in noise.

After administration of the tests in quiet and in noise with each aid, the results were weighted in order to emphasize the more difficult task. The discrimination test in quiet was given a value of one, and the discrimination test in noise was given a value of two. These two resultant figures were then summed and averaged. The aid with the highest score was labeled the clinically chosen aid. An aid from among the remaining three of the four tested was identified as the arbitrarily selected aid by means of a restricted Latin Square technique. Both the clinically chosen and the arbitrarily selected aids were worn during successive 1-month trial periods. The subjects in Group A wore the clinically chosen aid during the first month and the arbitrarily selected aid during the second month. The trial conditions were reversed for the Group B subjects. In order to avoid the effects resulting from changes in hearing-aid performance, the aids assigned to a subject were used exclusively by that subject throughout the remainder of the experiment. A total of 71 hearing aids was required to complete the study.

Upon completion of the 1-month trial period, each subject returned to the clinic and was retested with the aid used during that time. Thereupon he was loaned the other aid which had been set aside for him for the second 1-month trial period. After this trial period, discrimination scores were obtained with the second aid. In like manner, discrimination scores were again obtained with that aid. After each trial period, the subjects completed a questionnaire regarding quality judgments of the aid.

The primary purpose of the questionnaire was to force the individual to rate the performance of each aid in a uniform and thorough manner.

RESULTS

Discrimination scores obtained for the quiet and noise tasks as well as the weighted scores were tabulated for both the arbitrarily selected and clinically chosen aids. These results, further identified by initial and retest conditions, are reported in Figure 1. For the initial test the difference between the clinically chosen and arbitrarily selected aids in quiet was 7

percent, in noise 9 percent, and the weighted score difference was 8 percent. These differences were significant at the .05 level. By definition of course, the scores obtained during the initial test condition for the arbitrarily selected aid would be lower than the scores for the clinically chosen aid, since the clinically chosen aid was always the one performing best in the initial evaluation.

The differences in discrimination scores between the two aids on the initial test were not present after a 1-month trial period. Upon retest, the difference in discrimination scores between the clinically chosen and arbitrarily selected aids in quiet was 1 percent, in noise 1 percent, and the weighted score difference was also 1 percent.

An analysis of the changes in discrimination scores effected by the 1-month trial period with each aid was conducted. Each subject's improvement or decrement upon retest was tabulated, and the summary appears in Figure 2. Upon retest, nine subjects showed mean improvement of 6 percent with the clinically chosen aid. Also with that aid, 15 subjects got mean scores 7 percent lower than on the initial test. With the arbitrarily selected aid, 15 subjects showed mean improvement of 13 percent upon retest. Mean retest scores 5 percent lower than on the initial test were obtained by seven subjects with that aid.

At the end of the second trial period, each subject was asked which of

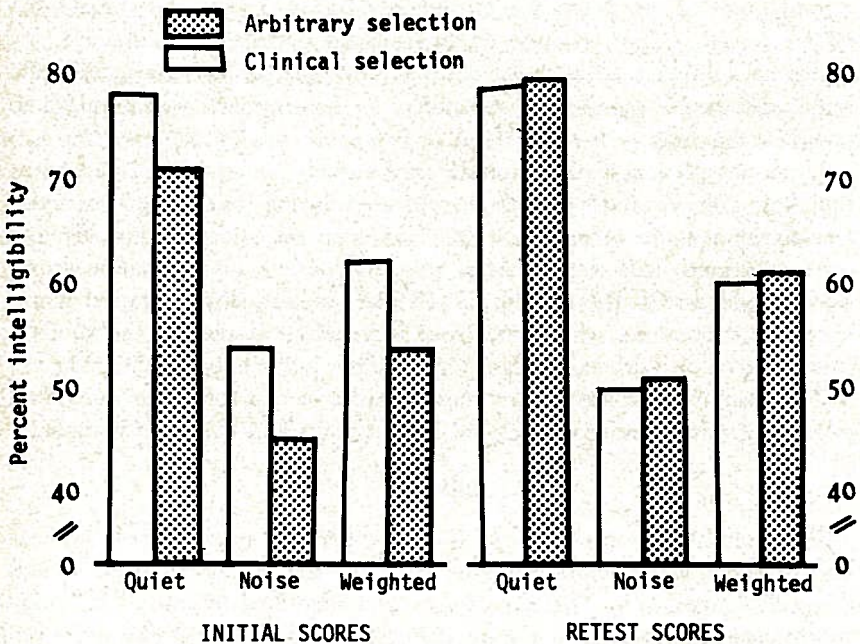


FIGURE 1.—Mean intelligibility scores.

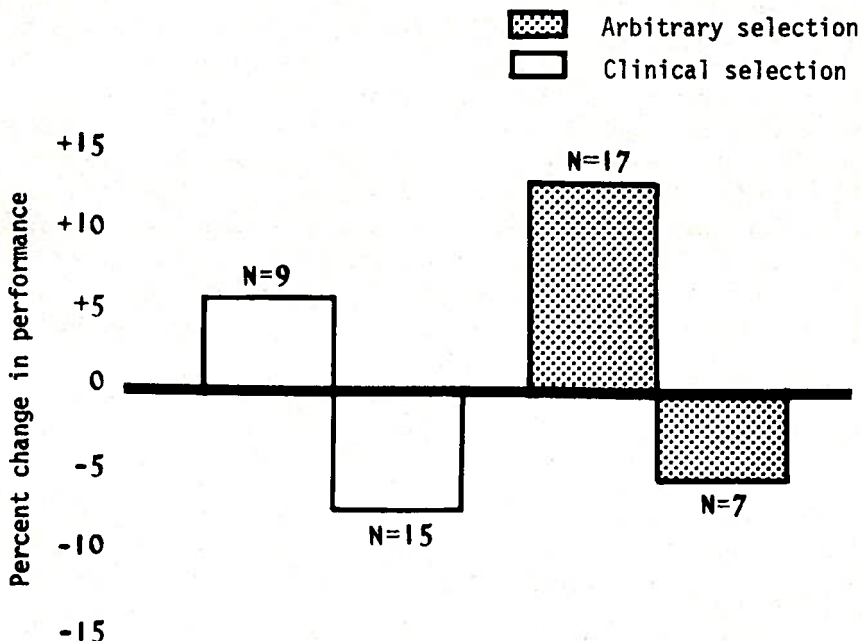


FIGURE 2.—Effect of trial period on weighted discrimination scores.

the two aids he tried seemed more beneficial. The clinically chosen aid was preferred by nine of the 24 subjects. Six individuals in this group had achieved their highest weighted discrimination scores with the aid they preferred. The arbitrarily selected aid was preferred by the remaining 15 subjects. Nine of these individuals had achieved their highest weighted discrimination score with the aid they preferred. The Chi Square Technique demonstrated no significant difference between the two alternative choices made by the user.

DISCUSSION

It should be emphasized that the hearing aids used in this study met VA criteria for acceptance on contract (Johnson and Causey, 1956; Davis and Silverman, 1965). Their electroacoustic characteristics were quite similar so test materials which would reveal subtle differences were needed. The CNC Revised Word Lists, heavily weighted with the noise condition, were effected to produce a more exacting and discriminating task.

Initial mean weighted discrimination scores did reveal significant performance differences among the hearing aids. This lends encouragement to those who feel that the hearing aid evaluation is a worthwhile procedure. The significant mean discrimination score differences which existed between the clinically chosen and arbitrarily selected hearing aids prior to a trial

period no longer were apparent after the trial period. This finding supports the feeling of Glorig (1966) that performance with a new hearing aid will improve if sufficient time is spent in learning the new encoding system. Since the mean scores of the clinically chosen and arbitrarily selected hearing aids were extremely similar upon retest, it was not surprising that there be approximately equal preference for these aids among the subjects.

While a host of inferences might be ventured from these data, it is recognized that further investigation is needed utilizing hearing aids with a wide variation in electroacoustic performance, rather than high homogeneity as in this case.

SUMMARY

Twenty-four subjects received a formal hearing-aid evaluation utilizing four different strong power hearing aids having extremely similar electroacoustic characteristics. Two of these aids, one clinically chosen and one arbitrarily selected, were loaned to each subject for two separate 1-month trial periods. After each trial period, the subjects' performance with the aid on loan was again formally evaluated. Upon completion of the second trial, the subjects were asked which of the two aids seemed more beneficial.

Analysis of performance for initial tests revealed significant performance differences among the four hearing aids. These significant performance differences were no longer apparent in the retest scores after the trial periods. The number of subjects preferring the clinically chosen aid rather than the arbitrarily selected aid was not significant.

REFERENCES

- American Standard Methods for Measurement of Electroacoustical Characteristics of Hearing Aids. S3.3-1960. American Standards Association, New York, 1960.
- CARHART, R.: Selection of Hearing Aids. *Arch. Otolaryng.* 44:1-18, 1946.
- CARHART, R.: Hearing Aid Selection by University Clinics. *J. Speech & Hearing Dis.*, 15:106-113, 1950.
- CARHART, R.: Evaluation of Hearing Aids. *ASHA*, 1: 115, 1959.
- CAUSEY, G. D. et al.: Characteristics and Procurement of Hearing Aids. *ASHA Reports*, 2, Chapter 3, 1967.
- DAVIS, H. and S. R. SILVERMAN: *Hearing and Deafness (Revised Edition)*. Holt, Rinehart, New York, 1960.
- GLORIG, A.: Principles Involved in Selecting a Hearing Aid. *Acta Otolaryng.*, 41:49-57, 1952.
- GLORIG, A., Personal Communication, 1966.
- JOHNSON, K. O. and G. D. CAUSEY: A Method for the Ranking of Hearing Aids According to Performance Characteristics. Paper presented at the Annual Convention of the American Speech and Hearing Association, 1956.
- LEHISTE, I. and G. PETERSON: Linguistic Considerations in the Study of Speech Intelligibility. *J. Acoust. Soc. Amer.*, 31:280-286, 1959.
- MILLIN, J.: "Conventional" Hearing Aid Selection. *ASHA*, 5:880-881, 1963.
- PETERSON, G. and I. LEHISTE: Revised CNC Lists for Auditory Tests. *J. Speech & Hearing Dis.*, 27:62-70, 1962.