SPEECH DISCRIMINATION ABILITY WITH EAR INSERTS

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Veterans Administration audiology clinics routinely provide hard or soft plastic ear inserts to hearing-impaired veterans requiring the use of hearing aids. These ear inserts are nearly solid plastic, individually fabricated to closely assume the contour of the concha and outer ear, and provided only with a sound-conducting channel. Within limits, this type of insert is generally expected to reasonably maintain the acoustic response of a hearing aid as generated in a 2 cc. coupler (Lybarger, 1958) (3).

It is known that variations in the structure of ear inserts can affect the acoustic output of a hearing aid. Aspinall et al. (1955) (1) have described the changes in the frequency response of an aid when the receiver is coupled to various inserts having alterations in the volume of the sound-conducting channel and/or alterations in the length and width of the canal portion.

Ear inserts with modifications in structure have been used to achieve intentional changes in the output of an aid, other than those which might be produced through tone control adjustment. Generally, the acoustic effect of insert modifications on a hearing aid's response is predictable. Today several commercial concerns manufacture a structurally-modified, vented insert which serves to reduce the low-frequency response of a hearing aid. In producing the low-frequency reduction, these modifier inserts are purported to favorably affect speech discrimination ability for hearing-aid users. This result was found by McClellan (1967) (5) who administered speech discrimination tests in the presence of noise to five hearing-aid users wearing vented and non-vented inserts. Better discrimination scores were obtained by all subjects when the vented inserts were worn. Dodds and Harford (1968) (2) recently reported a contrary effect. They found no significant difference between discrimination scores obtained with standard and vented inserts by 18 hearing-impaired subjects.

The incompatible findings of these studies have provided the impetus for reporting the complete results of an investigation presented, in part,

elsewhere (Revoile and Causey, 1965) (6). The purpose of the study was to determine the effects of certain ear insert types on discrimination ability among hearing-aid users.

EXPERIMENTAL DESIGN

The subjects were 18 hearing-impaired veterans ranging in age from 30 to 68, with a mean age of 48. All subjects had predominantly sensorineural disorders and were divided into two groups on the basis of audiometric threshold configuration for the better ear. Group A was comprised of nine subjects having relatively flat impairments of moderate severity. The nine subjects in Group B had precipitous impairments characterized by a difference of at least 40 dB among the thresholds for the test frequencies 250 through 4000 Hz. The mean thresholds for the subjects of both groups are shown in Figure 1.

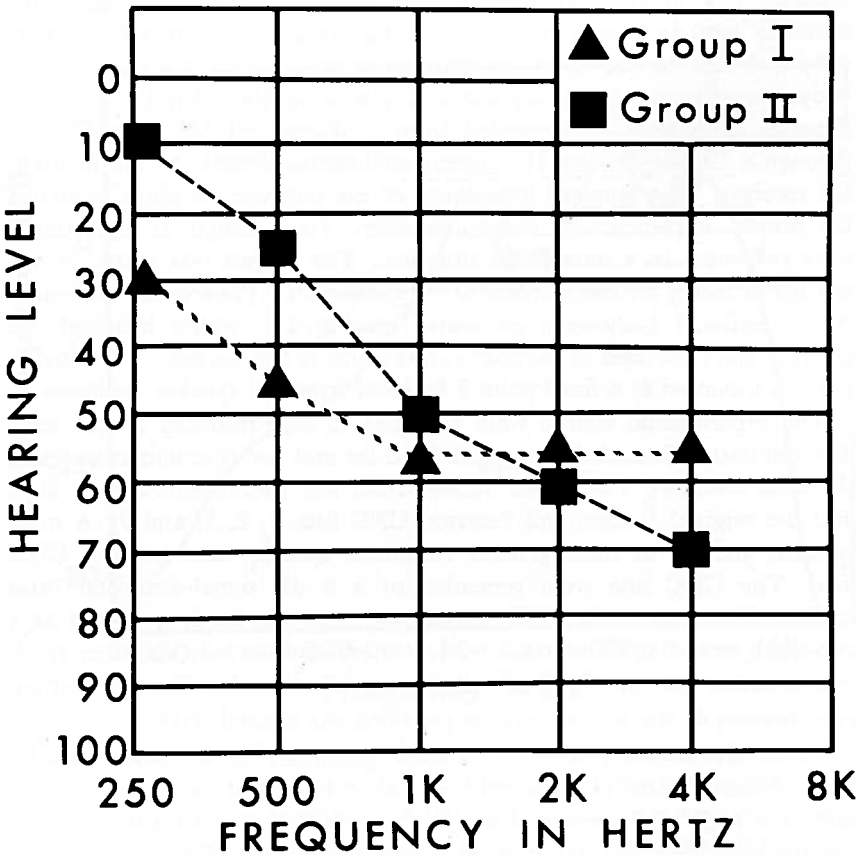

FIGURE 1.—Mean threshold configurations.

The subjects were scheduled for two appointments at the Audiology and Speech Pathology Service, Veterans Administration Hospital, Washington, D.C. During the first appointment clinical audiometric tests were administered and impressions taken of the test ear. The experimental tests were conducted during the second appointment. The three individual ear inserts, hard plastic, soft plastic, and vented, were prepared in the interim between the appointments. The hard plastic and soft plastic inserts (routine VA issue) were fabricated at the Plastic Eye and Restorations Clinic, VAH, Washington, D.C. The vented inserts were prepared by a commercial ear-mold laboratory. These latter inserts were structurally modified; the ear canal portions were shortened and sound-conducting channels widened. In addition two vents were drilled from the flat, exposed surface of the insert to the sound-conducting channel. The vents were packed with a fibrous material resembling lamb's wool.

Each subject was tested with his inserts by two different methods. For Method I a hearing-aid receiver was substituted for the headphones normally used in speech audiometry. The subject was seated in an IAC test booth and an ear insert was coupled to the receiver of a conventional body-worn monaural hearing aid and placed in the subject's ear. The stimulus materials were presented from a Magnecord 748 tape recorder through a Grason-Stadler 162 speech audiometer directly to the hearing-aid receiver. The nominal impedance of the receiver, 10 ohms, matched the output impedance of the audiometer. For Method II the stimuli were presented in a sound-field situation. The subject was seated in the test booth facing an Electrovoice SP 12 speaker in a Panacoustic enclosure. A conventional body-worn monaural hearing aid, which included the receiver and cord used in Method I, was worn by the subject. The hearing aid was mounted at a fixed point 6 ft. away from the speaker enclosure.

The experimental stimuli were a battery of tape-recorded speech tests. The test battery included a spondaic word list and two discrimination tests: the CID Auditory Test W–22 dubbed from the Technisonic Studio disks and the original Lehiste and Peterson CNC lists, 1, 2, 5, and 7. A male speaker, judged to have general American speech, recorded the CNC lists. The CNC lists were presented at a 6 dB signal-distortion ratio (S/D). Two sets of the CNC stimuli had been previously prepared as a two-track recording. One track was recorded undistorted; the other track was recorded with the CNC stimuli distorted nonlinearly. The appropriate combination of the two recordings provided the desired S/D.

The subjects were presented the battery of tests for each ear insert by both Methods I and II. Method I was always the first mode of presentation. For each trial, the initial step of the procedure was to determine the hearing level for speech utilizing the spondaic word list. The discrimination tests were then presented at a 30 dB sensation level. One list each of the

W–22 and CNC stimuli were serially administered. This same order was followed for the remaining two inserts. Regulated rest periods were given between the test series for each insert and between presentations by Method I and Method II. During the latter period the subject wore the complete hearing aid used in the experiment. He was instructed to adjust the gain to a comfortable loudness, similar to that level at which he wore his own aid. An informal listening situation was provided for this adjustment. The experimenter secured the volume control of the aid at the level selected. The subjects were then tested in the same manner described above for Method I.

Following the experimental tests the subject was given his three inserts for trial use in everyday environmental situations. He was instructed to wear the inserts interchangeably over a period of 12 weeks, using each insert for one week at a time. At the end of the trial period each subject completed a questionnaire designed to yield subjective evaluations of the inserts.

RESULTS

In examining the data obtained, an initial comparison was made between the results for Method I and Method II. Here, certain effects are self-evident. The subjects' matched threshold scores for the methods were dissimilar since aided speech scores were obtained by Method II; those obtained by Method I were essentially unaided. Conversely, a comparison of the matched discrimination scores revealed little difference between the subjects' scores obtained by the two methods. Figure 2 shows

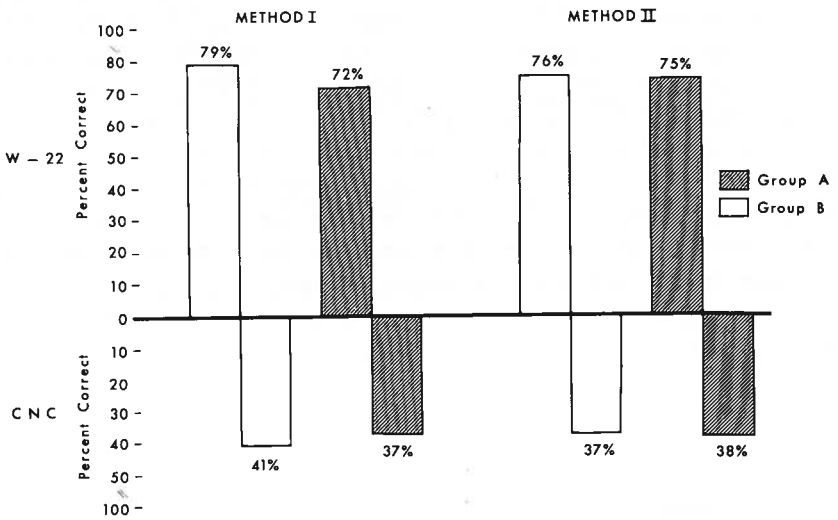

FIGURE 2.—Mean discrimination scores by group and method.

mean discrimination scores for both groups by Methods I and II. The scores obtained with all ear inserts have been averaged.

The differences between matched mean scores obtained by the two methods ranged from 1 to 4 percent. The size of these differences suggests that the two methods of testing were essentially similar.

Further examination of Figure 2 allows a comparison of the discrimination scores obtained by Groups A and B. Only small differences occurred between the groups for the mean scores of either discrimination test. The largest difference between the mean scores was 7 percent, that which occurred between the scores for the W–22 test by Method I. When an appropriate statistical test was applied, no significant difference was found between the means for the two groups on either discrimination test.

The dissimilarity between the two discrimination tests used in the experiment is apparent in Figure 2. For both groups and methods the CNC lists always yielded the poorest scores. The mean scores for the W–22 test were at least 35 percent better than those for the CNC lists. Of course, these differences were statistically significant beyond the .01 level.

Since the discrimination scores for the two subject groups by the two methods of testing were similar, these data were combined for further presentation of the results. Figure 3 shows the mean scores obtained with the three inserts for each discrimination test. The greatest differences among mean scores obtained with the ear inserts were 3 percent and 5 percent for the W–22 and CNC lists, respectively. When statistical measures were applied to the data, there were no significant differences among mean scores obtained with the inserts. On the basis of statistical analysis the three inserts, vented, soft plastic, and hard plastic, were found to have similar effects on discrimination ability among hearing-aid users.

Individual differences among the subjects' performances with the inserts were examined in conjunction with the analysis of the questionnaires completed by the subjects. The questionnaire had been constructed as a rating scale. The 28 items related to the effectiveness of the inserts in specific environmental situations. For each test item the ear inserts were rated from "one" to "three" depending upon the degree to which the item described hearing ability with a particular insert.

Analysis of the questionnaire data revealed that 12 of the subjects, 66 percent, evaluated the vented insert as providing better hearing than the soft or hard plastic inserts. On all items these subjects rated the vented insert higher than the other inserts. The remaining six subjects showed no consistent preference for any insert; their ratings of the inserts were variable among the items.

Finally, each subject's discrimination scores with the inserts were compared to his rating of the inserts on the questionnaires. No relationship

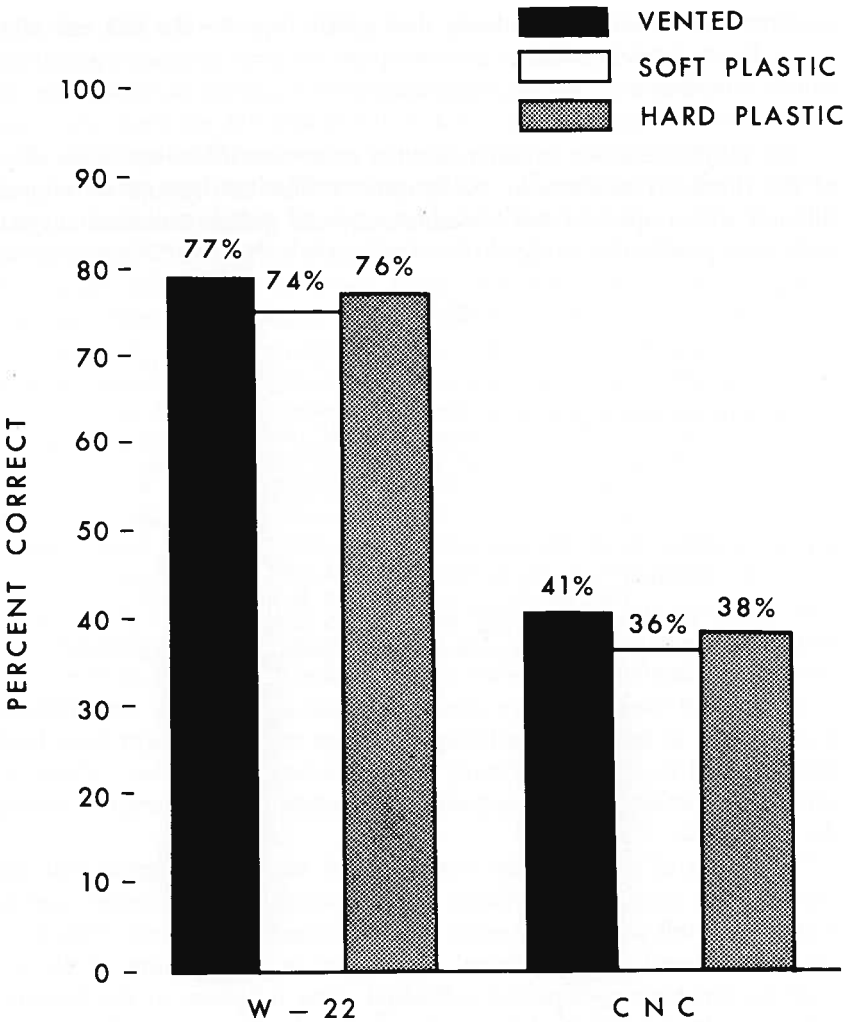

FIGURE 3.—Mean discrimination scores by ear insert.

appeared between the subjects' discrimination scores and their ratings of the inserts. The subjects who rated the vented insert over the others had obtained similar discrimination scores with all inserts.

DISCUSSION

For the purposes of reliability, two methods of testing were used in the study. It was anticipated that differences would occur among the discrimination scores obtained with the inserts. If these differences appeared

consistently for both test methods, then greater significance and reliability could be attributed to them. However, the subjects obtained consistently similar discrimination scores, regardless of the manner in which the test material was presented.

The subject selection criterion for the study was based upon the slope of the threshold audiometric configuration. The two groups of subjects differed with respect to this characteristic; one group contained subjects with more precipitous configurations than the other group. The precipitous group was included to test the vented insert on subjects for whom it is most recommended. It was expected that these subjects might perform better with the vented insert than with the other two inserts. In examining the results, however, neither group of subjects showed differences in their discrimination performances with the inserts.

In the choice of the stimulus materials used, tests were selected which would vary in difficulty. The recent controversies concerning hearing-aid evaluations had direct bearing on the selection. Currently, it remains a moot question as to whether differences between hearing aids as determined by selection procedures are valid or reliable. The discrimination tests used may not yield a true measure of an individual's performance with a particular hearing aid. For the same reasons, why would differences between ear inserts appear when discrimination tests similar to those used in hearing-aid evaluations are used as the test material? If test difficulty is considered to be a differentiating factor, an exception might have been demonstrated in the present study by the distorted CNC lists. However, neither discrimination test appeared to demonstrate differences among the ear inserts.

The results of the subjective evaluation of the inserts suggest that the vented insert may have provided better hearing than the other inserts, even though this was not borne out by more objective measures. This finding is meaningful to the clinical audiologist in his selection of an ear insert for the hearing-impaired individual. The judgment of the hearing-aid wearer in the choice of his ear insert may be the most realistic index of the improvement in hearing which the individual will derive.

SUMMARY

The effects of three ear inserts on speech discrimination ability among hearing-aid users was measured. A hard plastic, a soft plastic, and a vented insert were provided for each of 18 hearing-impaired males with sensorineural disorders. The subjects were tested with the ear inserts by two methods. Method II required the use of a complete hearing aid. For Method I a hearing-aid receiver was directly connected to a speech audiometer. For both methods the insert worn by the subject was coupled to the hearing-aid receiver. A threshold test and two speech discrimination

tests, the CID W–22 and CNC lists, were presented for each method. Following the experiment, the subjects used each insert for a month's trial period. Questionnaires were subsequently completed concerning the preferences developed for the inserts during the trial period.

No significant differences were found among the inserts when discrimination tests were used as the measuring indices. The analysis of the questionnaire data indicated that for some subjects, the vented ear insert provided subjectively better hearing than the hard plastic or soft plastic inserts.

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