SOME EFFECTS OF AUDITORY TRAINING ON SPEECH DISCRIMINATION PERFORMANCE OF HARD OF HEARING ADULTS

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This is to certify that the

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Herbert J. Oyer
Major professor

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ABSTRACT

SOME EFFECTS OF AUDITORY TRAINING
ON
SPEECH DISCRIMINATION PERFORMANCE
OF
HARD OF HEARING ADULTS

by Daniel L. Bode

The major purpose of this investigation was to study experimentally the effects of auditory training methods and materials on speech discrimination performance, as reflected by three speech discrimination tests. Hearing Handicap Scale self-ratings also were evaluated in relation to obtained performance measures.

Thirty-two adults with mild, sensori-neural hearing loss were selected to serve as subjects. These persons were seen initially to record the following measures: pure tone thresholds, speech reception threshold, speech discrimination in quiet (PB-Max), speech discrimination in speech babble, and intellectual performance (estimated by responses to the Vocabulary sub-test of the Wechsler Adult Intelligence Scale).

On the basis of the above data, together with case history information, the subjects were assigned systematically to one of four training groups. Groups were matched (means, variances, medians, and ranges) on the above measures.

Each training group of eight subjects responded under one of four auditory training conditions: Group 1-- write-down material with signal-to-noise ratio (S/N)-varied, Group 2--multiple-choice material with S/N-varied, Group 3--write-down material with S/N-constant, and Group 4--multiple-choice material with S/N-constant.

Practice materials, in a variable speech babble background, were delivered to the sound-field at calibrated intensities. Feedback regarding performance and rest breaks were provided at 25-minute intervals during the approximate three hours of training. Speech discrimination tests (W-22, Rhyme, and Semi-Diagnostic) were administered in the sound-field pre- and post-training at a 50 dB (re audiometric zero) intensity level in a 45 dB speech babble background.

Results indicated the following conclusions: (1) Short-term auditory training results in generally significant positive effects on speech discrimination performance. (2) The effects of concentrated three-hour training procedures are reflected by significant changes in total, W-22, and Rhyme test discrimination, but not by the positive changes in Semi-Diagnostic test performance. (3) Discrimination changes reflected by the W-22 test differ significantly from the changes revealed by either the Rhyme or the Semi-Diagnostic tests. Changes on the latter tests do not differ significantly. (4) S/N-Varied and S/N-Constant training methods do not differ in effects on speech discrimination performance. (5) Open

Set (write-down) and Closed Set (multiple-choice) training materials do not differ in effects on speech discrimination performance. (6) Discrimination changes differ significantly among four combinations of auditory training methods and materials. If multiple-choice, closed set materials are employed in training, the S/N-Varied method appears to be the method of choice. If write-down, open set materials are utilized in training, either S/N-Constant or S/N-Varied methods apparently can be employed for similar results. (7) Subjects tend to make similar progress in auditory training irrespective of the degree of reported difficulty reflected by self-ratings on the Hearing Handicap Scale.

Age, speech reception threshold, and intelligence appear to be potentially significant factors in auditory training research. Observed trends suggested that increased discrimination was most extensive for those subjects who showed higher intellectual performance, who were older, and who had the least speech reception loss.

Those subjects trained on closed set (multiple-choice) materials improved more on the closed set test (Semi-Diagnostic) than on the open set test (W-22). Similarly, subjects trained on open set (write-down) materials improved more on the open set test than on the closed set test. Those subjects rating themselves highest in hearing handicap tended to have slightly lower discrimination scores and slightly greater speech reception loss than subjects rating themselves lowest.

These findings appear to indicate that basic and applied research in auditory training can enhance audiology's rehabilitation function and provide a framework in which to advance knowledge regarding performance of those persons with impaired hearing.

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By

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CHAPTER I

INTRODUCTION

In 1959 two-hundred representatives of professions concerned with hearing disorders attended a working conference sponsored by the Department of Health, Education, and Welfare.[1] This group made a number of recommendations in the area of aural rehabilitation, two of which are pertinent: (1) that the techniques of habilitations and rehabilitations need to be re-examined for improved effectiveness and enhanced benefits, and (2) that pilot studies should be undertaken to evaluate various habilitation, rehabilitation, and restorative procedures through a controlled comparison of methodologies.

Similarly, Oyer in 1966 emphasizes the current state of knowledge:

> Scientifically based therapeutic approaches are greatly needed for use in programs of aural habilitation and rehabilitation. . . . One of the most neglected areas in the field of clinical audiology is evaluation of the results of habilitation and rehabilitation programs.[2]

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[1]Health Aspects of Hearing Conservation. Published as a Supplement to the Transactions of the American Academy of Ophthalmology and Otolaryngology, November-December, 1959.

[2]Herbert J. Oyer, Auditory Communication for the Hard of Hearing (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 134.

Suggested guidelines for research in this area were stated by a subcommittee on hearing problems in adults, appointed by the American Speech and Hearing Association.[1] This subcommittee in 1959 posed questions in areas felt to be worthy of further research: (1) What are the critical dimensions, from the social point of view, of auditory function at supra-threshold levels? (2) What new tests of hearing function are needed and what is the meaning of existing tests? (3) What new tests of communication efficiency are needed and what is the meaning of existing tests? The subcommittee defined aural rehabilitation as improvement in the capacity of an adult with hearing impairment to cope with his environment; they added that it was not possible at that time to give an adequate evaluation of procedures for such rehabilitation.

Statement of Purpose

Persons with hearing loss often seek rehabilitation services from an audiology clinic. Remedial procedures for medically and surgically non-reversible hearing loss may include a hearing aid recommendation, lipreading instruction, counseling, and auditory training.

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[1]Report of Subcommittee on Hearing Problems in Adults, Chapter 9 in Research Needs in Speech Pathology and Audiology, Journal of Speech and Hearing Disorders Monograph Supplement No. 5 (September, 1959).

These services have developed over the years but, as indicated above, have not received extensive, objective evaluation. The present study was conducted in an effort to obtain and evaluate data relative to a specific aural rehabilitation procedure, namely auditory training. More specifically, fundamental questions were posed regarding the effects of auditory training on the speech discrimination performance of hard of hearing adults:

1. Does auditory training result in significant change in speech discrimination performance?

2. Do three speech discrimination tests differ significantly in reflecting the effects of auditory training on speech discrimination performance?

3. Do two auditory training methods differ significantly in their effects on speech discrimination performance?

4. Do two auditory training materials differ significantly in their effects on speech discrimination performance?

5. Do four combinations of auditory training methods and materials differ significanlty in their effects on speech discrimination performance?

6. Are self-ratings of social efficiency related to the effects of auditory training?

Importance of the Study

Silverman in 1957 stated that quantitative information about the effect of auditory training is fragmentary, and that investigations suffer from the lack of

adequate and valid measuring devices and criteria.[1] These statements summarize the position of many individuals professionally involved in aural rehabilitation. Bergman, *et al.,* for example, pointed out in 1965 that it has been both written and stated that auditory training can improve speech discrimination, but the literature contains very little quantitative information about its effects.[2]

Oyer in 1966 further summarized the situation:

> A great amount of research has been carried out in the field of audition, but a real need exists for research that is aimed at measuring the effectiveness of auditory training methods as they are applied to the hard of hearing.[3]
>
> . . . .
>
> . . . . there is insufficient scientific evidence concerning the change in performance following the administration of auditory training procedures. Therefore, at the present stage of development, it is virtually impossible to attempt to predict the actual behavior of the hearing handicapped after any specific set of procedures used in auditory training has been administered.[4]

There is substantial indication that studies of auditory training have been few in number and limited in extent. Most of the generalizations concerning potential benefits were derived from informal observa-

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[1]S. Richard Silverman, *Handbook of Speech Pathology*, ed. L. E. Travis (New York: Appleton-Century-Crofts, Inc., 1957), pp. 430-31.

[2]Moe Bergman, *et al.*, Auditory Rehabilitation for Hearing-Impaired Blind Persons, *ASHA Monographs*, No. 12 (March, 1965), p. 39.

[3]Oyer, *op. cit.*, p. 12.

[4]*Ibid.*, p. 46.

tion with adults and from studies and observations with deaf children. A review of pertinent literature, reported in Chapter II, supported these statements regarding the present status of auditory training.

In spite of the lack of extensive research, methodology in auditory training is a minimally controversial topic. The majority of sources agreed on the general procedures and objectives of an auditory training program: subjects are given practice in identification of speech stimulus materials under a variety of listening conditions for the express purpose of improving speech discrimination performance in everyday situations.

Validity of speech discrimination tests is an area of some confusion and controversy, even though there have been extensive research and discussion on this subject. Attempts to measure or evaluate the efficiency of auditory aspects of communication usually have employed speech stimuli, undoubtedly because of the face validity of this material. As recently as 1965, however, Carhart stated that one can perform a diagnosis of social efficiency with hearing loss only in general and qualitative terms.[1] Similarly, Davis in

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[1]Raymond Carhart, "Problems in the Measurement of Speech Discrimination," Archives of Otolaryngology, 82 (September, 1965), pp. 253-60.

1963 indicated that the particular tests of the ability to receive auditory communication still need to be validated in the field.[1]

Among the criticisms that have been directed toward conventional monosyllabic speech discrimination tests are: (1) problems of word frequency or difficulty effects (i.e., words appearing most often in a language are familiar and therefore relatively easy to identify); (2) questionable validity of balancing phonetically the frequency of sounds (phonemes) and words (morphemes) within and among alternate test forms; (3) lack of demonstrated correlation between discrimination of monosyllables and discrimination of continuous discourse; (4) different responses of sophisticated versus naive listeners; and (5) differential effects of level of motivation. Inherent in each of these problems appears the question of validity; that is, criteria for evaluating the diagnostic or predictive value of specific tests and materials.

It seems from this review that agreement has not been reached about either the material or criteria for speech discrimination testing, and that the potential

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[1]Hallowell Davis, Hearing and Deafness, ed. Hallowell Davis and S. Richard Silverman (rev. ed.; New York: Holt, Rinehart and Winston, Inc., 1963), p. 194.

benefits of auditory training are difficult to evaluate relative to external criteria in the environment of individual subjects. It does seem, however, that specific tests in existence have value relative to criteria internal to the actual training conditions. In other words, progress in training might be evaluated validly and reliably within the structure of the training program, but the criteria external to the training program still are eluding objective specification.

As a consequence of a review of information regarding auditory training, it is believed that the present study not only answers the basic questions posed earlier, but also contributes to the understanding of one aspect of impaired auditory performance. The potential contribution of the study is enhanced by the use of self-ratings of social efficiency that are evaluated in relation to speech discrimination performance. In addition, test items and training materials were administered within the average loudness range of conversational speech and with a speech babble noise background. Incorporation of these dimensions improves the generalizability of obtained results to a realistic and practical external criterion.

One further contribution of this study is the use of subjects whose hearing loss generally is classified as being "mild" in both extent and effects. It is agreed that the measurable extent of loss for these subjects is mild

benefits of auditory training are difficult to evaluate
relative to external criteria in the environment of
individual [illegible]. It does seem, however, that specific
tests in existence have [illegible]
[illegible] training [illegible]

relative to normal and to those losses showing greater lack of sensitivity. It is not agreed, however, that the effects are mild.

Individuals with so-called mild hearing loss, who report substantial hearing difficulty, represent a fairly large portion of the hard of hearing population. These persons when seeking professional advice often are told, in essence, that they do not have a problem, that a hearing aid will not help, that otological treatment is not possible, and that they should return to the clinic in about one year when the hearing loss may be worse and services then can be provided. Lipreading, auditory training, and counseling may be suggested, but persons probably do not follow this recommendation automatically and the encouragement from the clinic to do so may be minimal.

It was assumed in this study that these subjects do have a problem, that they usually do not receive professional services for this problem (other than diagnosis), that clinical and research attention should be directed toward this population, and that, in so doing, their problems and the problems of hearing loss in general may be better understood and more adequately handled professionally.

Definition of Terms

The following definitions are employed in this investigation:

1. Auditory training is a set of procedures and conditions designed to increase the auditory speech discrimination of hearing-impaired adults.

2. Speech reception threshold (SRT) is the sound level in decibels (dB) at which fifty per cent correct identification of spondaic speech materials (CID W-1 disc recording)[1] is recorded.

3. Sound levels are of two types in this study: (a) the level of pure tones in dB relative to ISO-1964 standards[2] and (b) the level of speech and noise signals in dB relative to ASA-1953 standard reference level of 22 dB sound pressure (SPL).[3] From the latter definition, it follows that a 50 dB speech or noise signal re ASA-1953 standards corresponds to a 72 dB signal relative to the SPL reference of 0.0002 microbar.

4. Auditory speech discrimination is the performance indicated by the percentage of correct responses to speech discrimination tests delivered at specified sound levels in quiet and in noise.

5. Speech discrimination tests are those published, formal sets of speech stimuli presented to sub-

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[1]Commercial recording obtained from Technisonic Studios, Inc., 1201 South Brentwood Blvd., Richmond Heights, Missouri.

[2]*Standard Reference Zero for Calibration of Pure Tone Audiometers*, ISO/R 389-1964.

[3]*American Standard Specification for Speech Audiometers*, ASA Z24. 13-1953.

jects for auditory identification of component monosyllables. In this study, the selected tests are: (a) the CID W-22 test,[1] (b) the Rhyme test,[2] (c) the Semi-Diagnostic test.[3]

6. Noise refers to speech babble and designates the tape-recorded acoustical signal that results from twenty persons reading aloud different speech material at the same time. This type of signal shows primary energy concentration between 150 and 1000 cycles per second (cps) and intentisty flucuations of approximately 3 dB total variation.

7. Hard of hearing adults are those eighteen to sixty year old individuals who, as reported by case history, sustained a sensori-neural hearing loss after having developed normal auditory discrimination of American English. Furthermore, to qualify for this study, subjects demonstrated: (a) an unaided, sound-field speech reception threshold of 5 to 35 dB (mild loss of sensitivity); and (b) an unaided, auditory speech discrimination score greater than ten per cent and less than ninety per cent on the CID W-22 test delivered sound-field in speech babble at a 50/45 dB signal-to-noise ratio (S/N).

8. Intelligence-estimate refers to the raw score that results from individual administration of the Vocabulary sub-test of the Wechsler Adult Intelligence Scale.[4]

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[1]Ira J. Hirsh _et al._, "Development of Materials for Speech Audiometry," _Journal of Speech and Hearing Disorders_, 17 (September, 1952), pp. 321-37.

[2]Grant Fairbanks, "Test of Phonemic Differentiation: The Rhyme Test," _Journal of the Acoustical Society of America_, 30 (July, 1958), pp. 596-600.

[3]Charles Hutton, E. Thayer Curry, and Mary Beth Armstrong, "Semi-Diagnostic Test Materials for Aural Rehabilitation," _Journal of Speech and Hearing Disorders_, 24 (November, 1959), pp. 319-29.

[4]David Wechsler, _Manual for the Wechsler Adult Intelligence Scale_ (New York: The Psychological Corporation, 1955), pp. 42-43, 63-75.

9. Auditory training methods designates the listening conditions (signal-to-noise ratios) operating during five successive training sessions. Two methods (or conditions) are evaluated in this study: (a) S/N-constant, where a 5 dB S/N is maintained over the five sessions: 57/52, 54/49, 51/46, 48/43, and 45/40 during the first through fifth sessions in this order; and (b) S/N-varied, where the signal is maintained at 50 dB and the noise is increased in 2 dB steps in each of five sessions: 50/40, 50/42, 50/44, 50/46, and 50/48 during the first through fifth sessions in this order.

10. Auditory training materials refers to the type of material utilized during five successive training sessions. Two types of material are evaluated in this study: (a) Open Set: monosyllabic write-down items,[1] and (b) Closed Set: monosyllabic multiple-choice items,[2,3]

11. Self-rating of social efficiency is the numerical score resulting from administration of the Hearing Handicap Scale.[4]

12. Average loudness range of conversational speech is defined as the sound levels at or near 50 dB re audiometric zero. This is an operational definition; in everyday listening situations loudness levels can vary substantially above and below the defined "average" level.

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[1]Gordon E. Peterson and Ilse Lehiste, "Revised CNC Lists for Auditory Tests," Journal of Speech and Hearing Disorders, 27 (February, 1962), pp. 62-70.

[2]Laila Larsen, Lists published in Hearing and Deafness, op. cit., pp. 542-44.

[3]J. C. Kelly, Clinician's Handbook for Auditory Training (Dubuque, Iowa: William C. Brown, Inc., 1953), pp. 76-113.

[4]Wallace S. High, Grant Fairbanks, and Aram Glorig, "Scale for Self-Assessment of Hearing Handicap," Journal of Speech and Hearing Disorders, 29 (August, 1964), pp. 215-30.

Limitations of the Study

Only one aspect of the aural rehabilitation process was examined in this study, namely auditory training. Any generalizations are confined to the population of hard of hearing adults who have the characteristics of, and who perform similarly to, the present subjects. Primary variables of interest included monosyllabic test and training items, signal-to-noise testing and training procedures, conversational loudness range, and average performance of groups. Any variables not designated and/or not controlled in the statistical design were assumed to be normally distributed among subjects within each of four systematically-matched training groups. Any actual differences that may have existed among these groups were assumed to be non-significant statistically; and, where this assumption was questionable, appropriate caution was exercised in the interpretation of observed results.

Organization of the Study

Chapter I is organized to give an overall view of the subject matter, the apparent status of knowledge on this subject, the questions and population of interest, and the research approach influencing the conduct of the investigation. In Chapter II literature pertinent to this study is reviewed, interpreted, and summarized under the general headings of historical developments, speech

reception and discrimination, auditory training procedures and goals, research in auditory training, hearing loss and hearing handicap, and hearing and listening. The subject population, the selection of subjects from this population, their assignment to four training groups, the training methods and materials administered, the speech discrimination criterion measures, and the statistical design are described in Chapter III. In Chapter IV results of the investigation are presented and discussed in relation to questions posed earlier in the present chapter. The study is summarized, the conclusions are stated, and the implications for additional research are set forth in Chapter V.

CHAPTER II

REVIEW OF PERTINENT LITERATURE

Literature pertinent to the purposes, scope, and limitations of this study--as described in Chapter I--is reviewed in this chapter. The literature review is classified under general headings of historical developments, speech reception and discrimination, auditory training procedures and goals, research in auditory training, principles of learning and training, hearing loss and hearing handicap, and hearing and listening. A summary of this review is given at the end of the chapter.

For the purpose of introducing the material in this chapter, definitions and objectives of auditory training--suggested by various authors--are given below:

> The treatment calculated to improve the hearing consists in the use of trumpets whereby the nerve apparatus may be gradually excited as to become sensitive to ordinary sonorous undulations and external stimulants.[1]

> Stimulation or education of the hearing mechanism and its associated sense organs by sound vibration as applied either by voice or any sonorous instruments.[2]

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[1]Toynbee in 1860, quoted in Max Goldstein, The Acoustic Method for the Training of the Deaf and Hard-of-Hearing Child (St. Louis: Laryngoscope Press, 1939), p. 13.

[2]Goldstein in 1939, ibid., p. 18.

> . . . the development of auditory speech perception.[1]

> *Auditory training* implies training with amplified sound. . . . In auditory training the person is taught to deal with distorted sound, to recognize a new pattern of sound, and to attach meaning to it.[2]

> Auditory training for the hearing handicapped is a process by which the hard-of-hearing individual learns to make maximum use of residual hearing.[3]

> Auditory training is the process of teaching the child or adult who is hard of hearing to take full advantage of the sound clues which are still available to him.[4]

> . . . a series of communication exercises of progressive difficulty leading to greater attention in listening, improved discrimination for the sounds of speech, and improved auditory memory span.[5]

Thus, it appears that the term, auditory training, in general, designates the activities and processes by which the hearing-handicapped are given the opportunity to make full use of acoustic events impinging upon the auditory mechanism. The development of this concept through the years provides some insight into the current status of auditory training.

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[1]C. V. Hudgins, "Auditory Training: Its Possibilities and Limitations," *The Volta Review*, 56 (1954), p. 339.

[2]John J. O'Neill, *The Hard of Hearing* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964), pp. 89-90.

[3]Herbert J. Oyer, *Auditory Communication for the Hard of Hearing* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 45.

[4]Raymond Carhart, Auditory Training, *Hearing and Deafness*, ed. Hallowell Davis and S. Richard Silverman (rev. ed.; New York: Holt, Rinehart and Winston, Inc., 1963), p. 373.

[5]J. C. Kelly, *Clinician's Handbook for Auditory Training* (Dubuque, Iowa: William C. Brown, Inc., 1953), p. iv.

Historical Developments

Auditory training, from an historical viewpoint, can be viewed conveniently within two broad chronological categories. In the next two sections information is presented regarding auditory training before and following World War II. During the former period auditory training was viewed primarily as a possible educational procedure for deaf children. During the latter period, however, and following the advent of modern amplifiers, auditory training received new stature, both as an important means for educating deaf and hard of hearing children and as one among several procedures included in aural rehabilitation programs for hearing-impaired adults.

Pre-World War II

One of the most comprehensive descriptions of the history of auditory training before 1940 was provided by Goldstein.[1] In his review, Goldstein traced auditory training developments from the first century A.D. to the 1920's and 1930's when his "acoustic method" was incorporated into the educational program at the Central Institute for the Deaf in St. Louis, Missouri. Prior to the publication of his book in 1939, most of the accounts of auditory training were to be found in European books and journals. A

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[1]Goldstein, op. cit., pp. 11-17.

major share of the credit for introducing auditory training to the United States is given to Goldstein. The next few paragraphs trace the pre-1940 history of auditory training, as described by Goldstein.

Archigenes, in the first century, recommended the use of sound amplified by a hearing trumpet as a means of stimulating the hearing of deaf persons. Similarly, Alexander of Tralles in the sixth century--followed by Guido Guidi in the sixteenth century--emphasized stimulation of hearing by presenting to the ear various noises and loud shouting.

Ernaud in 1761 demonstrated before the Academy of Sciences in Paris how, by means of practice in differentiating vocal sounds, pupils with substantial residual hearing were able to develop some discrimination for words. Pereire in 1767 claimed that practically all deaf subjects showing some remnant of hearing could be trained to hear words.

Credit for the first objective study of auditory training is given to Itard, a Paris otologist, who in 1802 suggested that improved hearing performance could be developed in congenitally deaf children. He tested this hypothesis in 1805 by experimenting with a class of six deaf pupils. Improvement was observed as a result of practice in discriminating among bells, among musical tones, among the rhythms of a drum beat, among notes produced by a flute, and among vowels and consonants.

Itard's work, following his death in 1832, was continued first by Blanchet and then by teachers at the Institute for the Deaf at Nancy. During this same period Beck, Jager, Wolff, and Frank in Germany, and Toynbee and Wilde in England were giving auditory training to deaf pupils who had residual hearing. Toynbee cited three cases where auditory training was given to adults who showed improvement following training. This perhaps is the only published account in the pre-World War II period where adults were considered as candidates for auditory training.

Interest in auditory training reportedly decreased in Europe during the last half of the nineteenth century. During this same period, however, the United States was beginning to consider it seriously as an important form of training for deaf children. Gallaudet in 1884, Gillespie in 1892, Taylor in 1893, and Currier in 1895 reported on their observations. During this period a representative committee studied Itard's work and concluded that the idea of re-stimulating or awakening impressions in the auditory apparatus by means of "sonorous vibrations" had value as an educational procedure.

Another important contributor to the development of auditory training was Urbantschitsch, a professor of otology at the University of Vienna. In 1892 he arranged daily practice sessions for a group of deaf pupils. The

following year a public demonstration was given before the Vienna Medical Society showing his results with eighteen of these pupils. The subjects--diagnosed before training as totally deaf--reportedly showed performance after training ranging from vowel to sentence discrimination.

Goldstein at this time was doing post-graduate work in medicine in Vienna and observed both Urbantschitsch's training program and his public demonstration. Upon his return to St. Louis in 1895, Goldstein directed an experimental program at the St. Joseph School for the Deaf while at the same time establishing a medical practice. Sixteen girls received daily practice for two years with Goldstein observing and supervising the work two afternoons a week. He presented some encouraging results in 1897 before a meeting of the American Academy of Ophthalmology and Otolaryngology. Medical practice then diverted his attention for several years. It was the founding in 1914 of the Central Institute for the Deaf when Goldstein began elaborating his Acoustic Method, continuing its development from then until 1939.

Post-World War II

Newby noted that before World War II, auditory training was given primarily to deaf children as a [illegible] a public demonstration was given before the Vienna Medical Society showing its results with eighteen of these pupils. The subjects--diagnosed before training as totally deaf--reportedly showed performance after training [illegible]

[illegible]

means of establishing gross awareness of sound.[1] He observed that this was paradoxical since the hard of hearing, with substantial residual hearing,seem to be ideal candidates for potential benefits from auditory training.

Newby,[2] O'Neill,[3] and Oyer[4] indicated that war-time aural rehabilitation programs for servicemen and the development of modern, wearable hearing aids provided major impetus for the establishment of auditory training as a rehabilitative procedure for the hard of hearing.

Oyer emphasized the developing importance of auditory training since World War II, stating that it has been an integral part of the aural rehabilitation services rendered veterans.[5] As a result of these programs, the general public and various professions became aware of the contribution of auditory training to the aural rehabilitation process. Oyer cited Downs' 1961 survey data that indicated that auditory training was provided on the following percentage basis by the 166 hearing centers responding to the survey;[6]

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[1]Hayes A. Newby, Audiology (2nd ed. rev.; New York: Appleton-Century-Crofts, Inc., 1964), p. 291.

[2]Ibid.

[3]O'Neill, op. cit., p. 89.

[4]Oyer, op. cit., p. 11.

[5]Ibid.

[6]Ibid.

University	100.0%
Medical Schools or Hospitals	83.3
Hearing Societies	100.0
Federal Agencies	82.2
State Agencies	60.0
Public Agencies	88.9
Private Agencies	100.0

These figures suggest the emphasis and importance placed on auditory training by professional workers in audiology.

With reference to auditory training for children, Silverman stated that despite unsolved problems, there is no longer any question about the usefulness of the auditory system in the education of deaf children.[1] Hudgins similarly pointed out that auditory training for deaf children can lead to development of auditory speech perception, better speech production, and broader language development.[2] He suggested that as a result of these improved communication skills, there is a concomitant acceleration in the general educational program.

Costello summarized the recent status of auditory training for children.[3] She indicated that the rewarding results in the past led to this training being used more widely. However, the development of an objective and differentiated rationale has not been established. She

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[1]S. Richard Silverman, Deaf Children, Chapter 16 in Hearing and Deafness, op. cit., p. 439.

[2]Hudgins, op. cit., p. 399.

[3]M. R. Costello, "Realistic Goals in Auditory Training," Processes 39th Meeting, American Instructors of the Deaf (Washington D. C.: U. S. Government Printing Office, 1960), pp. 133-45.

suggested that auditory training is ceasing to be a general exposure to sound, now emphasizing objective approaches.

In total then, an historical review of auditory training through the years indicates that the concept has existed for about 2000 years, but that its implications and possibilities have been exploited only recently. Auditory training has become a routine procedure offered to the hearing-handicapped.

Speech Reception and Discrimination

Research and clinical attempts to evaluate the effectiveness of auditory training must take into consideration certain known features of auditory speech perception, as well as limitations inherent in existing measurement procedures. Pertinent literature is extensive and includes numerous articles and books that have been written from the professional viewpoints of clinical and experimental psychology, communication and acoustical engineering, experimental phonetics, audiology, linguistics, and other related disciplines. The orientation in the next sections of this chapter is toward clinical audiology. However, some information from other sources is reviewed to delineate the features of speech reception and discrimination most directly involved in the design, conduct, interpretation, and conclusions of the present study. Broad areas suggested that auditory training is ceasing to be a general exposure to sound, now emphasizing objective approaches.

In total then, an historical review of auditory training through the years indicates that the concept has existed [illegible] discussed include measurement, normal and impaired speech perception, and primary versus secondary signals. Of necessity there is some overlap among these topics.

Measurement

Clinical audiometry generally includes pure tone testing, speech audiometry, and special tests. The latter category encompasses differential diagnostic tests and is not described here. Pure tone testing is given some description, but the major emphasis is on speech audiometry.

The results of pure tone testing usually are plotted on an audiogram where the ordinate represents intensity and the abcissa shows frequency. Tests of this type require that the subject indicate, directly or indirectly, his threshold for each of the different frequencies or tones. Air conduction testing involves presentation of the tones individually to each ear by means of an earphone or receiver (on the ear) that delivers the test tone directly to the external ear canal. Subsequent bone conduction testing involves presentation of the test tones individually to each ear via a vibrator (oscillator) pressed against either the mastoid region or the midline of the forehead.

Calibration is such that comparison of air and bone conduction thresholds shows either (a) both types of thresholds are similar, suggesting either normal hearing

or sensori-neural hearing loss; or (b) the air conduction thresholds show less sensitivity than the bone conduction thresholds, suggesting a conductive or middle-ear type hearing loss. Many combinations of air and bone responses can be recorded for individual subjects, and require interpretation by an otologist and an audiologist. Specific procedures and possible interpretations of pure tone audiograms--and of the results of speech audiometry--are given by Newby[1] and by Davis and Silverman.[2]

Speech audiometry usually is administered to record some or all of the following measures: (a) speech reception threshold (SRT), (b) speech discrimination score (DS), (c) detection threshold (DT), (d) most comfortable loudness level (MCL), and (e) discomfort or tolerance level (TL). The first two measures--SRT and DS--are pertinent to the present study.

Speech reception threshold designates the intensity level (in dB) at which speech is understandable to the subject about fifty per cent of the time. Spondaic words--stress on each of two syllables--are most often used for this measure. The CID W-1 and W-2 disc-recordings were standardized for this procedure.[3]

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[1]Newby, op. cit.

[2]Davis and Silverman, op. cit.

[3]Ira J. Hirsh, et al., "Development of Materials for Speech Audiometry," Journal of Speech and Hearing Disorders, 17 (September, 1952), pp. 321-37.

The subject's task is to repeat vocally--or write down--the test word as each word accompanied by a carrier phrase is presented above his presumed SRT (suggested by pure tone responses). The average intensity level is decreased until the subject is only able to repeat correctly fifty per cent of the words. The associated intensity level is then operationally defined as that subject's SRT and is compared to normal and to other performance measures for confirmation of pure tone results, for diagnostic purposes, and sometimes for estimating social efficiency.

This testing--and speech discrimination testing--is done for each ear individually and also by sound-field presentation of the test words through a loud-speaker, all at calibrated intensity levels and in a sound-treated test room.

The measurement of speech discrimination is a procedure of primary importance to the present study. Historically, speech discrimination testing can be traced from the early studies of telephone systems at Bell Telephone Laboratories.[1] A second major development was the extensive research at Harvard Psycho-Acoustic

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[1]Harvey Fletcher, Speech and Hearing in Communication (Princeton, New Jersey: D. Van Nostrand Co., Inc., 1953).

Laboratory during World War II.[1] A third major contribution to discrimination testing in the clinic occurred in the early 1950's with the standardization and distribution of disc-recorded discrimination tests (the W-22 lists) that have enjoyed substantial research and clinical use.[2]

Speech discrimination testing in the clinic usually involves the presentation of 50-item monosyllabic word lists at specified intensity levels above the subject's SRT. A popular discrimination measure called PB-Max (suggesting maximum discrimination of phonetically-balanced word lists) requires presentation of the test items some 30 to 40 dB above the SRT. The subject's task is to repeat the words while an audiologist monitors the responses and records the percentage of words correctly identified.

Carhart indicated that the above procedure has many limitations, even for diagnostic audiometry which has an entirely different purpose from the evaluation of auditory performance in everyday situations.[3] He further stated that existing tests are imperfectly standardized

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[1]James P. Egan, "Articulation Testing Methods," Laryngoscope, 58 (September, 1948), pp. 955-991.

[2]Hirsh, op. cit.

[3]Raymond Carhart, "Problems in the Measurement of Speech Discrimination," Archives of Otolaryngology, 82 (September, 1965), pp. 253-60.

and lack validation, but that with appropriate revision they can become much more definitive clinical tools. This does not deny the importance of either discrimination tests or the research conducted with them. Instead, what is suggested is that these tests have not demonstrated the validity required for interpretation or prediction of an individual subject's performance outside a sound-treated test room. Giolas and Epstein, for example, compared the discrimination of Harvard PB-50 and CID W-22 word lists with the discrimination of continuous discourse (sentence material), and did not find any accurate predictions of the latter from either of the word lists.[1]

Although validity of discrimination tests has been questioned and subjected to much discussion, reliability of obtained measures apparently is quite high. Ross and Huntington reported reliability coefficients higher than 0.90 for each of the W-22 lists.[2] In addition, Elpern compared the four W-22 lists with respect to level and range of difficulty, using approximately 1500 discrimination scores from six different

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[1]Thomas G. Giolas and Aubrey Epstein, "Comparative Intelligibility of Word Lists and Continuous Discourse," Journal of Speech and Hearing Research, 6 (December, 1963), pp. 349-58.

[2]M. Ross and D. A. Huntington, "Concerning the Reliability and Equivalence of the CID W-22 Auditory Tests," Journal of Auditory Research, 2 (1962), 220-28.

Veterans Administration audiology clinics.[1] He found that differences among lists are not sufficiently great to introduce serious errors when used interchangeably in clinical audiometry.

The availability of test material is not a problem. Moser published a systematic listing of monosyllables in American English according to phonemes, with frequency of occurrence in various combinations presented in tabular form.[2] Lehiste and Peterson developed CNC lists that reportedly have a simpler phonetic and phonemic composition and a more exact phonemic balance than the PB lists.[3]

Fairbanks published alternate lists of discrimination test items that require consonant discrimination for correct identification.[4] Hutton, Curry, and Armstrong developed Semi-Diagnostic tests (with alternate forms) for aural rehabilitation--using a multiple-choice format--that is described as sensitive to different kinds

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[1]Barry S. Elpern, "Differences in Difficulty among the CID W-22 Auditory Tests," Laryngoscope, 70 (1960), pp. 1560-65.

[2]Henry M. Moser, One-Syllable Words: Revised and Arranged by Ending Sounds (United States Air Force CCDD Technical Note, NO. 60-58, 1960).

[3]Ilse Lehiste and Gordon E. Peterson, "Linguistic Considerations in the Study of Speech Intelligibility," Journal of the Acoustical Society of America, 31 (March, 1959), pp. 280-86.

[4]Grant Fairbanks, "Test of Phonemic Differentiation: The Rhyme Test," Journal of the Acoustical Society of America, 30 (July, 1958), pp. 596-600.

of hearing loss while yielding reliable estimates of discrimination ability.[1]

Harris indicated that most tests are too simple and need to be made more sensitive to discrimination defects not obvious by conventional test procedures.[2] He recommended further research in assessing an individual's communication efficiency, and stated that some type of masking or distortion should be included in tests designed to simulate everyday listening conditions.

Egan's observation some years ago (1948) still seems to summarize present measurement problems.[3] He stated that all discrimination scores are relative, and that little trust can be placed in absolute statements about them.

Normal Speech Reception and Discrimination

Normal speech reception threshold for spondees is approximately 22 dB re 0.0002 microbar with standard test materials, conditions, and procedures.[4] A normal speech

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[1]Charles Hutton, E. Thayer Curry, and Mary Beth Armstrong, "Semi-Diagnostic Test Materials for Aural Rehabilitation," Journal of Speech and Hearing Disorders, 24 (November, 1959), pp. 319-29.

[2]J. Donald Harris, Research Frontiers in Audiology, Chapter 11 in Modern Developments in Audiology, ed. James F. Jerger (New York: Academic Press, 1963), pp. 420-23.

[3]Egan, op. cit.

[4]Raymond Carhart, "Inconsistency Among Audiometric Zero Reference Levels," Asha, 8 (March, 1966), pp. 63-66.

discrimination score is 98 to 100 per cent for the W-22 recordings at 60 dB re 0.0002 microbar (i.e., about 40 dB re audiometric zero).[1]

Most of what has been described in the preceding section of this chapter is applicable to the present topic of normality in speech perception. However, several additional findings and comments of various researchers seem appropriate for this section.

In the normal development of speech and language in children, Eeckhout pointed out that this development involves several different levels of auditory functioning, such as auditory acuity, listening, memorization, recognition, and recall.[2] Licklider described three operations involved in normal speech perception: (1) translation of the speech wave, (2) segmentation of the stream into elements that are recognized and identified, and (3) comprehension of the meaning or significance of the message.[3] The complexity of this process was suggested by Ladefoged and Broadbent, who stated that the listener does not deal with each phoneme separately but rather responds to groups of sounds.[4]

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[1]Hirsh, op. cit.

[2]M. J. Eeckhout, "Auditory Imperception," Western Speech, 25 (1961), pp. 180-83.

[3]J. C. R. Licklider, "On the Process of Speech Perception," Journal of the Acoustical Society of America, 24 (November, 1952), pp. 590-94.

[4]Peter Ladefoged and Donald E. Broadbent, "Perception of Sequence in Auditory Events," Quarterly Journal of Experimental Psychology, 12 (1960), pp. 162-70.

discrimination score is 96 to 100 per cent for the W-22 recordings at 60 dB re 0.0002 microbar (i.e., about 40 dB re audiometric zero).[1]

Most of what has been described in the preceding section of this chapter is applicable to the present topic of [illegible]. However, [illegible]

Various authors have pointed out the relationship between frequency of occurrence of words in American English and resulting discrimination scores. Rosenzwieg, for example, found that speech intelligibility increases as the frequency of usage in the language increases.[1] According to Egan, it is natural for rare words to be less intelligible than frequent words, and for this reason, research in evaluating effects other than frequency of usage should employ trained listeners who are familiar with the test material.[2] Decker, Rubenstein, and Pollack found that when a message set is unknown (open set), there are substantial word frequency effects, but when it is known (closed set), there are no consistent effects.[3]

Miller, Heise, and Lichten emphasized the contribution of context to the intelligibility of speech.[4] Words selected from a small vocabulary familiar to the listener are more intelligible than words from a large

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[1]Mark R. Rosenweig, "Intelligibility as a Function of Frequency of Usage," Journal of the Acoustical Society of America, 28 (1956), p. 759.

[2]James P. Egan, "Remarks on Rare PB Words," Journal of the Acoustical Society of America, 29, (1957), p. 751.

[3]Louis Decker, Herbert Rubenstein, and Irwin Pollack, "Word Frequency and Speech Intelligibility for Unknown and Known Message Sets," Journal of the Acoustical Society of America, 30 (July, 1958), p. 67.

[4]G. A. Miller, G. A. Heise, and W. Lichten, "The Intelligibility of Speech as a Function of the Context of the Test Materials," Journal of Experimental Psychology, 41 (1951), pp. 329-335.

vocabulary. In other words, those words with a greater probability of occurrence are reflected by higher discrimination scores than words with smaller probability. This indicates that when phrases and sentences are used for testing, the redundancy and the syntactic rules of language allow for correct discrimination even though much of the original signal may be missing. The hard of hearing person receives decided advantages from this feature of language.

Impaired Speech Reception and Discrimination

Much of what is relevant to the present topic has been suggested in earlier sections of this chapter. Again, however, some description of effects of hearing loss on speech perception seems indicated.

The degree of hearing loss--indicated by the SRT measure--can range from near-normal to the maximum limits of the apparatus used to present the test items. Maximum limit on most clinical audiometers is 100 dB re audiometric zero. The effects of the loss on speech discrimination--indicated by percentage of words correctly identified--can range, of course, from 0 to 100 per cent.

Silverman and Hirsh stated that useful tests of hearing, for clinical purposes, suggested at least one of the following functions:[1]

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[1]S. Richard Silverman and Ira J. Hirsh, "Problems Related to the Use of Speech in Clinical Audiometry," Annals of Otology, Rhinology, and Laryngology, 64 (1955), pp. 1234-44.

(1) diagnosis and prognosis connected with ear disease, (2) evaluation of medical or surgical treatment or a hearing aid, and (3) estimation of the social adequacy of hearing. They indicated that the first two functions are fairly well satisfied by present monosyllabic test items, but that the third function still requires validation studies. They believed that there is a need to think in terms of different discrimination tests for different purposes.

Attempts have been made to predict speech reception threshold on the basis of some average of pure tone thresholds.[1] Among the methods suggested are: (a) a simple average of 500, 1000, and 2000 cycles per second (cps); (b) the average of the two of the above frequencies showing the greatest loss of sensitivity; and (c) a simple average of thresholds at 1000, 2000, and 3000 (cps). Newby indicated that audiological opinion is divided, and that research has not demonstrated the superiority of any one of the procedures.[2]

Webster compared the average of 500, 1000, and 2000 cps versus the average of 1000, 2000, and 3000, and concluded that no decision can be made regarding the best pre-

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[1]Newby, op. cit., p. 100.

[2]Ibid.

diction of impairment until certain terms and concepts are better defined.[1] Harris, Haines, and Myers, on the other hand used sentence materials spoken at a faster than normal rate, and suggested that while frequencies above 2000 cps may not contribute significantly to the intelligibility of undistorted speech in laboratory listening conditions, they may be important for discrimination of distorted speech in ordinary listening situations.[2] Ross _et al._ studied speech discrimination of hearing-impaired individuals in noise.[3] The only factor that appeared to be related to speech discrimination was the extent or configuration of the hearing loss. Those subjects with high-frequency hearing loss demonstrated less relative effect of noise than did subjects with flatter pure tone threshold configurations.

It appears that prediction of impairment remains a problem requiring additional research. Carhart suggested that one of the most important considerations in discrimination testing with hard of hearing subjects is the linguistic background of the individual.[4] In

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[1]John C. Webster, "Important Frequencies in Noise-Masked Speech," _Archives of Otolaryngology_, 80 (1964), pp. 494-504.

[2]J. D. Harris, H. L. Haines, and C. K. Myers, "The Importance of Hearing at 3 kc for Understanding of Speeded Speech," _Laryngoscope_, 70 (1960), pp. 131-46.

[3]Mark Ross _et al._, "Speech Discrimination of Hearing-Impaired Individuals in Noise," _Journal of Auditory Research_, 5 (1965), pp. 47-72.

[4]Carhart, "Problems in the Measurement of Speech Discrimination," _op. cit._

diction of impairment until certain terms and concepts are better defined. Harris, Haines, and Myers, on the other hand, used sentence materials spoken at a faster than normal rate, and suggested that while frequencies above 2000 cps may not contribute significantly to the intelligibility [illegible]

listener [illegible]

other words, differences in word familiarity limit the generalizability of speech discrimination test results. Some of the effects of word familiarity on test results with hard of hearing subjects were described by Oyer and Doudna.[1] Schultz reported similar effects.[2]

Primary versus Secondary Signals

One of the possible reasons for the lack of demonstrated validity of conventional discrimination tests is that these tests usually are performed without a noise background. Davis pointed out that the proper test for this type of discrimination is one in which a standard background noise is kept at a constant intensity while speech, heard along with noise, is varied in intensity.[3] The reverse process also is feasible. Kelly and Steer, using a multiple-choice test format, evaluated the reliability of such measures and concluded that discrimination scores obtained under reduced noise levels are as reliable as those obtained under high levels.[4]

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[1]Herbert J. Oyer and Mark Doudna, "Word Familiarity as a Factor in Testing Discrimination of Hard-of-Hearing Subjects," Archives of Otolaryngology, 72 (1960), pp. 351-55.

[2]Martin C. Schultz, "Word Familiarity Influences in Speech Discrimination," Journal of Speech and Hearing Research, 7 (December, 1964), pp. 395-400.

[3]Davis, Hearing and Deafness, op. cit., p. 198.

[4]J. C. Kelly and M. D. Steer, "Intelligibility Testing in Three Conditions Involving Masking Noise," Journal of Speech and Hearing Disorders, 14 (1949), pp. 369-72.

Egan described the normal-hearing listener's task in noise, indicating that listener performance depends on the discriminability of the message and on the listener's criterion for either accepting his response as correct or rejecting it as incorrect.[1] Hogan and Hanley reported that when either the number, rate, or level of interfering signals is increased, there is an associated decrement in discrimination scores.[2]

The masking of speech by bands of noise was studied by Hirsh and Bowman.[3] They found that a middle frequency band (670 to 1000 cps) is most effective in masking the speech signal. Moser, Dreher, and O'Neill similarly found that prolonged vowel sounds with high concentration of energy between 700 to 1000 cps are most effective in masking words.[4]

The masking effects of speech on discrimination were described by several researchers. For example, Hodgson used sixty talkers to produce a noise back-

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[1]James Egan, "Monitoring Task in Speech Communication," Journal of the Acoustical Society of America, 29 (April, 1957), pp. 482-89.

[2]D. D. Hogan and T. D. Hanley, "Some Effects on Listener Accuracy of Competing Messages Varied Systematically in Number, Rate, and Level," Journal of the Acoustical Society of America, 35 (1963), pp. 293-95.

[3]Ira J. Hirsh and W. D. Bowman, "Masking of Speech by Bands of Noise," Journal of the Acoustical Society of America, 25 (November, 1953), pp. 1175-80.

[4]Henry M. Moser, John J. Dreher, and John J. O'Neill, "Masking of English Words by Prolonged Vowel Sounds," Journal of the Acoustical Society of America, 29 (1957), p. 1254.

ground, and found that this speech noise and white noise are equally effective in masking monosyllables, but that the speech noise is a better masker of continuous discourse.[1] Pollack and Pickett designated different signal-to-noise ratios required for 50 per cent intelligibility of PB lists.[2] These S/N's range from 12 dB with one background talker to 6 dB with seven talkers. The use of speech babble appears to have potential value when used to sensitize conventional speech discrimination tests, although it is but one type of distortion faced by both normal-hearing and hearing-impaired subjects.

This section of the present chapter--devoted to an overall description of speech reception and discrimination--was presented to indicate the complexity of the speech perception process and to suggest some of the problems involved in the study of speech discrimination. This material should demonstrate some of the difficulties faced by researchers and clinicians when they attempt to evaluate the effects of auditory training.

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[1]William R. Hodgson, "A Comparative Study of the Effects of White Noise, Speech Noise, and Complex Noise on the Intelligibility of Speech" (unpublished Ph.D. dissertation, Ohio University, 1961).

[2]I. Pollack and J. M. Pickett, "Stereophonic Listening against Voice Babble," Journal of the Acoustical Society of America, 30 (February, 1958), pp. 131-33.

Auditory Training: Procedures and Goals

Carhart emphasized that sensory habits are as fundamental to life's activities as are the more obvious muscular habits.[1] On this basis, auditory training for very young children is designed to establish auditory habits that allow maximum use of residual hearing and of acoustical stimuli in the environment. In this context, Carhart indicated that there are four major stages in auditory training for children: (1) development of awareness of sound, (2) development of gross discrimination, (3) development of broad discrimination among simple speech patterns, and (4) development of finer discriminations for speech. Newby similarly reccommended that training proceed from simple, gross discrimination of environmental sounds to the more complex discrimination of vowel and consonant sounds.[2] These efforts are advised even though initially there may not be evidence of the child's response to auditory stimulation.

Training with deaf children should begin as soon as a hearing loss is suspected. DiCarlo outlined some objectives for this training, including development of: (a) auditory

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[1]Raymond Carhart, Auditory Training, Hearing and Deafness, op. cit., pp. 373-77.

[2]Newby, op. cit., 309-16.

recognition, (b) auditory memory span, (c) auditory discrimination, (d) auditory synthesis, (e) auditory scanning, and (f) auditory recall.[1] The main objective is the establishment of auditory contact with the environment so that this sensory avenue may be used to its maximum.

Auditory training for adults requires a different frame of reference. Here the task, according to Carhart, is the re-education of an impaired ability.[2] He further indicated that the subject's task with a hearing aid involves adjustment to loud sounds, development of speech discrimination in noise, improvement in localization, and so forth.

Oyer, as well as other writers, emphasized the importance of combining auditory training with other procedures--lipreading, speech therapy if indicated, speech conservation, hearing aid orientation, and counseling--and devoted a chapter to this topic.[3] He stressed the need for adequate motivation and suggested means whereby the hearing clinician can stimulate a satisfactory level. Materials for auditory training with both children and

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[1]Louis M. DiCarlo, "Speech and Communication for the Deaf," Volta Review, 62 (1960), pp. 317-19.

[2]Carhart, op. cit., p. 380.

[3]Oyer, op. cit., Chapter 11.

adults were described,[1] and the importance and contribution of listening were given emphasis.[2]

Benefits to be derived from auditory training, according to Alpiner, include improvement in the tolerance threshold for amplified sound, adjustment to the way speech and noise sound when amplified, and possible changes in speech discrimination.[3]

Browd suggested that a hearing aid alone--without auditory training--seldom provides a satisfactory level of hearing.[4] He stressed discrimination and interpretation of phonemes and gave secondary emphasis to pitch, accent, rhythm, inflection, and duration. Frankel provided an auditory training program for those who cannot receive daily training at a hearing center.[5] Three long-playing records for playback in the home allow practice with or without a hearing aid. Larsen also prepared disc-recordings for practice in the home or clinic.[6]

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[1]Ibid., Chapter 12. [2]Ibid., Chapter 8.

[3]Jerome G. Alpiner, "Aspects of Auditory Rehabilitation: Part II," Audecibel, 13 (1964), pp. 47-51.

[4]Victor L. Browd, "Hearing Education without the Use of Hearing Aids," Archives of Otolaryngology, 49 (1949), pp. 511-28.

[5]George W. Frankel, "A Planned Home Auditory Training Program," The Eye, Ear, Nose and Throat Monthly, 40 (April, 1961), pp. 560-62.

[6]Laila Larsen, Consonant Sound Discrimination (Bloomington, Indiana: The University of Indiana, 1950).

Adjustment to a hearing aid during early stages of use was described by Haskins.[1] Subjects are instructed in how to listen again by using the aid first in easy listening situations,then progressing in steps to more complicated conditions.

Heineman et al. discussed the aural rehabilitation program at Walter Reed Army Medical Center.[2] The authors emphasized auditory training with and without hearing aids, and stated that the primary goal of auditory training is to teach good listening habits. Some discrimination practice is given for gross sounds, but major effort is expended toward improved speech discrimination by contrast of similar sounding words and by use of recorded practice material. The authors indicated that auditory training is extremely beneficial, even for persons with fairly good low-frequency hearing but poor high-frequency hearing (i.e., the usual non-candidate for a hearing aid).

O'Neill suggested several basic approaches to auditory training with adults.[3] The first approach begins with phoneme-discrimination practice, then moves to syllable drills, and concludes with word-discrimination

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[1]Harriet L. Haskins, "Listening with the Aid of a Hearing Aid," Volta Review, 57 (1955), p. 408.

[2]Jan Heineman et al., "Listening Through Visual Hearing," Hearing News, 32 (July, 1964), pp. 5-8.

[3]John J. O'Neill, The Hard of Hearing, op. cit., pp. 89-91.

practice. The second approach emphasizes discrimination of phrases and sentences. Decision regarding approach depends on the particular needs of the individual subject. Recognition of pairs of words or syllables differing in either the vowels or consonants is a usual training method.

A set of twenty lesson plans for adults was described by Johnson and Siegenthaler.[1] According to these authors, the goals of auditory training are: (a) to improve personal-social attitudes and relationships by understanding and accepting one's hearing problem; (b) to learn the care, operation, and limitations of the hearing aid; (c) to increase tolerance for amplification; (d) to improve sound localization ability; and (e) to improve perception of speech by training with a hearing aid. They reported a general increase in discrimination test results for twenty subjects enrolled in this program, but did not show actual data.

Hutton suggested that when both auditory and visual stimuli are combined in aural rehabilitation, phoneme intelligibility is high enough for effective communication.[2]

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[1]A. F. Johnson and B. M. Siegenthaler, "A Clinical Auditory Training Program," Journal of Speech and Hearing Disorders, 16 (March, 1951), pp. 35-39.

[2]Charles Hutton, "A Diagnostic Approach to Combined Techniques in Aural Rehabilitation," Journal of Speech and Hearing Disorders, 25 (1960), pp. 267-72.

Davis stated that speech discrimination cannot be improved by a hearing aid or by surgery, but that sometimes it can be improved wholly or in part by auditory training.[1] Hirsh, however, was not so enthusiastic, suggesting that it is unusual for auditory training to change speech discrimination.[2] He stated though that the discrimination score might be changed and that he has had reports of some successfully trained subjects. Hirsh indicated that most teachers of auditory training do not propose changes in the auditory systems, but hope only to increase use of residual auditory capacities.

The use of alphabet letters for discrimination testing and for early stages of training was recommended by Kelly.[3] He indicated that lists of these letters in various combinations avoided word familiarity problems, were suitable for multiple presentation, were simple enough for children, and could be presented and scored in minimum time. An extensive set of drill material is presented with emphasis placed on group training with talker-listener panels.

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[1]Hallowell Davis, "The Articulation Area and the Social Adequacy Index for Hearing," Laryngoscope, 58 (August, 1948), pp. 761-78.

[2]Ira J. Hirsh, The Measurement of Hearing, (New York: McGraw-Hill Book Co., Inc., 1952), p. 300.

[3]Kelly, Clinician's Handbook, op. cit.

Whitehurst also collected extensive drill materials for teenagers and adults.[1] These drills stress contrast of phonemes in initial, medial, and final positions within single words. Sentences and supplementary material are included.

Thus, there are numerous sources available for suggestions concerning the form and content of an auditory training program. The general procedures and objectives appear to be similar among these sources. Subjects are given practice in the recognition and discrimination of speech stimulus items with emphasis on contrasts among similar-sounding phonemes, words, and sentences. Improved speech discrimination performance in everyday listening situations is the primary objective. The relative efficiency of various approaches and the effects of individual, task, and environmental variables usually are not described in training manuals.

Research in Auditory Training

Much of the research in the United States on auditory training for children was conducted by Hudgins. In one study he compared a high fidelity auditory training unit with an older-type model, and found that the newer model resulted in substantially more improvement in speech

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[1]Mary Whitehurst, Auditory Training Manual (New York: Hearing Rehabilitation, 330 East 63rd Street, 1955).

perception than the older model.[1] In another paper he reported on the positive effects of combining auditory training with visual training for profoundly deaf children, indicating that such success may best be measured in terms of the difference between scores obtained by lipreading and those obtained by both lipreading and auditory stimulation.[2] Recent research by Ling also suggested the importance of low-frequency hearing aid amplification in auditory training programs for deaf children.[3]

Of more immediate concern to the present study are those investigations that relate directly or indirectly to auditory training with adults. Most of what is now considered basic to this training originated from research with normal-hearing listeners during and immediately following World War II. Flanagan et al. summarized wartime research concerning the learning and reception of codes and speech in noise.[4] Rosenzweig and Stone reported rapid

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[1]C. V. Hudgins, "The Response of Profoundly Deaf Children to Auditory Training," Journal of Speech and Hearing Disorders, 18 (1953), pp. 273-88.

[2]Hudgins, "Auditory Training: Its Possibilities and Limitations," op. cit., p. 349.

[3]Daniel Ling, "Implications of Hearing Aid Amplification Below 300 CPS," Volta Review, Reprint No. 828 (Washington, D. C.: The Volta Bureau, 1537 35th St., N.W., 1965).

[4]J. C. Flanagan, et al., Psychological Research in the Armed Forces, Special Edition, Review of Educational Research, 18 (December, 1948), pp. 528-655.

and extensive improvement in performance following training of both talkers and listeners.[1]

Steer, Hadley, and Kerr demonstrated that a training program in listening produces significant gains.[2] An experimental group of flight students received two hours of instruction and practice in listening to frequency-distorted speech. This group and a control group were tested twice with both groups improving in performance on the second test, but with the experimental group showing significantly greater gains.

Egan summarized the extensive research programs at the Harvard Psycho-Acoustic Laboratory during the war, and reported that discrimination improvement with normal-hearing listeners is considerable under difficult listening conditions.[3] Data are presented that describe learning curves for speaker-listener combinations during eight successive days of practice; scores improved from approximately 59 per cent on the first day to a plateau of about 76 per cent on the eighth day. It is difficult to determine whether this increase was due to improved listening, to

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[1]Mark R. Rosenzweig and Geraldine Stone, "Wartime Research in Psycho-Acoustics," ibid., pp. 642-54.

[2]M. D. Steer, J. Hadley, and W. Kerr, "Listening Training Aids for Pre-Flight and Primary Flight Students," Cited in Kelly, op. cit., p. 26.

[3]Egan, "Articulation Testing Methods," op. cit., p. 970.

increased speaking skill, or to some combination of the two. Egan showed that discrimination scores are relatively stable among six one-hour training sessions given on the same day.

These results with normal-hearing listeners, together with the large number of veterans sustaining hearing loss, led to the incorporation of auditory training into service-connected aural rehabilitation programs. DiCarlo sought to measure the effectiveness of this training at Borden General Hospital.[1] Comparison of pre- and post- training discrimination tests (given live-voice) indicated that 472 veterans receiving auditory training improved about 19 per cent in mean performance, while 53 veterans not receiving training improved only about 3 per cent.

Research other than armed services sponsored was conducted during this period. Goodfellow in 1942 reported his observations with six hearing-impaired subjects who received four months of auditory training.[2] Improvement was observed that Goodfellow attributed to adaptation to frequency distortion, clarification of phonetic concepts, attention to secondary cues contained in the gross pattern

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[1]Louis M. DiCarlo, "Auditory Training for the Adult," Volta Review, 50 (September, 1948), pp. 490-96.

[2]Louis D. Goodfellow, "The Re-Education of Defective Hearing," Journal of Psychology, 14 (1942), pp. 53-58.

of speech, and changes in the subjects' attitude toward their handicap.

Silverman in 1944 reported that six out of seven adult subjects (hearing aid users), after receiving systematic auditory training, showed improvement in speech discrimination ranging from 0 to 36 per cent for words and 8 to 52 per cent for sentences.[1] Browd in 1949 indicated that thirty-seven out of forty-six subjects showed either no disability or only occasional evidence of it after training.[2] He emphasized training without hearing aids and suggested that among persons who are not candidates for hearing aids and who receive auditory training, few fail to attain a satisfactory level of hearing.

In 1953 Kelly reported the effects of talker-listener drills with two groups of teenagers seen during two summer sessions of one-half hour daily practice for six weeks.[3] One group of fifteen subjects showed a significant mean improvement in discrimination of 21 per cent, and the second group (sixteen subjects) showed a significant improvement of 17 per cent. Neither group showed

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[1]S. Richard Silverman, "Training for Optimum Use of Hearing Aids," Laryngoscope, 54 (1944), pp. 29-36.

[2]Browd, op. cit.

[3]Kelly, op. cit., pp. 26-27.

significant improvement in speech reception threshold, although both groups showed some improvement.

Hutton in 1960 used the multiple-choice Semi-Diagnostic Test, by live-voice testing, as a criterion measure.[1] He found a mean improvement of 6 per cent in auditory discrimination for eighteen subjects receiving approximately three months of training.

Other researchers were not interested in auditory training per se. Rather, their research interest concerned changes in speech and/or pure tone discrimination as a function of test-retest or of duration of practice. Subjects usually were normal-hearing.

Thurlow et al. in one study found that PB scores decreased significantly among three tests given over several weeks and months,[2] but then in a second study reported significantly better discrimination on test-retest comparisons.[3] Moser and Dreher, concerned with listener variability in intelligibility studies, demonstrated that normal-hearing listeners show progressive improvement in performance with training.[4]

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[1]Hutton, op. cit.

[2]W. R. Thurlow et al., "A Statistical Study of Auditory Tests in Relation to the Fenestration Operation," Laryngoscope, 58 (January, 1948), pp. 43-66.

[3]W. R. Thurlow et al., "Further Statistical Study of Auditory Tests in Relation to the Fenestration Operation," Laryngoscope, 59 (1949), pp. 113-29.

[4]Henry M. Moser and John J. Dreher, "Effects of Training on Listeners in Intelligibility Studies," Journal of the Acoustical Society of America, 27 (November, 1955), pp. 1213-19.

Thwing compared listener performance on four successive presentations, one per second, of single PB words under three conditions of noise.[1] He found at all signal-to-noise ratios that major improvement (about 10 per cent) occurred with the second presentation of the test word; third and fourth presentations had negligible effects. Campbell and Small studied the effects of practice and feedback on difference-limens for pure tones, and found that these limens decreased as a function of training.[2]

Changes in pure tone thresholds as a function of practice were investigated by Zwislocki et al.[3] Five experimental treatments--administered to five groups of listeners--resulted in significant gains in threshold detection with greater improvement at 100 cps than at 1000 cps.

Licklider and Miller summarized research in training, stating that there seems to be no better way to teach listeners than to motivate them and have them

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[1]Edward J. Thwing, "Effect of Repetition on Articulation Scores for PB Words," Journal of the Acoustical Society of America, 28 (March, 1956), pp. 302-303.

[2]Richard A. Campbell and Arnold M. Small, Jr., "Effect of Practice and Feedback on Frequency Discrimination," Journal of the Acoustical Society of America, 35 (1963), pp. 1511-14.

[3]Jozef Zwislocki et al., "On the Effect of Practice and Motivation on the Threshold of Audibility," Journal of the Acoustical Society of America, 30 (1958), pp. 254-62.

listen.[1] They indicated that subject variability among normal listeners is considerable, even after extensive training. It appears that information from studies in learning and training has general relevance to auditory training as a specific type of sensory learning or re-learning. Studies thus far reviewed indicate positive effects of training on speech discrimination.

Principles of Learning and Training

Wolfle suggested a convenient dichotomy between learning and training, one which serves as a guide for the discussion in this section. He stated that if an investigator's primary interest is in the processes by which knowledge or skill is acquired, then his studies are classified under the heading of learning; if his primary purpose is to investigate the teaching of knowledge or skill, his work is classified under the heading of training.[2] The latter category was of main interest in the present study.

World War II gave psychologists an opportunity to give practical tests to theoretical hypotheses about learn-

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[1] J. C. R. Licklider and G. A. Miller, The Perception of Speech, Chapter 26 in Handbook of Experimental Psychology, ed. S. S. Stevens (New York: John Wiley and Sons, Inc., 1951), p. 1068.

[2] Dael Wolfle, Training, Chapter 34 in Handbook of Experimental Psychology, ibid., pp. 1267-86.

ing behavior, particularly those changes in behavior that result from training. Wolfle described some of the useful parts of learning theory applicable to training, and suggested the following guidelines for training programs.[1] First, the distribution of practice should be suitable for the task to be learned. Second, active participation by the learner is superior to passive receptivity. Third, practice material should be varied so that the learner can adapt to realistic variation and so that motivation during drill is improved. Fourth, accurate performance records must be kept in order to evaluate progress and effects of training. Fifth, the most useful single contribution of psychology to training was the provision for immediate knowledge given to learners regarding their performance.

Postman and Egan--writing shortly after World War II --provided suggestions and guidelines for research in training.[2] In general, the more distributed the practice trials, the better the learning, although this depends to some extent on the particular task. Meaningful materials

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[1]Dael Wolfle, "Military Training and the Useful Parts of Learning Theory," Journal of Consulting Psychology, 10 (1946), pp. 73-75.

[2]Leo Postman and James P. Egan, Experimental Psychology (New York: Harper and Brothers, Inc., 1949), pp. 395-462.

are better retained than nonsense items. Ideally, subjects learn best by performing tasks with full awareness of the principles guiding successful performance. Of potential relevance to the present study is the authors' statement regarding sensory capacity. They stated that the beneficial effects of past experience probably are due to the transfer of observational techniques and attitudes.[1]

McGeoch and Irion summarized a great deal of the research and theorizing in learning behavior.[2] A number of principles, in addition to or complementary to those mentioned above, are pertinent to the present study. The importance of adequate motivation was emphasized. The subject must initiate and sustain his practice of a given task in order to reach a satisfactory performance level. The beneficial effects of spacing practice--particularly with motor-type skills--can be demonstrated in a large number of situations. The authors stated that the conditions necessary for learning is a subject of considerable theoretical dispute.[3]

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[1]*Ibid.*, p. 426.

[2]John A. McGeoch and Arthur L. Irion, *The Psychology of Learning* (New York: Longmans, Green and Co., 1952).

[3]*Ibid.*, p. 296.

Further relevant information was suggested by Kingsley.[1] He stated the principle that the smaller the interference between practice sessions, the more substantial the learning. In addition, it appears that the shorter the practice period, within limits, the greater the learning that occurs.

The question of the importance of spaced practice was discussed by Mednick, who indicated that spacing only wastes time when the responses to be learned are familiar but have to be given new meaning or connected to a different stimulus.[2] This condition seems to exist in auditory training with hard of hearing adults. Their task is one of attaching new meaning to distorted acoustic signals. Therefore, a concentrated training program may have some advantage over excessively-spaced sessions.

The relations between learning and practical demands of instruction and training were described by Hilgard.[3] He indicated that the decline in learning

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[1]Howard L. Kingsley, The Nature and Conditions of Learning (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1957), pp. 237-57.

[2]Sarnoff A. Mednick, Learning (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1964), p. 87.

[3]Ernest R. Hilgard, Theories of Learning (2nd ed.; New York: Appleton-Century-Crofts, Inc., 1956), pp. 485-87.

ability with age, in adult years, depends on what it is that is being learned. A comment of interest is that a motivated learner acquires what he learns because he practices more than an unmotivated person. Furthermore, excessive motivation may be detrimental, particularly for tasks requiring difficult discriminations. Hilgard emphasized the importance of providing knowledge of performance during training.

This brief review of training principles suggests the following applications to auditory training. An adequate level of motivation should be maintained. Spaced practice may be of minimal importance. Knowledge of performance is indispensable in improving skill. Variation in practice is needed to maintain interest and to prepare the subject for variations in situations where the training is to be applied. Interference between training sessions should be anticipated. The subject should have an active rather than a passive role in the training. The subject should be aware during training of realistic objectives, and should be informed regarding principles aiding successful performance. These and other basic principles guided the formulation of the training procedures evaluated in the present investigation.

Hearing Loss and Hearing Handicap

In recent years effort was made by various professions to delineate the meaning of three different terms:

impairment, disability, and handicap. The distinguishing features among these terms are fairly well specified at this time. Hamilton described the distinctions:

> A disability is a condition of impairment, physical or mental, having an objective aspect that can usually be described by a physician . . . A handicap is the cumulative result of the obstacles which disability interposes between the individual and his maximum functional level.[1]

Wright further recommended that a handicap must be evaluated in terms of the demands of the situation in which the person finds himself, and that disability cannot be equated with handicap.[2] A person may feel physically handicapped even though from the medical point of view, his physical limitations are not disabilities. In addition, the obstacles that the physical disability interposes may be as much social in character as physical. These considerations led Wright to conclude that (a) a physical attribute is a physical handicap only when it is seen as a significant barrier to the accomplishment of particular goals, and (b) a physical attribute may become handicapping not because it is physically limiting but because it adversely affects social relationships.

Oyer indicated that measurements of deficit and handicap are not the same, stating that a person might

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[1]K. W. Hamilton, Counseling the Handicapped in the Rehabilitation Process (New York: Ronald Press, 1950), p. 17.

[2]Beatrice A. Wright, Physical Disability: A Psychological Approach (New York: Harper and Row, 1960), pp. 9-10.

have a disorder but not be handicapped by it while another person may have several handicaps because of only one disorder.[1] He stated that hearing handicap varies as a function of demands placed on the hearing-impaired individual.[2]

Several attempts have been made to assess hearing handicap. Davis' Social Adequacy Index was given some clinical use.[3] Only two measures were required--SRT and Harvard PB-Max--to enter a prepared SAI table in which values had been correlated with subjects' reports of the degree of handicap they encountered in various listening situations. Davis, however, recently indicated that the SAI has not been too successful:

> . . . we do not yet seem to know quite enough about the relation of the hearing and understanding of connected speech in words and sentences to its component frequencies, phonemes, and syllables. Speech is a very dynamic, variable affair and we can define it only in broad statistical terms or in terms of word- and sound-patterns that have not yet been standardized.[4]

Carhart agreed, stating that SAI merely ranks subjects along a scale whose practical significance has not been clarified throughout its entire range.[5]

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[1]Oyer., Auditory Communication . . ., op. cit., p. 126.

[2]Ibid., p. 14.

[3]Davis, "The Articulation Area . . .," op. cit.

[4]Davis, and Silverman, Hearing and Deafness, op. cit. p. 194.

[5]Carhart, "Problems in the Measurement . . .," op. cit.

Davis devoted an entire chapter to this complex problem, and described some of the considerations and controversies surrounding military standards and medico-legal ruling.[1]

Consideration of this problem led High, Fairbanks, and Glorig to state that systematic investigation of hearing handicap has lagged far behind the development of techniques for the measurement of hearing impairment.[2] Beginning with this apparently valid assumption, these researchers developed a Hearing Handicap Scale for assessment of one aspect of hearing handicap--the subject's self-report of the degree of difficulty he experiences in hearing-related activities. The authors reported that significant correlation coefficients (about 0.70) were obtained between this scale and all measures of hearing <u>sensitivity</u> for the subjects' <u>better</u> ear. The scale did not correlate significantly with either better or poorer ear speech discrimination. One of two alternate forms of this scale was used in the present study and is described further in Chapter III. (A copy is included in Appendix D).

Attempts have been made to develop sentence-type tests that would have high face-validity for representing everyday speech. Silverman and Hirsh specified criteria as described

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[1]Davis and Silverman, <u>op. cit.</u>, Chapter 9.

[2]Wallace S. High, Grant Fairbanks, and Aram Glorig, "Scale for Self-Assessment of Hearing Handicap," <u>Journal of Speech and Hearing Disorders</u>, 29 (August, 1964), pp. 215-30.

by a panel of experts,[1] and Davis and Silverman published a set of sentences that reportedly meet these criteria.[2] Standardization studies, however, have not been published. The complexities involved in this type of investigation apparently have delayed specification of the operations required for a comprehensive validity-study.

Hearing and Listening

The distinction between hearing and listening is not often very clear in the literature. It is easy to assume that if a person hears an acoustical event, he is also listening to it. This actually may or may not be happening. In fact, audition possibly might not be either a necessary or sufficient condition for the listening act. For example, O'Neill discussed "visual listening" in describing the attitude of a lipreader required for success in interpreting the visual cues offered by the positions and movements of a speaker's lips, facial musculature, and gestures.[3]

Listening and attention may be somewhat analogous terms. Kingsley stated that attention is an indispensable condition for learning, and defined attention as a process that selects stimuli for perception.[4] O'Neill suggested

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[1] Silverman and Hirsh, "Problems Related to . . .," op. cit.

[2] Davis and Silverman, Hearing and Deafness, op. cit., pp. 548-52.

[3] O'Neill, op. cit., p. 85.

[4] Kingsley, op. cit., p. 359.

a broader definition of listening, indicating that it may be considered to be an analysis of the impressions resulting from concentration where an effort of will is required.[1] Oyer recently devoted an entire chapter to the discussion of listening in relation to auditory communication.[2] He defined listening in this context as an attitude, a posture, or a mental set that prepares a person in his attempt to receive and use information transmitted by acoustic events.[3]

The growing interest in listening as a phenomenon worthy of academic, scientific, and general interest is indicated by two recent publications edited by Duker. The first one presents some fifty articles by over thirty-five authors.[4] The second book is an annotated bibliography of over 1000 entries, all dealing with listening.[5]

The relevance of listening to studies in audition was suggested by Farrimond, who stated that at low intensity levels of signals, listening techniques appear to affect performance.[6] Oyer has emphasized the contribution of

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[1]O'Neill, op. cit.

[2]Oyer, op. cit., Chapter 8.

[3]Ibid., p. 81.

[4]Sam Duker, Listening: Readings (New York: The Scarecrow Press, Inc., 1966).

[5]Sam Duker, Listening Bibliography (New York: The Scarecrow Press, Inc., 1964).

[6]T. Farrimond, "Factors Influencing Auditory Perception of Pure Tones and Speech" Journal of Speech and Hearing Research, 5 (1962), pp. 194-204.

listening to auditory training.[1] He designated possible barriers to successful listening, and suggested means of improving listening performance by clinical procedures.

The importance of listening to auditory training also was indicated by O'Neill:

> Listening may be active, passive, or partial. The good listener must be involved in what is being said ---not a mere spectator or eavesdropper. The person who has had a hearing loss for any length of time will have lost the ability to be an active listener.[2]

The responsibility of the audiologist, therefore, is to establish or re-establish optimum listening performance in the hard of hearing subject receiving auditory training.

There seem to be many directions in which both clinical endeavors and related research might investigate, describe, and relate listening behavior to auditory behavior. The contingencies among these behaviors and other aspects of human communication remain challenges for systematic study.

Summary

Auditory training designates the procedures by which the hearing-handicapped are given the opportunity to make full use of acoustic signals impinging on the auditory mechanism. The rationale for these procedures has been known for almost 2000 years, but it was not until the 19th

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[1] Oyer, op. cit.

[2] O'Neill, op. cit., p. 83.

century that it was given major consideration as a means of educating deaf children. Max Goldstein, a St. Louis otologist, is considered as one of the leaders who introduced and established auditory training practices in the United States.

The introduction of modern, wearable hearing aids, and the aural rehabilitation programs during World War II, gave impetus to the incorporation of auditory training in rehabilitation programs for hard of hearing adults. In recent years auditory training has become a standard practice in practically every audiology clinic offering services to the hearing-handicapped.

Research or clinical attempts to evaluate the effectiveness of auditory training require recognition of basic known features of auditory speech perception, particularly the necessary conditions for measurement and the complexities involved therein.

Auditory training for adults generally includes supervised practice in the recognition and discrimination of distorted speech, with emphasis on contrasts among similar-sounding phonemes, words, and sentences. Improved speech discrimination performance in everyday listening situations is the primary objective.

Research in auditory training has suggested that listener performance can be improved to some degree by practice. The extent of this improvement and the relative efficiency

of various procedures apparently have not been studied extensively with a substantial number of subjects or statistical controls. Generalizations concerning potential benefits were derived from informal observations with adults and from studies and observations with deaf children and with normal-hearing listeners.

Basic principles of learning and training have application to both research and clinical efforts in auditory training. Clarification of terms such as impairment, disability, and handicap is advisable when describing auditory training processes and objectives. Diagnosis of hearing "handicap" on an objective basis remains a challenge to the audiology profession. Dimensions of "listening" may be critical in determining the effectiveness of auditory training.

CHAPTER III

SUBJECTS, INSTRUMENTATION, AND PROCEDURES

In this chapter specifics are given regarding the selection of subjects, their assignment to four training groups, the actual training administered to them, and the overall research design. In brief, subjects were selected from a population of mildly hard of hearing individuals. These subjects were seen first for preliminary audiological testing and then were assigned systematically to one of four training groups, each group being matched on speech reception threshold, discrimination in noise, intelligence, discrimination in quiet, age, education, sex, and duration of hearing loss.

Each of the four groups participated in auditory training under one of four combinations of methods and materials. Methods involved experimental manipulation of signal-to-noise ratios and materials consisted of open set (write-down) and closed set (multiple-choice) types of stimulus materials. Three discrimination tests were administered both before and after training to determine the relative effectiveness of the methods and materials. The criterion measures were obtained by means of the W-22, Rhyme, and Semi-Diagnostic tests.

Subjects

Interest was focused on adults who have mild, sensori-neural hearing loss. The term "sensori-neural" indicates the absence of a significant difference between air and bone conduction threshold responses, suggesting that the hearing loss is not amenable to surgical or medical treatment. Mild hearing loss was operationally defined as a speech reception threshold between 5 and 35 dB sound-field. This population was further limited to those subjects who reported that their hearing loss was sustained after acquisition of normal auditory discrimination of American English (i.e., after approximately five years of age). In addition, the population was defined in terms of persons who were referred to or sought the assistance of an audiology clinic. The relationship between this clinical population and the total hearing loss population in the United States was unknown.

This population generally reports a primary hearing difficulty in noise-background situations. Significant hearing impairment for speech usually is not shown for quiet listening conditions. Listening to speech at a distance from the speaker presents discrimination difficulties for this group. A hearing aid often does not alleviate the discrimination problem. Pure tone testing may show one of the following configurations: (a) flat

responses across frequencies, (b) gradual decrease (or increase) in responses, (c) abrupt decrease in responses, or (d) some combination of these between ears.

Selection of Subjects

Names of subjects meeting the above criteria for consideration were obtained from the files of (a) the Speech and Hearing Clinic, Michigan State University, and (b) the Speech and Hearing Department, Rehabilitation Medical Center, Edward W. Sparrow Hospital in Lansing, Michigan. Both clinics are staffed and supervised by faculty members in the Speech and Hearing Science area of the Department of Speech, Michigan State University.

Files at the above clinics were surveyed, and data on each potential subject were recorded. These data included information about educational background, reported duration of loss, occupation, hearing aid status, therapy status, address, phone number, pure tone air and bone conduction threshold responses, speech discrimination scores for each ear and by sound-field testing, and the date of the most recent audiological evaluation.

Subject Contact

Approximately fifty potential subjects were contacted by letter, a copy of which is shown in Appendix A. Some thirty-six persons agreed to participate in the study, and were seen for preliminary testing to establish their

candidacy for this study. Four of these persons were eliminated from consideration because they either failed to meet selection criteria or decided not to participate in the subsequent training program. All subjects were informed regarding the overall purposes and procedures of this investigation, but were not given information concerning specific questions of interest.

Instrumentation

The following instrumentation was utilized during preliminary audiological testing and during the subsequent testing and training procedures. Tape-recording instruments and calibration apparatus also are listed below.

Preliminary Testing

Commercial test-room (Suttle)
Commercial dual-channel audiometer (Allison, Model 22)
    microphone (Electro-Voice, Model 636)
    stereo tape transport (Viking, Model 87)
    phonograph (Bogen, Model B62)
    binaural ear-receivers (TDH-39, MX41AR)

Sound-field-speaker (Electro-Voice, Model SP12)

Recording Apparatus

Microphone (Electro-Voice, Model 654)
Dual-channel tape-recorder (Ampex, Model 602)
Tape-recorder (Ampex, Model 601)
High-fidelity tape (Scotch Low Noise 203)

Analysis of Speech Babble

Tape-recorder (Ampex, Model AG350)
AF Spectrometer (B & K, Model 2112)
Graphic level-recorder (B & K, Model 2305)

Calibration Equipment

Microphone (B & K, Model 4132)
Artificial ear (B & K, Model 4152, 6 cc coupler)
Sound level meter (B & K, Model 2203)

Testing and Training

(Same as apparatus described above under Preliminary Testing).

The specific employment of this instrumentation is described in subsequent sections of this chapter.

Procedures

Subjects were seen individually to obtain performance measures that then were used to establish four training groups with eight subjects in each group. The procedures described in this section were preliminary steps conducted prior to the auditory training procedures.

When subjects were seen for this testing, case history information in clinic files was verified. The mean age of subjects was 44 years (median: 44 years) with a range of 21 to 60 years. Mean educational background was 13.4 years (median: 12 years) with a range of 8 to 20 years of formal schooling. The reported duration of hearing loss was 2 to 30 years with a mean of 12.4 years. There were 26 males and 6 females, and 9 hearing aid users. (See Appendix C for individual data and Table 1, page 71 for summary statistics).

Audiological Measures

Audiometric measures for each subject included pure tone air conduction thresholds, speech reception thresholds, and speech discrimination scores in quiet and in noise.

All testing was conducted in a commercial test-room (Suttle) and with a commercial dual-channel audiometer (Allison, Model 22). The audiometer and accessories were capable of delivering input signals at calibrated output levels through either binaural ear-receivers (matched set of TDH-39 phones with MX41AR cushions) or sound-field speakers (Electro-Voice, Model SP12). Only one of the two available sound-field speakers was used in this study (for both the testing and training conditions). The following audiometer input-channels were used: (a) microphone (Electro-Voice, Model 636), used for giving instructions to the subject; (b) pure tone input channels; (c) tape transport (Viking, Model 87), used for playback of the speech babble recording; (d) white noise generator, used for calibration of the sound-field speaker; and (e) phonograph (Bogen, Model B62), used for playback of the CID W-1 and CID W-22 disc-recordings.[1]

[1]Commercial recordings obtained from Technisonic Studios, Inc., 1201 South Brentwood Blvd., Richmond Heights, Missouri.

The output of each ear-receiver and of the sound-field speaker was calibrated prior to the testing procedures, and was checked periodically during the several weeks of preliminary testing. Pure tone calibration of ear-receivers was done according to recommended ISO procedures.[1] Instrumentation included an artificial ear (B & K, Model 4152, 6 cc coupler), a microphone (B & K, Model 4132), and a sound level meter (B & K Precision Sound Level Meter, Model 2203). Coupler sound pressure levels (re 0.0002 microbar) resulting from these procedures were transformed to equivalent standard values in audiometric decibels for each frequency.

Output of the sound-field speaker was calibrated at the anticipated head-level position of the subjects.[2] White noise was used as a calibrating signal in such a way that zero-reference on the audiometer attenuator-dial corresponded to approximately 22 dB sound pressure level. Subsequent attenuator readings thus were with reference to this audiometric-zero. All remaining intensity-level data in this study are expressed with this reference, speech babble levels included.

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[1] Standard Reference Zero for Calibration of Pure Tone Audiometers, ISO/R 389-1964.

[2] American Standard Specification for Speech Audiometers, ASA Z24.13-1953.

The output of each ear-receiver and of the sound-field speaker was calibrated prior to the testing procedures and was checked periodically during the several weeks of preliminary training. [illegible] ear-receivers was [illegible] cedures. [illegible]

The experimenter was seated at the audiometer console in a room adjacent to the test-room and could observe and communicate with each subject during the individual evaluation. Each subject was seated in the test-room, facing directly toward the sound-field speaker with his head approximately 56 inches from the speaker. The test arrangement is shown in Figure 1.

Pure tone testing.--Pure tone air conduction thresholds were determined by the Hughson-Westlake ascending technique.[1] Frequencies tested were 500, 1000, 2000, 3000, and 4000 cps. The better ear, as indicated by previous test results, was tested first and appropriate masking, if necessary, was delivered to this ear during poorer ear testing. The majority of the subjects had similar pure tone sensitivity between ears. (Pure tone results for each subject are reported in Appendix B).

Speech reception threshold.--SRT measurements were obtained for each ear and for the sound-field condition. The CID W-1 disc-recording was the source of spondaic speech stimulus items. A conventional descending-ascending, "bracketing" procedure was employed. In other words, the intensity of the recording was varied near threshold until the intensity was found at which the sub-

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[1]Walter Hughson and Harold Westlake, "Manual for Program Outline for Rehabilitation of Aural Casualties Both Military and Civilian," Transactions of the American Academy of Ophthalmology and Otolaryngology Supplement, 48 (1944), pp. 1-15.

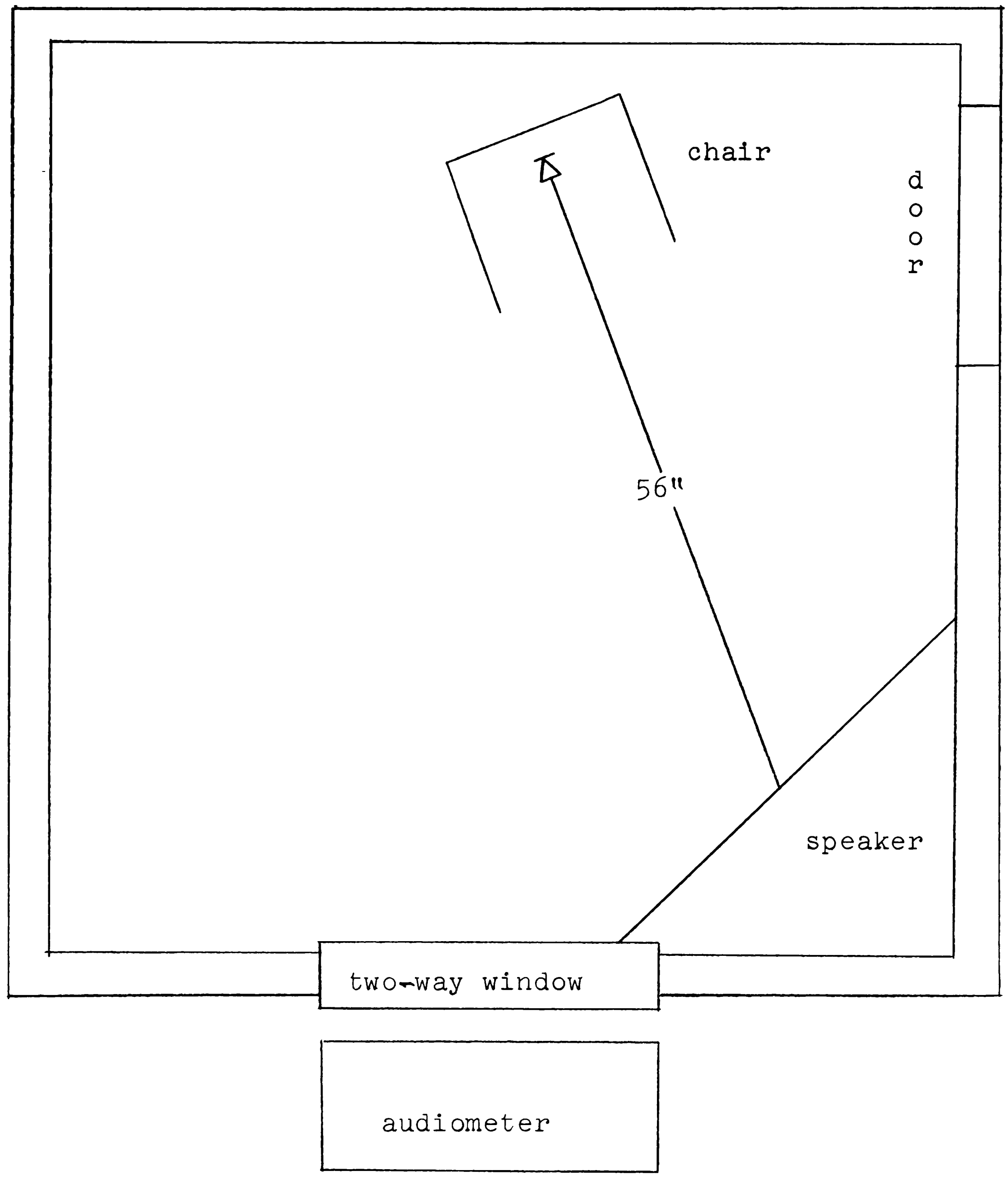

Figure 1.--Schematic representation of physical arrangements during preliminary testing and selection of subjects.

ject repeated 50 per cent of the test words correctly. The better ear was tested first, followed by the other ear, and then concluded with the sound-field measurement. (Results of this testing for each subject are reported in Appendices B and C).

Speech discrimination in quiet.--Three of the four different CID W-22 disc-recordings were used as the source of monosyllabic testing items, a different test for each ear and for the sound-field measure in this test order. Each list was presented at SRT plus 35 dB. This represented a compromise between conventional 30 and 40 dB levels above SRT. The experimenter monitored subject responses and recorded the number of correct items for each list. (Percentage of correct responses for each subject on these selection tests is reported in Appendices B and C).

Speech discrimination in noise.--The last audiological measure was speech discrimination in noise, and the remaining W-22 list was utilized. This list was delivered to the sound-field at 50 dB, with speech babble (described in the next section) delivered simultaneously through the same speaker at an average 45 dB intensity-level. The subject's task again was to identify correctly the monosyllabic test item. Number of items correct was recorded for each subject. (See Appendix C for percentage correct data).

Speech babble.--A speech babble signal was employed to sensitize the discrimination task so that it would be more difficult than a similar task in quiet. This procedure, though arbitrary, not only enhanced inter-subject differences not easily detected otherwise, but also approximated the type of listening condition in which many hard of hearing subjects report their greatest hearing difficulty.

The source of the speech babble--both during the present testing and during subsequent training conditions--was a tape-recording of twenty male and female college students reading aloud different speech material at the same time. The recording was prepared by Higgins, who reported that a microphone (Electro-Voice, Model 605) connected to a tape-recorder (Ampex, Model 601) was placed in the middle of a classroom during the simultaneous oral readings.[1] A segment of this recording showing a minimal amount of intensity fluctuation (no more than 3 dB) was made into a loop. A thirty-minute recording of this loop then was made (i.e., the signal was transferred from an Ampex 601 recorder to a Wollensak T-1500 recorder).

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[1]Doris Mary Higgins, "The Effects of White Noise and Speech Babble on the Intelligibility of Phonetically Balanced Lists of Monosyllabic Words" (unpublished Master's thesis, The University of Tennessee, 1965).

Both Higgins' analysis and present analysis (B & K Spectrometer, Model 2112 and B & K Level Recorder, Model 2305) of this recording showed primary energy concentration for the filter-frequencies between 150 and 1000 cps, and an amplitude-time display for filter-frequencies within this range showed minor intensity fluctuations (3 dB range).

WAIS Vocabulary Testing

The Vocabulary sub-test of the Wechsler Adult Intelligence Scale was given to estimate the intellectual performance of the present subjects. Since this sub-test reportedly correlates approximately 0.83 with the Full-Scale score (about 0.90 with Verbal score), and because its reported split-half reliability coefficient is about 0.95,[1] it was believed to be suitable for present purposes.

This estimate was needed as a control factor for intelligence. For an assumption of "equivalency" among training groups on factors important to amount of learning in a training situation, some estimate of intelligence (i.e., ability to learn) was necessary. The Vocabulary sub-test of the WAIS should meet this requirement rela-

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[1]David Wechsler, The Measurement and Appraisal of Adult Intelligence (4th ed.; Baltimore: Williams and Wilkins, Inc., 1958), pp. 99-103.

tive to group performance. This procedure is not followed or recommended in a clinical situation where individual performance is evaluated. Any conclusions in this study relative to the intellectual factor were interpreted with due caution.

Recommended procedure for individual administration and scoring was followed.[1] Each subject was given a printed listing of the forty words included in the Vocabulary sub-test. The experimenter then asked the subject the meaning of each successive word. Responses were recorded by the experimenter for later scoring. Scoring of all responses of the thirty-two subjects was done with each response scored according to criteria given in the WAIS manual. The subject could receive 0, 1, or 2 points for each word, making a range of possible scores from 0 to 80 points. During the scoring the experimenter did not know whose responses were being evaluated. Scores assigned to items were re-evaluated on a second occasion with no significant change in original scores. (See Appendix C for raw scores on each subject).

Assignment of Subjects to Four Training Groups

On the basis of test performance and case history information--described in previous sections of this

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[1]David Wechsler, Manual for the Wechsler Adult Intelligence Scale (New York: The Psychological Corporation, 1955), pp. 42-43, 63-75.

chapter--the thirty-two subjects were assigned systematically to one of four training groups. Group means, standard deviations, ranges, and medians were matched among groups. This was done to establish relative "equivalency" among groups so that potential effects of auditory training can be attributed to the training rather than to possible initial differences among groups. Substantially more confidence then can be given to conclusions drawn regarding the effects of the specific treatments under experimental control.

The results of the above matching-among-groups procedure are shown in Table 1. Mean performance of all thirty-two subjects was as follows: (a) sound-field discrimination-in-noise score of 47.0 per cent, (b) sound-field speech reception threshold of 22.2 dB, (c) WAIS Vocabulary sub-test score of 49.1 points, and (d) sound-field PB-Max score of 78.1 per cent. Mean age was 44.0 years, mean educational level was 13.4 years, and mean duration of hearing loss was 12.4 years. There were one female in each of two groups and two females in each of the two remaining groups. There were two hearing aid users in three groups and one in the remaining group. As can be noted, there were no major discrepancies among groups on these measures. However, these measures now having been specified can be consulted, if necessary, and results reported in Chapter IV qualified accordingly.

TABLE 1.--Means, standard deviations, medians, ranges, and descriptive data resulting from group matching procedures (N = 32, n = 8).

	Group 1	Group 2	Group 3	Group 4	Total
DS/Noise (%)	48.3	46.5	45.5	47.5	47.0
stnd. dev.:	16.6	15.7	18.1	19.2	
range:	28-86	18-70	24-76	16-72	
SRT (dB)	21.3	21.9	23.1	22.5	22.2
stnd. dev.:	9.3	10.9	9.7	9.0	
range:	5-35	5-35	5-35	5-35	
WAIS Vocab.	50.4	49.6	47.5	49.0	49.1
stnd. dev.:	13.7	13.1	15.2	13.1	
range:	28-72	26-72	18-67	31-67	
PB-Max (%)	76.5	80.8	75.3	79.8	78.1
range:	52-96	64-94	48-98	52-96	
Age (years)	43.4	46.0	43.3	44.3	44.0
range:	28-54	21-60	26-60	35-55	
median:	45	46	42	42	
Educ. (years)	13.5	13.1	13.3	13.9	13.4
range:	9-20	8-20	8-19	11-20	
median:	12	12	13	12	
Duration of Loss (years)	12.6	13.3	9.0	14.8	12.4
range:	4-20	3-25	2-20	4-30	
Males	6	7	7	6	26
Females	2	1	1	2	6
Hearing Aid Users	2	3	2	2	9

Six factors were of interest in this investigation: (a) comparison of pre- and post-training discrimination performance; (b) comparison of speech discrimination tests (W-22 vs Rhyme vs Semi-Diagnostic); (c) comparison of auditory training methods (S/N-constant vs S/N-varied); (d) comparison of auditory training materials (open set monosyllables vs closed set multiple-choice); (e) comparison of differential training effects among the four training groups; and (f) comparison of Hearing Handicap Scale self-ratings and effects of auditory training on speech discrimination. These factors are described in the following sections.

Speech Discrimination Tests

The selected tests of speech discrimination were: (a) CID W-22 lists 3 and 4,[1] (b) Rhyme lists 1 and 2,[2] and (c) Semi-Diagnostic forms A and B.[3] The disc-recordings of the W-22 lists were used, while tape-recordings of the Rhyme and Semi-Diagnostic tests were made for this study. (The test-items for each of the three discrimination tests are given in Appendix E).

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[1]Ira J. Hirsh et al., "Development of Materials for Speech Audiometry," Journal of Speech and Hearing Disorders, 17 (September, 1952), pp. 321-37.

[2]Grant Fairbanks, "Test of Phonemic Differentiation: The Rhyme Test," Journal of the Acoustical Society of America, 30 (July, 1958), pp. 596-600.

[3]Charles Hutton, E. Thayer Curry, and Mary Beth Armstrong, "Semi-Diagnostic Test Materials for Aural Rehabilitation," Journal of Speech and Hearing Disorders, 24 (November, 1959), pp. 319-29.

The selection of these particular tests was somewhat arbitrary; however, several criteria were employed: (1) the tests are published and thus easily available to both researchers and clincians; (2) the W-22 lists have received extensive research and clinical use; (3) the Semi-Diagnostic test was developed specifically for evaluating aural rehabilitation candidacy and progress, but has not been evaluated extensively; (4) the Rhyme Test similarly has not received extensive study with hearing loss populations, and is noteworthy because of its emphasis on consonant discrimination; (5) some information was available regarding correlation between the W-22 and Semi-Diagnostic tests; and (6) most important of all, for the purposes and conditions of this study, these tests were believed to have satisfactory validity and reliability for specifying the pre- and post-training discrimination performance of the present subjects.

All subjects received the same test-items through counter-balanced alternate forms of each test. That is, half the subjects in each group received one form of each test pre-training and the other form post-training, while the remaining four subjects in each group received the reverse order of presentation. Each subject served as his own control, receiving both forms of all tests on the same day. All tests were administered at a 5 dB signal-to-noise ratio with the discrimination tests at 50 dB sound-field and the speech babble at 45 dB sound-field.

The subject's task for the W-22 test was to repeat vocally the monosyllable heard in the noise background, with the experimenter monitoring the responses.

The Rhyme Test required a written response from the subject. He was given a response sheet of 50 word-stems with each stem preceded by a blank space in which he entered one letter to complete the spelling of the word (e.g., __ot, __ay, __op, __ake). The subject was told that he would hear 50 words and that he was to write in the appropriate letter as he heard each word. This test required discrimination of consonants as they appear at the beginning of monosyllables. The test was thought to be an ideal one for the present subjects since their primary discrimination problem was with consonant sounds, particularly in a noise background condition.

The multiple-choice format was employed with the Semi-Diagnostic test. The subject's response sheet showed four words that differed only in vowels or consonants; his task was to circle the correct word. Fifty such foils, with fifty associated test items, constituted a single form of this test.

In this study, two of the four W-22, two of the five Rhyme, and two of the four Semi-Diagnostic comparable lists were employed.

Auditory Training Methods

Out of a number of possible methods of training subjects, two were selected that seemed to be most pertinent to the present objectives. One of the main interests concerned the effects of auditory training on the discrimination of speech that was delivered at the loudness-level of average conversational speech, defined here as 50 dB re audiometric zero. In addition, the discrimination task involved listening to speech in a speech babble noise background of 45 dB re audiometric zero. These considerations led to the selection of two training "methods" that seemed to have relevance to the required discrimination task.

Two methods were selected for evaluation: (a) signal-to-noise ratio constant with the overall intensity-level decreased from conversationally-loud to conversationally-soft speech as a function of five training sessions, and (b) signal-to-noise ratio varied with the signal held constant at the intensity-level of conversationally-average speech and the noise level increased as a function of the five training sessions.

Each subject participated in five training sessions over an approximate three-hour period (not including pre- and post-training discrimination testing). Those sixteen subjects who received the S/N-constant method listened under the following five conditions as training progressed:

Session 1: signal at 57 dB, speech babble at 52 dB
Session 2: signal at 54 dB, speech babble at 49 dB
Session 3: signal at 51 dB, speech babble at 46 dB
Session 4: signal at 48 dB, speech babble at 43 dB
Session 5: signal at 45 dB, speech babble at 40 dB

Those sixteen subjects who received the S/N-varied method listened under the following five conditions as training progressed:

Session 1: signal at 50 dB, speech babble at 40 dB
Session 2: signal at 50 dB, speech babble at 42 dB
Session 3: signal at 50 dB, speech babble at 44 dB
Session 4: signal at 50 dB, speech babble at 46 dB
Session 5: signal at 50 dB, speech babble at 48 dB

As can be observed above, the first method maintained a 5 dB S/N with overall intensity decreased during training, and the second method maintained a 50 dB signal throughout while S/N was varied from 10 to 8 to 6 to 4 to 2 dB during successive sessions. Therefore, both methods differed in intensity-levels and signal-to-noise ratios but were similar in that the difficulty of the listening task increased as training progressed. It was believed that, all thing being equal, success early in training with a simpler task served to motivate the subjects and to prepare them to accomplish more as listening conditions became more difficult. It was presumed further that these accomplishments would reflect themselves in post-training discrimination, and that if differences actually existed between the S/N methods, these differences would be indicated by a statistically significant difference between the mean gains for each method.

Auditory Training Materials

Since most of the subjects in the present population experience primary difficulty in consonant discrimination, training materials should be of the type where speech discrimination is dependent on consonant identification rather than on contextual influences. This was one reason why monosyllables--instead of multisyllabic or sentence-type materials--were employed in this study.

It was decided to include type of practice material as a factor of interest. Multiple-choice (closed set) materials and write-down (open set) materials were selected. The subject's task was considerably different, depending on which type of material was utilized. The multiple-choice task merely required the ability to select one out of only a few possible alternatives, each of which was conveniently listed in front of him. The write-down task, however, required that the subject select one out of numerous choices. This question of multiple-choice versus write-down training materials seemed to be a basic consideration in the planning and evaluation of auditory training. The interest in this study was to evaluate objectively this question and to determine if either type of material was most effective in auditory training.

By the line of reasoning suggested above, interest was drawn away from what seemed to be a less fundamental question at this time; that is, evaluation of specific material published by a particular author. Though this topic

has some importance, most collections of training materials were not derived from auditory training research, but were either borrowed from other sources or selected arbitrarily. In addition, it was difficult to note any real differences among most of these materials. For these reasons then, it was decided not to evaluate specific materials, but to select those published materials that met the multiple-choice or write-down criteria.

Monosyllabic write-down material.--The ten 50-word CNC lists published by Peterson and Lehiste were selected as write-down material.[1] The lists were compiled by the authors for the purpose of intelligibility testing; however, these lists were employed in this study as training items. They have a simple phonemic composition and are among the most common monosyllables in spoken American English.

The sixteen subjects who used the write-down training material were required to listen as each monosyllable was presented in speech babble and to write the word they believed was spoken. The interval between items was approximately seven seconds. Subjects were instructed not to be too concerned about spelling, but to spell their responses well enough so that later scoring by the subjects would be

[1]Gordon E. Peterson and Ilse Lehiste, "Revised CNC Lists for Auditory Tests," Journal of Speech and Hearing Disorders, 27 (February, 1962), pp. 62-70.

possible. Each subject scored his own responses after each of the five practice sessions. This procedure served to encourage the subjects' active participation in the training and to give them periodic feedback regarding their performance.

One-hundred words were included in each of the five practice sessions, making a total of five-hundred stimulus items during the entire training procedure. (See Appendix F for a listing of the write-down training material).

Multiple-choice material.--Two sets of multiple-choice items were employed in this study. The first set was Larsen's discrimination drill material,[1] and the second set was selected from Kelly's manual (lists VA to VJ).[2] There were two response alternatives on the Larsen lists and three on the Kelly lists. This means that the subjects selected from either two or three possible choices, depending on which particular lists were being presented. The pairs and the triplets differed only in consonant sounds (e.g., filed, child, wild). Accuracy with this material required a high level of emphasis on consonant discrimination.

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[1]Laila Larsen, Lists published in Hearing and Deafness, ed. Hallowell Davis and S. Richard Silverman (rev. ed.; New York: Holt, Rinehart and Winston, Inc., 1963), pp. 542-44.

[2]J. C. Kelly, Clinician's Handbook for Auditory Training (Dubuque, Iowa: William C. Brown, Inc., 1953), pp. 76-113.

possible. Each subject scored his own responses after each of the five practice sessions. This procedure served to encourage the subjects' active participation in the training and to give them periodic feedback regarding their performance.

One-hundred [illegible]

practice sessions [illegible]

items [illegible]

for [illegible]

Each of the five practice sessions with the multiple-choice material included 48 words from the Kelly lists and 52 words from the Larsen lists. (See Appendix G for a listing of the multiple-choice training material). Total training consisted of 240 words from the Kelly lists and 260 words from the Larsen lists. Therefore, the sixteen subjects who used the multiple-choice material responded to the same number of words during training as the sixteen subjects who used the write-down material.

The subjects who used the multiple-choice training material scored their own responses after each practice session. Again, active participation and periodic feedback regarding performance were the primary purposes for this procedure.

Four Training Groups

Each group of eight subjects responded under one of four training conditions: Group 1--write-down material with S/N varied, Group 2--multiple-choice material with S/N varied, Group 3--write-down material with S/N constant, and Group 4--multiple-choice material with S/N constant. These specific treatment combinations were assigned randomly to the four groups.

It was believed that comparisons among mean responses of these four independent groups would answer one of the questions posed in this study. That is, do four combinations of auditory training methods and materials differ

significantly in their effects on speech discrimination performance. It was thought that the answer to this question might have direct clinical applicability, and also might be of theoretical importance.

Hearing Handicap Scale

One of the questions posed in this study concerned the possible relationship between self-ratings of social difficulty (i.e., hearing handicap) and speech discrimination performance in auditory training. It was of interest to know whether subjects who rated themselves high in degree of hearing handicap showed greater or lesser response to training than subjects who rated themselves low. Self-concept and/or degree of motivation may be different between these two types of subjects, and these possible differences might reflect themselves through responses in auditory training.

To answer the above question, a recently published scale for self-rating of degree of hearing difficulty was administered to the present subjects immediately before the auditory training procedures. The Hearing Handicap Scale was developed and described by High, Faribanks, and Glorig.[1] The final form of the Scale consists of two 20-

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[1]Wallace S. High, Grant Fairbanks, and Aram Glorig, "Scale for Self-Assessment of Hearing Handicap," Journal of Speech and Hearing Disorders, 29 (August, 1964), pp. 215-30.

item parallel forms, A and B. Form A was employed in the present study. (See Appendix D where this form is shown).

Items on the Hearing Handicap Scale refer to common auditory experiences or situations, particularly those encountered in an urban environment. It requires that subjects indicate on a 5-point scale of relative frequency how often they experience difficulty in each of the specified listening situations. Using a sample of fifty hearing-impaired men and women, the authors found an internal reliability coefficient of 0.96.[1] The response scaling is designed so that the higher the numerical value, the greater the degree of reported hearing difficulty.

Additional comments regarding the Hearing Handicap Scale and the topic of hearing handicap in general are found in Chapter III, pages 55-59.

Recording of Test and Training Materials

Three master tape-recordings were required: (a) a Discrimination Test Tape, (b) a Multiple-Choice Training Tape, and (c) a Write-Down Training Tape. The commercial disc-recording of the W-22 test was reproduced directly by the audiometer's phonograph during pre- and post-training discrimination testing. The Rhyme and Semi-Diagnostic

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[1] *Ibid.*, p. 222.

tests, however, as well as the training materials, were pre-recorded using the experimenter's voice.

Recording Procedures.--The experimenter was seated in a quiet room approximately six-inches from a high-fidelity microphone (Electro-Voice, Model 654). The speech signal transduced by this microphone was fed directly into Channel A of a dual-channel tape-recorder (Ampex, Model 602) located in an adjacent room. This recorder was situated in front of a two-way window so that the experimenter could monitor his production of a carrier phrase preceding each stimulus word. An electronics technician--located in the adjacent room with the recording apparatus--monitored the overall recording procedures. He also was responsible for monitoring the record-level of the speech babble that was being delivered simultaneously from a second tape-recorder (Ampex, Model 601) into Channel B of the master recorder. All recordings were made at 7 ½ ips using high-fidelity tape (Scotch Low Noise 203).

The carrier phrase for each stimulus word was one of the following:

"The first word is ____."

"The next word is _____."

"The last word is _____."

The experimenter attempted to maintain a 0 dB VU-meter deflection during his production of the two words underlined above. The stimulus word was produced in a natural manner without any deliberate effort to "peak" at 0 dB. Such

an effort would have distorted both the "real-life" relative intensities among stimulus words and the relative intensities of the consonant-vowel or vowel-consonant relationships within words. An assumption underlying this procedure was that the cumulative average intensity of the stimulus words and phonemes approximated 0 dB on the VU-meter. If this assumption were not valid, comments regarding specific signal-to-noise ratios--during either testing or training--would be inaccurate.

A regular time interval was maintained between carrier phrases, 5-seconds for the test words and 8-seconds for the training words. The latter interval served two purposes. First, those subjects using the write-down training material needed sufficient time to write their responses. Second, duration of training among all thirty-two subjects was not a factor of interest in this study, and thus was kept constant for all subjects, whether they wrote or circled their responses.

Discrimination Test Tape.--The Test Tape contained the following order of test stimuli, although only half of the subjects received this particular ordering:

a. No signal on track A (The W-22 test was delivered directly from the audiometer's phonograph). Six-minutes of speech babble on track B.

b. Rhyme Test 1 on track A. Speech babble on track B.

c. Semi-Diagnostic form A on track A. Speech babble on track B.

d. Rhyme Test 2 on track A.
Speech babble on track B.

e. Semi-Diagnostic form B on track A.
Speech babble on track B.

The dual-track recording procedure provided playback of either or both tracks from the audiometer's stereo-playback recorder. Intensity of each track was controlled independently by means of separate attenuators on the audiometer console. Therefore, the tests could be administered to the subjects in any desired order with average intensities and signal-to-noise ratios under experimental control. Separate VU-meters allowed direct monitoring of input-calibration throughout the testing procedures.

Training Tapes.--Two master tapes were recorded, a Multiple-Choice Training Tape and a Write-Down Training Tape. The Larsen and Kelly multiple-choice items and the CNC write-down items were pre-recorded in a manner and with equipment identical to that used for recording the discrimination tests. The speech stimulus words and the speech babble were recorded simultaneously on separate tape-tracks of the dual-channel recorder. Either tape could be played back during the training sessions with the input of either track on either tape under experimental control.

Training of Subjects

Subjects were seated in a commercial test-room (Suttle) for both discrimination testing and training. Training materials were delivered at calibrated intensity-levels

through a single sound-field speaker (Electro-Voice, Model SP12). Input to this speaker was controlled by the experimenter, who was seated at the audiometer console (Allison, Model 22) in a room adjacent to the training room. Two subjects from each group participated simultaneously in training and were seated facing toward the sound-field speaker with head-level approximately 56 inches from the speaker. The training arrangement is shown in Figure 2. Two-way communication and observation was possible during the training sessions.

Subjects participated in the following format of pre-test, training, and post-test procedures during the approximate three and one-half hour duration of the testing and training:

a. The Hearing Handicap Scale was completed by the subject.

b. Pre-training speech discrimination tests were administered.

c. After a 5-minute rest period, instructions were given regarding subsequent training sessions.

d. Five 25-minute practice sessions were given with 10-minute rest periods between sessions for feedback regarding performance. A longer rest period (20-minutes) was provided between the 3rd and 4th sessions.

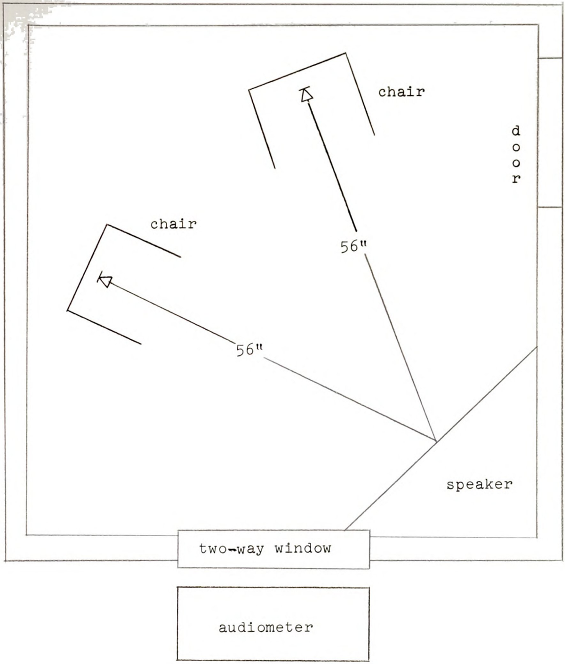

Figure 2.--Schematic representation of physical arrangements during auditory testing and training procedures.

e. Following the 5th training session, and after a final rest period and feedback condition, post-training speech discrimination tests were administered.

General instructions to subjects were as follows:

> You are going to listen to single words delivered through this loudspeaker. There also will be noise along with the words, so you must listen carefully and attempt to ignore the noise. There will be five 25-minute practice sessions during the next few hours. Your task will be the same for each session: listen to the words and write-down (circle) what you hear. Here are sheets of paper on which you are to write (circle) the words.
>
> Each session will be slightly more difficult than the previous one, so you will have to listen more closely. Do not worry if you miss some words or do not understand others. There is no penalty here for mistakes. These are practice sessions designed to give you a chance to improve your listening.
>
> After each 25-minute session, we will have a rest break and you can step into the reception area to see how well you are doing. You will check your own work as I tell and/or show you the words which were spoken. After the third session, there will be a longer rest break and you can relax and have coffee or coke.
>
> You then will complete the remaining two practice sessions, there will be a final rest break, and three tests similar to the ones you just had will be given to see how much your listening has improved. Feel free to ask questions at any time. Do you have any now?

Statistical Design

This investigation used a 2 x 2 x 3 (methods x materials x tests) analysis of variance, factorial design suggested by Winer.[1] The last factor, discrimination tests,

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[1]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Co., Inc., 1962), pp. 337-49.

had repeated observations (i.e., all subjects received all three discrimination tests). Statistical comparison among training groups involved a one-way analysis of variance. Dependent measures for all of the above statistical procedures were difference-scores between pre- and post-training speech discrimination performance. Related or paired t-tests were used to evaluate the pre- versus post-training comparisons. Descriptive statistics were employed where necessary to specify particular aspects of subject performance.

These statistical procedures provided an objective basis for answering the questions posed by this study.

Summary

Thirty-two subjects were selected for this study. Each potential subject was seen first for preliminary testing, at which time the following measures were recorded: pure tone thresholds, speech reception thresholds, speech discrimination scores in quiet (PB-Max), speech discrimination score in noise (sound-field at a 5 dB S/N), and WAIS Vocabulary raw score. On the basis of these measures, together with case history information, subjects were assigned to one of four training groups. Means, variances, medians, and ranges of recorded data were matched systematically among groups in order to support a pre-training "equivalency" assumption.

Two subjects participated simultaneously in training in a commercial sound-treated room. Practice materials were delivered to the sound-field in a variable speech babble background. Feedback regarding performance and rest breaks were provided at 25-minute intervals during the approximate three hours of training. Speech discrimination tests were administered in the sound-field pre- and post-training at a 50 dB (re audiometric zero) intensity level in a 45 dB speech babble background.

Discrimination tests included alternate forms of W-22, Rhyme, and Semi-Diagnostic tests, administered in this order, but with counter-balanced presentation of the alternate forms. The commercial disc-recording of the W-22 test was reproduced directly during pre- and post-training testing. The Rhyme and Semi-Diagnostic tests, as well as the training materials, were tape-recorded using the experimenter's voice.

Each training group of eight subjects responded under one of four auditory training conditions: Group 1--write-down material with S/N-varied, Group 2--multiple-choice material with S/N-varied, Group 3--write-down material with S/N-constant, and Group 4--multiple-choice material with S/N-constant.

Instrumentation provided for administration of discrimination tests and training materials in any desired order, and with average intensities and signal-to-noise

ratios under experimental control. The speech stimulus words and the speech babble were pre-recorded simultaneously on separate tape-tracks using a dual-channel recorder.

Primary factors of interest included discrimination changes among tests, among training groups, between methods, and between materials. An introspective report of hearing difficulty--the Hearing Handicap Scale --also was administered for evaluation in relation to obtained performance measures.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the major results obtained by the procedures described in Chapter III. Thirty-two subjects were assigned systematically to one of four groups in such a way that means, variances, ranges, and medians of extraneous variables were matched among groups. This was done in order to support an equivalency-among-groups assumption prior to the training. Somewhat greater confidence then can be given to conclusions regarding the effects of specific factors under experimental control. The results of these matching procedures are shown in Table 1, Chapter III, page 78.

The subjects participated in three and one-half hours of practice responding (write-down or multiple-choice) to stimulus words delivered to the sound-field in a variable speech babble background. Each group of eight subjects responded under one of four possible auditory training conditions. Pre- and post- training speech discrimination tests were administered in the sound-field in a speech babble background as a means of evaluating differential effects of the training procedures.

Following presentation of statistical results and associated conclusions, these results are interpreted and discussed in terms of the original questions posed in this investigation.

Obtained Performance Measures

In Table 1 is presented a summary of the mean percentage effects of the present auditory training procedures on the subjects' speech discrimination performance.

TABLE 1.--Mean percentage effects of auditory training on speech discrimination performance.

	Multiple-Choice		Write-Down	
Tests	S/N-C (Group 4)	S/N-V (Group 2)	S/N-C (Group 3)	S/N-V (Group 1)
W-22	4.0	8.7	9.3	8.8
Rhyme	2.8	6.0	2.8	2.3
Semi-Diag.	-0.5	4.8	2.3	-0.5

The dependent variable, represented by the means in Table 1, was the difference-score for each subject. It was calculated by subtracting pre-training from post-training discrimination test performance. Alternate forms of each test were used with a counter-balanced order of presentation among subjects within each group. (Pre-

training, post-training, and difference-scores for each subject on each test are given in Appendix H).

The mean percentage of discrimination change for any group on any test under any combination of auditory training methods and materials may be observed in Table 1. As can be noted, ten out of twelve indices of performance change showed positive effects; that is, subjects improved in discrimination test performance. The remaining two indices--both recorded on the Semi-Diagnostic test--showed negative effects in that subject performance decreased. It should be remembered, however, that means in each column in Table 1 are not independent (i.e., subjects in each group received all three discrimination tests). Therefore, even though slight negative effects were recorded for two groups on the Semi-Diagnostic test, these same two groups showed positive effects on both the W-22 test and the Rhyme test. The data indicate then that the auditory training procedures resulted generally in increased discrimination test performance.

Pre- vs Post-Training Performance

In Table 2 are shown the mean difference-scores on each test and on total discrimination performance. The thirty-two subjects improved 7.7% in W-22 discrimination, 3.5% in Rhyme discrimination, and 1.5% in Semi-Diagnostic discrimination, for an overall mean improvement of 4.2% in total discrimination.

Calculation of t-tests for paired observations[1] indicated that: (a) the W-22 increase was significant beyond the 0.01-level, (b) the Rhyme increase was significant beyond the 0.05-level, (c) the Semi-Diagnostic increase was non-significant at the 0.05-level, and (d) the total discrimination increase was significant beyond the 0.05-level.

TABLE 2.--Mean percentage effects of auditory training as indicated by three discrimination tests.

W-22	Rhyme Test	Semi Diagnostic	Total
7.7[a]	3.5[b]	1.5	4.2[b]

[a]Significant beyond the 0.01-level, df = 31.
[b]Significant beyond the 0.05-level, df = 31.

Assuming that test-retest carry-over effects were negligible,[2] these results indicate that the auditory training procedures brought about significant increase in speech discrimination as measured by total, by W-22, and by Rhyme test performance, but that these significant

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[1]William L. Hays, Statistics for Psychologists (New York: Holt, Rinehart and Winston, Inc., 1963), pp. 333-35.

[2]Egan's data ("Articulation Testing Methods," cited in Chapter III) suggests that listener performance on discrimination tests is relatively stable during six one-hour testing sessions on the same day; in fact, scores tended to decrease during each of the two three-hour testing segments.

effects were not similarly reflected by performance on the Semi-Diagnostic test. One possible explanation of these results is that the Semi-Diagnostic test may be a fairly stable measure of speech discrimination, and therefore resistive to the effects of auditory training, at least with a mild hearing loss population. Perhaps the W-22 and Rhyme tests are structured in such a way that they are more sensitive to discrimination changes than the Semi-Diagnostic test.

Analysis of Variance

Of primary interest in this study were the comparisons between and among levels of each of the main factors or independent variables. Therefore, two auditory training methods, two types of auditory training materials, three discrimination tests, and four groups of subjects were comparisons of interest. The statistic involved was mean change in speech discrimination performance (i.e., mean difference-score). For multiple statistical tests of means, a factorial design with associated analysis of variance procedures provided for the above comparisons.

Normality of Distribution

One of the assumptions for the fixed-effects model analysis of variance is that the distribution of errors for any treatment population is normal. According to Hays, this is equivalent to the assumption that each population

has a normal distribution of dependent scores.[1] He stated that, other things being equal, inferences made about means that are valid in the case of normal populations are also valid when the forms of the population distributions depart considerably from normal, provided that the number of subjects in each sample is relatively large.

In the present study, dependent scores were the differences between pre- and post-training discrimination test performance. For descriptive purposes, the standard deviations within each set of dependent measures are given in Table 3. As can be noted, calculated standard deviations range in size from 5.1% to 10.2%.

TABLE 3.--Standard deviations for percentage effects of auditory training on speech discrimination performance.

	Multiple-Choice		Write-Down	
Tests	S/N-C (Group 4)	S/N-V (Group 2)	S/N-C (Group 3)	S/N-V (Group 1)
W-22	8.5	7.9	5.1	6.3
Rhyme	9.5	10.2	6.1	6.9
Semi-Diag.	5.1	6.3	6.7	6.1

[1] *Ibid.*, pp. 378-79.

Distribution of raw scores within each group also was inspected. This inspection did not reveal any gross departures from normality, suggesting normal distribution of errors in the treatment populations. It was assumed, therefore, that normal distributions existed within the populations of interest, and that if departures from normality actually did exist, they were not sufficient to invalidate analysis of variance procedures.

Homogeneity of Variance

A second assumption of the present analysis of variance was that error variance among treatment populations was the same; that is, no statistically significant differences existed among these error variances. Hays stated that, other things being equal, this assumption of homogenous variances can be violated without serious risk, provided that the number of cases in each sample is the same.[1] There were equal numbers of subjects in each of the present treatment groups, supporting a homogeneity assumption. However, as a statistical test of this assumption, comparisons among error variances (estimated from sample values) were made. The estimated error variances are shown in Table 4.

Two tests were used to evaluate the homogeneity of variance hypothesis.[2] The first, Hartley's F-max test--

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[1]Ibid.

[2]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book, Co., Inc., 1962), pp. 92-96.

TABLE 4.--Estimates of error variances within treatment populations.

	Multiple-Choice		Write-Down	
Tests	S/N-C (Group 4)	S/N-V (Group 2)	S/N-C (Group 3)	S/N-V (Group 1)
W-22	83.4	70.8	29.6	45.6
Rhyme	103.9	118.9	42.2	54.2
Semi-Diag.	29.4	45.1	50.8	42.0

simply the largest variance estimate divided by the smallest--gave a value of 4.04 with a critical value of 24.0 required for rejection. The second, Cochran's C test--the largest variance estimate divided by the sum of the estimates--resulting in a value of 0.166 with a critical value of 0.31. Thus, for a 0.01-level test--number of variances equal to 12, degrees of freedom equal to 7--the hypothesis of homogeneity of variance was not rejected by either test.

Statistical Independence

The fixed-effects model also requires--according to Hays--an assumption of independence of errors among the dependent measures.[1] The present study was conducted in a manner designed to satisfy this requirement. Measures were obtained in such a way that each subjects's score was independent

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[1]Hays, op. cit.

from any other subject's score. It was noted that this assumption of independence was not necessary for the comparison of discrimination tests. Even though each subject received all three discrimination tests, the selected design was one in which the relatedness or dependency among the three tests was built into the calculation of mean square values.

F-Tests and Individual Comparisons

The present analysis of variance procedure involved a three-factor fixed-effects design with repeated measures on one of the factors.[1] The main factors were auditory training methods, auditory training materials, and discrimination tests, the latter having repeated measures on the same subjects. A summary of the results of this analysis is given in Table 5. As can be noted, the only factor

TABLE 5.--Summary of analysis of variance comparing differences between methods, between materials, and among tests.

Source of Variation	df	Mean Square	F
Between Subjects	31		
Materials(A)	1	1.04	
Methods(B)	1	63.38	
A x B	1	187.04	2.26(NS)
error (b)	28	82.9	
Within Subjects	64		
Tests (C)	2	326.0	6.86(S)*
A x C	2	48.67	
B x C	2	1.5	
A x B x C	2	8.09	
error (w)	56	47.49	

*Significant beyond the 0.01-level.

[1]Winer, *op. cit.*, pp. 337-349.

showing statistical significance was the tests factor. Levels within methods, levels within materials, and interactions were non-significant.

Auditory Training Methods.--Mean discrimination changes recorded for each of the two groups of sixteen subjects receiving either S/N-Varied or S/N-Constant methods are shown in Table 6. Mean discrimination change was 4.995% for the S/N-Varied condition and 3.415% for the S/N-Constant condition. The mean difference of 1.58% between these two auditory training methods was non-significant, as indicated by analysis of variance.

TABLE 6.--Comparative mean percentage effects of auditory training methods (signal-to-noise ratios) on speech discrimination performance.

S/N-Varied	S/N-Constant	Difference
4.995	3.415	1.58*

*Non-significant.

These two methods of training subjects apparently have similar significant effects on speech discrimination performance. This conclusion can only be generalized to the population from which present subjects were selected (i.e., adult, mildly hard of hearing individuals with the particular characteristics specified earlier).

Auditory Training Materials.--Mean discrimination changes recorded for each of the two groups of sixteen subjects using either multiple-choice (closed set) or write-down (open set) materials are shown in Table 7. Mean discrimination change was 4.285% for the multiple-choice condition and 4.125% for the write-down condition. The mean difference of 0.16% between these two types of auditory training materials was non-significant, as tested by analysis of variance.

TABLE 7.--Comparative mean percentage effects of auditory training materials (multiple-choice vs write-down response) on speech discrimination performance.

Multiple-Choice	Write-Down	Difference
4.285	4.125	0.16*

*Non-significant.

These two types of training materials seemingly have similar significant effects on speech discrimination performance. It should be remembered that this conclusion--as well as the previous one regarding methods--represents a summary statement of overall effects. Means for materials and means for methods were obtained by summing across levels of the other factor. In other words, the materials do not differ when both are used in conjunction with both methods. Similarly, the methods do not differ when both are employed with both types of material.

Speech Discrimination Tests.--The analysis of variance indicated that the W-22, Rhyme, and Semi-Diagnostic tests differed significantly (0.01-level) in reflecting the effects of auditory training. Mean percentage discrimination changes recorded for the thirty-two subjects on each test were 7.7% on the W-22 test, 3.5% on the Rhyme Test, and 1.5% on the Semi-Diagnostic test. Differences between each pair of tests are shown in Table 8. The use of a priori individual comparison procedures (k = 3, df = 56)[1] showed critical differences to be 4.14 (0.05-level) and 5.21 (0.01-level).

TABLE 8.--Percentage differences between pairs of speech discrimination tests reflecting effects of auditory training.

	W-22	Rhyme Test	Semi-Diagnostic
W-22	--	4.2[a]	6.2[b]
Rhyme	--	--	2.0

[a]Significant beyond the 0.05-level.
[b]Significant beyond the 0.01-level.

These results indicate, with reference to speech discrimination changes brought about by auditory training, that: (a) the W-22 test differs significantly from both the Rhyme test (0.05-level) and the Semi-Diagnostic test (0.01-level), and (b) the Rhyme test and the Semi-Diagnostic test do not differ significantly. Pearson correlations were calculated

[1]Winer, ibid,. p. 85

between each pair of tests and are shown in Table 9. These coefficients were 0.57 between W-22 and Rhyme, 0.01 between W-22 and Semi-Diagnostic, and 0.02 between Rhyme and Semi-Diagnostic tests. These indicate that some linear prediction between W-22 and Rhyme test performance is possible when describing the changes that occur in auditory training with a mild hearing loss population. This prediction is not perfect and considerable error exists. Linear predictive power between the Semi-Diagnostic test and either of the other two tests was not demonstrated in this study

TABLE 9.--Pearson product-moment correlations between pairs of speech discrimination tests reflecting effects of auditory training.

	W-22	Rhyme Test	Semi-Diagnostic
W-22	--	0.57	0.01
Rhyme	--	--	0.02

It should be remembered that statistical comparisons (pages 101-103) of pre- versus post-training performance indicated significant positive change in both W-22 and Rhyme test discrimination, and non-significant change in Semi-Diagnostic performance.

Training Groups.--A comparison of interest was the differential effects among four training groups of combinations of methods and materials on speech discrimination. Mean percentage change for each group of eight subjects is shown in Table 10.

TABLE 10.--Comparative mean percentage effects of four combinations of auditory training methods and materials on speech discrimination performance.

	S/N-Varied	S/N-Constant
Multiple-Choice	6.5 (Group 2)	2.08 (Group 4)
Write-Down	3.5 (Group 1)	4.75 (Group 3)

Specific mean values were as follows: (a) multiple-choice and S/N-Varied: 6.5%, (b) multiple-choice and S/N-Constant: 2.08%, (c) write-down and S/N-Varied: 3.5%, and (d) write-down and S/N-Constant: 4.75%. A one-way analysis of variance[1] showed that the four means differed significantly beyond the 0.05-level. A summary of the analysis is given in Table 11.

TABLE 11.--Summary of analysis of variance comparing differences among training groups.

Source of Variation	df	Mean Square	F
Between Subjects	3	84.5	3.89(S)*
Within Subjects	28	21.70	
Total	31		

*Significant beyond the 0.05-level.

[1] _Ibid._, pp. 48-56.

Differences between each pair of training combinations are shown in Table 12. The use of a priori individual comparison procedures (k = 4, df = 28)[1] showed a critical difference to be a 2.74 at the 0.05-level. The difference of 2.67 between Group 3 and Group 4, although non-significant by strict statistical definition, was given a liberal interpretation in this study.

TABLE 12.--Percentage differences between pairs of treatment means.

	Group 2	Group 3	Group 1	Group 4
Group 2	--	1.75	3.0[a]	4.42[a]
Group 3	--	--	1.25	2.67[b]
Group 1	--	--	--	1.42

[a]Significant beyond the 0.05-level.
[b]Significant near the 0.05-level.

The information in Table 12 may be summarized schematically as follows:

Group 2	Group 3	Group 1	Group 4
6.5	4.75	3.5	2.08

Those group means underlined by a common line did not differ significantly from each other; group means not underlined by a common line did differ from each other (beyond or near the 0.05-level).

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[1]*Ibid.*, p. 85.

These results suggest the following rank-ordering of the combinations of auditory training methods and materials:

(a) Multiple-Choice, S/N-Varied (gain: 6.5%)

(b) Write-Down, S/N-Constant (gain: 4.75%)

(c) Write-Down, S/N-Varied (gain: 3.5%)

(d) Multiple-Choice, S/N-Constant (gain: 2.08%)

Since (a) and (b), (b) and (c), and (c) and (d) do not differ significantly, it seems as though the combination (a) (b) would be the auditory training procedures of choice, with somewhat greater emphasis given to (a). If multiple-choice items are used in training, the S/N-Varied method should be the method of choice. If write-down items are used, either S/N-Constant or S/N-Varied methods apparently can be employed for similar training results. These conclusions may only be applicable to the mildly hard of hearing population from which present subjects were selected.

Descriptive Statistics

In addition to the inferential statistics employed in previous comparisons, several descriptive statistics were calculated. This was done in an effort to gain additional information regarding factors that might have influenced present results, and that may be important to future clinical activity and research in auditory training. Type of training, the Hearing Handicap Scale, age, speech reception threshold, and intelligence are discussed in the following sections.

Type of Training vs Type of Test Response

A trend was noted in subject performance on the three types of tests. Those subjects trained on closed set (multiple-choice) materials improved more on the closed set test, the Semi-Diagnostic, than on the open set test, the W-22. The opposite tendency was noted for those subjects trained on open set (write-down) materials. This overall trend is more clearly shown as follows:

	Subjects Trained with Closed Set (n=16)	Subjects Trained with Open Set (n=16)
W-22	6.37%	9.0
Rhyme	4.37	2.5
Semi-Diag.	2.25	0.87

On the open set test (W-22), subjects trained with open set materials (write-down) showed 9.0% improvement while subjects trained with closed set materials (multiple-choice) showed only 6.37% improvement. Conversely, on the closed set test (Semi-Diagnostic), subjects trained with closed set materials showed 2.25% increase in comparison to only 0.87% for those subjects trained with open set material. These results support the hypothesis that subjects should receive training similar to the type of performance expected of them either on criterion tests or in criterion situations. It was noted that performance on the Rhyme Test seemingly is enhanced more by closed set training than by open set training, at least with the present subjects.

The Hearing Handicap Scale

Subjects rated themselves on degree of handicap experienced in everyday listening situations. On the Hearing Handicap Scale the higher the numberical score, the greater the degree of reported difficulty. (See Appendix D for a copy of the scale and Appendix H for raw scores). On the basis of these ratings, subjects were viewed arbitrarily in three categories: (a) eleven with "high handicap" ratings, (b) ten with "middle handicap" ratings, and (c) eleven with "low handicap" ratings. Mean ratings were 68, 58, and 43, respectively. Percentage improvement, discrimination in noise, and speech reception threshold for these three groups were as follows:

	High	Middle	Low
% Improvement	3.8	4.5	4.3
Discrim./Noise (%)	66.0	73.0	69.0
SRT (dB)	26	18	22

As can be noted above, there were no obvious trends among groups with respect to these particular performance measures. Comparing the high and low groups, however, those subjects rating themselves high in handicap showed slightly less improvement than those rating themselves low. The high handicap group had a lower discrimination in noise score than the low handicap group. Speech reception thresholds also were greater (i.e. worse) for the high than for the low handicap group. It appears then that Hearing

Handicap Scale ratings had some correspondence to objective measures (DS/Noise and SRT) with the present mild hearing loss population.

Spearman rank-order correlations between Hearing Handicap Scale (HHS) ratings and discrimination in noise (-0.18), and between HHS and SRT (0.02), suggested that predictive power is negligible with this population. Similarly, an obtained product-moment correlation of -0.02 between PB-Max and per cent improvement suggests that a linear prediction between these two measures is not possible. Since the present subjects were relatively homogeneous with respect to range of hearing loss, these are descriptive statements. Correlations might be higher with a more extensive range in degree of hearing loss than represented by subjects in this study.

The Hearing Handicap Scale seems to have potential value as one means of complementing objective performance measures. Continued evaluation of its relevance to aural rehabilitation in general and auditory training in particular appears to be a worthwhile research and clinical endeavor. Validity of objective measures might be determined by these studies.

Age

An additional observation was that the older subjects showed more discrimination improvement than the younger ones. Those fifteen subjects having a mean age of 54 years in-

creased 5.73% while those fifteen subjects with a mean age of 34 years improved 2.3%. This trend was more noticeable when the thirty-two subjects were viewed in three groups on the basis of age. That is, ten subjects with a mean age of 56 years showed 7.2% increase, twelve subjects with a mean age of 45 years showed a 4.1% increase, and ten subjects with a mean age of 31 years showed only 1.3% increase.

One possible explanation of this trend is that as age increases, subjects with mild hearing loss may not function near their optimum on pre-training tests, and therefore have more room for improvement as a result of training. Listening habits may decrease in effectiveness as a function of age and/or duration of hearing loss. In any event, present results suggest some optimism for those older subjects enrolled in auditory training. Subsequent research might investigate the specific effects of age on response to different training procedures. It may be found that some procedures are most appropriate for older subjects, while other methods and materials are most effective for younger ones.

Speech Reception Threshold

The trend with respect to SRT and per cent improvement in discrimination was for subjects hearing test and training materials at a loud level to show more improvement than subjects responding to a low level. Since the testing and

training conditions, involved sound-field intensity levels around 50 dB (re audiometric zero), those subjects with a slight speech reception loss heard the signals some 30-40 dB above their SRTs. Subjects with greater speech reception losses, however, responded to the signals only 15-25 dB above their SRTs.

Those nine subjects with 5-15 dB SRTs improved 5.18% in discrimination, those twelve subjects with 20-25 dB SRTs improved 4.83%, and those eleven subjects with 30-35 dB SRTs improved 2.66%. This trend suggests that initial gains from auditory training increased as a function of sensation levels at which testing and training materials were presented. Subjects seemingly should receive training that is related to what has been assumed here to be a realistic and practical criterion--the loudness of average conversational speech in a noise background.

All of the present subjects were trained without hearing-aids. In a clinic, persons with 30-35 dB SRTs probably would receive most of their auditory training while using a hearing aid. Therefore, the criterion average loudness level is still a feasible training condition since a hearing aid would increase the effective sensation level to a point where these individuals could show discrimination improvement similar to that recorded for the present 5-15 dB SRT group.

WAIS Vocabulary

The range of possible scores on the WAIS Vocabulary sub-test was 0-80 points. Arbitrarily viewed, the top sixteen subjects (with a mean score of 60 points) improved 5.83% in discrimination while those sixteen subjects scoring lowest (with a mean score of 38 points) improved 2.58%. In addition, the ten subjects scoring highest showed 6.86% improvement while the ten subjects scoring lowest improved 2.13%. The trend was for intelligence (as estimated by the WAIS sub-test) to be a relevant factor in auditory training research. However, the relationship within the present population did not provide substantial linear prediction of individual performance in auditory training. A product-moment correlation of 0.21 was obtained between WAIS Vocabulary performance and per cent discrimination improvement. Use of a larger sample than employed in this study and administration of the entire WAIS might show a more adequate relationship for predicting response to auditory training. Research in auditory training should take into account intelligence as a possible factor influencing results. Present training groups were matched (means, variances, and ranges) with respect to intelligence as estimated by the Vocabulary sub-test of the WAIS. This procedure was assumed to be satisfactory for a training group size of eight subjects.

Discussion

Several questions were posed at the outset of this study regarding the effects of auditory training on the speech discrimination performance of a population of mildly hard of hearing individuals. These questions are re-stated in the following sections, with an effort made to answer them in terms of the present results.

One of the preliminary questions asked was whether auditory training results in significant changes in speech discrimination. Research was cited in Chapter III that suggested an affirmative answer to this question. However, there did not appear to be specific research that exercised control of extraneous variables and used a sufficient number of subjects.

Ten out of twelve measures of discrimination change showed positive increase following auditory training. This increase was significant on total, W-22, and Rhyme Test performance, but non-significant on the Semi-Diagnostic test, although in the positive direction. It appears that auditory training results in generally significant positive effects on speech discrimination with a mild hearing loss population.

It is interesting to speculate on what further effects might be observed in a longer-term training program. If effects are positive following a concentrated three and one-half hour program, could these effects be enhanced even further by additional training? On the basis of usual learning curves, one could expect that performance would continue

to increase to a plateau level. This assumes that sufficient motivation is maintained, and that any interference effects are overcome by positive gains. The location of the plateau for hard of hearing subjects remains to be determined. Individual variation around this plateau is of clinical and research interest. Since auditory training seeks to assist individuals to make "maximum use of residual hearing," the objective specification of performance plateaus seems to have practical and theoretical importance. Training goals and information regarding auditory capacity are potential benefits to be derived from further speculation and research on this aspect of auditory training.

A second question asked whether the W-22, Rhyme, and Semi-Diagnostic tests differed in reflecting the effects of auditory training with the present population. It was found that the W-22 changes differed significantly from those revealed by either the Rhyme or the Semi-Diagnostic, and that the latter tests did not differ significantly in changes. A product-moment correlation of 0.57 between W-22 and Rhyme tests indicates that some slight linear prediction between these two tests is possible with regard to discrimination gains in auditory training. One instead of both tests might be used as a criterion measure of auditory training progress.

The question of which test(s) to use in evaluating auditory training was not an easy one to answer, especially

since a mild hearing loss population was studied here. The answer undoubtedly depends on the tester's purpose. If he wishes to measure progress in responding to open set stimuli, the W-22 test seems best. If he wishes to measure progress in responses to closed set stimuli, the Semi-Diagnostic test might be suitable, although initial gains with the present population probably would be minimally reflected by this test. The Rhyme Test might be a better choice. It not only reflects the significant effects of auditory training but seems to be a closed set indice (p. 115), and also stresses consonant discrimination. The latter emphasis appears to be a valuable contribution of the Rhyme Test to discrimination testing with a mild hearing loss population. Subjects in this population usually do not experience much difficulty discriminating vowels. Their problem manifests itself by impaired consonant discrimination, and it is this type of discrimination training (and testing) that should be emphasized in auditory training.

It is noted that present conclusions regarding discrimination tests apply only to the signal-to-noise testing conditions employed in this study. An S/N of 5 dB appears satisfactory as a means of sensitizing the W-22 and Rhyme tests. A different S/N--perhaps 0 dB--might have altered present results with the Semi-Diagnostic test. The closed set, four-choice response form of this test perhaps was too easy for present subjects, reducing the net gain to be expected on a pre- vs post-training test basis. A number of

the test items require only vowel discrimination that, as indicated earlier, does not present much of a task for a mild hearing loss population. It is suggested that this test might be better sensitized by either decreasing the S/N ratio or scoring only those items that emphasize consonant discrimination.

This entire problem of discrimination testing in auditory training remains to be solved. Do significant changes in test performance also indicate significant changes in everyday speech discrimination performance? The question now is finding how much change in test performance is needed before concomitant changes in everyday listening are observed by the subject, his associates, and the clinical audiologist. The question is not whether auditory training helps but rather how much it helps and what its limitations are in reducing communication breakdown. From research and clinical viewpoints, continued evaluation on a large scale of the tests used to evaluate auditory training seems mandatory.

A third question concerned the differential effects of manipulating signal-to-noise ratios during auditory training. A comparison of S/N-varied versus S/N-constant showed non-significant differences between these training methods. This finding suggests that either method can be used for similar results. Present subjects were both tested and trained with a speech babble noise background. One wonders what could be expected if subjects were trained

with speech babble and then tested with some other noise background (e.g., music, traffic, and the like) or vice versa. What transfer of training effects might be expected? How does an audiologist duplicate complex and variable listening conditions for training purposes?

Subjects seemingly should be trained in conditions highly similar to those that exist when the results of training are to be applied. This suggests that a factory worker should be trained with a tape-recorded background of unique machinery noises, an office worker with a background of typewriter noises, and so forth. It would be desirable to have one, two, or three standard noise backgrounds suitable for a wide range of application. Perhaps listening with noise, filtered speech, variation in talker-types, and/or variation in materials might be shown eventually to enhance general discrimination performance. In any event, speech babble appears to have value as one means of partially duplicating the type of situation in which subjects with mild hearing loss report their most significant hearing difficulty.

A fourth question was posed regarding the effects of one type of training material versus another type. This study failed to demonstrate a significant difference between effects of open set (write-down) and effects of closed set (multiple-choice) materials. Either type of stimulus-response training apparently can be used effectively

in auditory training. It was observed that subjects trained with open set materials performed better on the open set test (W-22) than on the closed set test (Semi-Diagnostic). The opposite result also was observed: subjects trained with closed set materials improved more on the closed set test than on the open set test. Subjects trained on specific skills logically should perform better on tests that demand these types of skills. This is consistent with other research in learning, and with the suggestion that subjects should be trained in conditions similar to those that exist when the results of training are to be applied.

An initial preference for closed set (multiple-choice) materials is suggested, since most listening situations (i.e., listening to sentences) involve contextual, closed set types of listening skills. However, this preference is not too logical when one remembers that all words in sentences are not bound by contextual or closed set limits. Proper nouns and less familiar words in a language, for example, are not easily identified by context and do not obey closed set rules enough to be of direct assistance to the hard of hearing listener. A certain level of open set speech discrimination is required before sentence discrimination is possible. For these reasons then, auditory training should not be limited to closed set, multiple-

choice items, but also should include open set items. This topic is discussed further in the following paragraphs.

A fifth question was asked concerning the effects of specific combinations of methods and materials on speech discrimination. Discussion thus far has considered methods and materials separately. Now, attention is drawn to the combined effects of these two variables. A fairly definite rank-ordering of the four combinations was observed:

(a) Multiple-Choice, S/N-Varied

(b) Write-Down, S/N-Constant

(c) Write-Down, S/N-Varied

(d) Multiple-Choice, S/N-Constant

The above (a) through (d) ordering represents a descending order of combination effectiveness. The most obvious and significant characteristic of these findings concerns the two extreme combinations. Multiple-choice materials were used with both; the only apparent factor distinguishing these combinations was the S/N method employed. Subjects making the most improvement participated in training under a S/N-Varied listening condition, while those making least improvement participated with S/N-Constant.

Theoretical explanation of these findings is limited. Perhaps the discrimination required for multiple-choice items in the S/N-Constant condition is so simple that demands are minimal and subjects do not expend the effort required to learn sufficiently from the training. Perhaps

an optimum listening condition (i.e., training condition) exists when multiple-choice items are used with S/N-Varied so that the task is not too difficult and yet not too simple. Replication of this particular feature of the present study might provide additional information of both theoretical and practical importance. Additional research is needed to determine if these findings are fortuitous (i.e., peculiar to the specific conditions of this study) or more general and basic to speech discrimination performance in auditory training.

Clinical application of these results is as follows. If multiple-choice items are used in training, the S/N-Varied method seemingly should be employed for most substantial gains. If write-down, open set materials are used, the S/N-Constant method could be slightly more beneficial than the S/N-Varied method, although either combination gives similar initial results. These suggestions might only be applicable to a mild hearing loss population.

Ideally, until additional information is obtained, clinicians perhaps would be functioning best if they used both (a) multiple-choice materials with S/N-varied and (b) write-down materials with S/N-constant. These combinations did not differ significantly but their combined effects possibly are better than any other two of the procedures. These suggestions are consistent with the earlier suggestion that training should include both closed set and open set material.

The sixth and last primary question of this study involved Hearing Handicap Scale self-ratings. The subjects reported substantial hearing difficulty. This supports one of the basic premises of this study that a "mild" hearing loss population does not always experience "mild" hearing difficulty. The mild measurable loss does not indicate categorically mild effects.

Some correspondence between objective measures and Hearing Handicap Scale ratings was found in this study. Subjects rating themselves high in handicap (relative to other subjects) had a lower discrimination-in-noise score than subjects rating themselves low. Similarly, speech reception thresholds, on the average, showed greater loss of sensitivity for the high than for the low handicap subjects. Predictive power, however, between ratings and both discrimination-in-noise and SRT was low for the present subjects. Correlations might be higher with a less homogeneous hearing loss population.

Those subjects rating themselves high in handicap showed slightly less discrimination improvement than those subjects rating themselves low. Self-concept perhaps could influence progress in auditory training, although this question was not answered in the present investigation. In this same context, PB-Max scores did not provide linear prediction of response to auditory training. In any event, continued evaluation of the Hearing Handicap Scale--as one means of correlating measured performance with everyday listening performance--

seems to be a potentially important means of increasing the validity of discrimination tests. In addition to self-reports of hearing difficulty, ratings by family and associates may provide information of importance in evaluating the effectiveness of auditory training.

Supplementary observations suggested that age, speech reception threshold, and intelligence are factors to be controlled in auditory training research. An unexpected trend with the present subjects was for older individuals to show greater gains from auditory training than the younger ones. A second trend was for responses to auditory training to improve as the sensation level of test and training materials increased. The third trend was for training response to improve as intelligence (estimated by WAIS Vocabulary scores) increased. The specific effects of these factors on auditory training remain topics for future research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The basic purpose of this research was to evaluate experimentally the effects of auditory training on speech discrimination performance of adults who have mild, sensori-neural hearing loss. Questions were posed concerning the relative discrimination changes resulting from specific auditory training methods and materials, as reflected by three published speech discrimination tests. Self-reports of hearing difficulty--indicated by Hearing Handicap Scale ratings--also were obtained for evaluation in relation to speech discrimination performance in auditory training.

Summary

Thirty-two subjects were selected for this study. The subjects had been seen for audiological testing on previous occasions. Each potential subject was seen for re-testing, at which time the following measures were recorded: pure tone air conduction thresholds, speech discrimination in quiet (PB-Max), speech discrimination in speech babble (sound-field at 5 dB S/N), and WAIS (Wechsler Adult Intelligence Scale) Vocabulary score.

On the basis of the above test data, together with case history information, subjects were assigned systematically to one of four training groups. To support an equivalency-among-groups assumption, groups were matched (means, variances, medians, and ranges) on recorded measures.

Each training group of eight subjects responded under one of four auditory training conditions: Group 1--write-down material with S/N-varied, Group 2--multiple-choice material with S/N-varied, Group 3--write-down material with S/N-constant, and Group 4--multiple-choice material with S/N-constant.

Two subjects participated simultaneously in a commercial sound-treated room. Practice materials, in a variable speech babble background, were delivered to the sound-field at calibrated intensities. Feedback regarding performance and rest breaks were provided at 25-minute intervals during the approximate three hours of training. Speech discrimination tests (W-22, Rhyme, and Semi-Diagnostic) were administered in the sound-field pre- and post-training at a 50 dB (re audiometric zero) intensity level in a 45 dB speech babble background.

Results indicated that the auditory training procedures resulted in significant increase in speech discrimination performance as measured by total, W-22, and Rhyme tests, but that these effects were not reflected by the Semi-Diagnostic test. Analysis of variance indicated that: (a) discrimination changes differed significantly among the three tests, (b)

On the basis of the above [illegible] case history information, subjects were assigned [illegible] to one of four treatment groups [illegible] equivalency among groups [illegible]

[illegible] Each [illegible]

one of the [illegible]

discrimination changes differed significantly among the four training groups, (c) discrimination changes did not differ significantly between S/N-Varied and S/N-Constant methods, and (d) discrimination changes did not differ significantly between Multiple-Choice (closed set) and Write-Down (open set) materials.

The use of a priori individual comparison procedures indicated that W-22 discrimination changes differed significantly from both Rhyme Test and Semi-Diagnostic changes, and that the latter tests did not differ significantly in discrimination changes. Similar critical-difference procedures indicated the following rank-ordering of training combinations: (1) Multiple-Choice with S/N-Varied, (2) Write-Down with S/N Constant, (3) Write-Down with S/N-Varied, and (4) Multiple-Choice with S/N-Constant. Differences were not significant between (1) and (2), between (2) and (3), or between (3) and (4).

Descriptive statistics with Hearing Handicap Scale self-ratings indicated that subjects rating themselves high in handicap showed slightly less discrimination improvement than those subjects rating themselves low. It also was observed that the high handicap group had a slightly lower discrimination-in-noise score than the low handicap group. In addition, speech reception thresholds showed slightly greater loss of sensitivity for the high than for the low handicap group.

Several trends were noted in the data. Those subjects trained on closed set (multiple-choice) materials improved more on the closed set test (Semi-Diagnostic) than on the open set test (W-22). Similarly, subjects trained on open set (write-down) materials improved more on the open set test than on the closed set test. Performance on the Rhyme Test seemingly was enhanced more by closed set than by open set training. Additional trends were for (a) older subjects to show greater discrimination changes than younger subjects, (b) discrimination changes to improve as sensation levels of test and training materials increased, and (c) discrimination changes to improve as intelligence (estimated by WAIS Vocabulary scores) increased.

Conclusions

Within the limits imposed by the present selection, testing, and training procedures, and by the use of adult subjects with mild hearing loss, the following conclusions seem warranted:

1. That short-term auditory training results in generally significant positive effects on speech discrimination performance. Stability of discrimination-gains remains to be determined.

2. That these effects, following a concentrated three-hour training program, are reflected by significant changes in total, W-22, and Rhyme Test discrimination, but not by the positive changes in Semi-Diagnostic test performance.

3. That W-22 discrimination changes differ significantly from changes revealed by either the Rhyme or the Semi-Diagnostic tests. Changes on the latter tests do not differ significantly.

4. That some linear prediction between W-22 and Rhyme Test discrimination changes is possible, though this prediction is not perfect and considerable error exists. Linear predictive power between Semi-Diagnostic changes and changes on either W-22 or Rhyme Test was not demonstrated.

5. That S/N-Varied and S/N-Constant training methods do not differ in effects on speech discrimination performance. If a difference does exist, it was not demonstrated in this study.

6. That Open Set (write-down) and Closed Set (multiple-choice) training materials do not differ in effects on speech discrimination performance. If a difference exists, it was not shown in this study.

7. That discrimination changes differ significantly among four combinations of auditory training methods and materials. If multiple-choice, closed set materials are employed in training, the S/N-Varied method seemingly should be the method of choice. If write-down, open set materials are utilized in training, either S/N-Constant or S/N-Varied methods apparently can be employed for similar results, i.e., if a difference between these alternatives exists, it was not demonstrated in this study.

8. That some general correspondence exists between objective performance measures and Hearing Handicap Scale self-ratings of degree of hearing difficulty. The exact specification of these relationships remains to be determined. Subjects tend to make similar progress in auditory training irrespective of the degree of reported difficulty.

9. That age, speech reception threshold, and intelligence appear to be potentially significant factors in the conduct of research in auditory training and seemingly should be experimentally controlled when other factors or effects are being investigated. If these and other extraneous variables had not been controlled in this study, the above conclusions would be weakened substantially.

Recommendations for Further Research

The long-term effects of auditory training should be studied. This, however, represents a major undertaking because of difficulties regarding measurement criteria. Measurement problems perhaps could be clarified through research in auditory training where speech discrimination performance can be observed over a period of hours, days, weeks, and months. Subject variation under a variety of listening conditions could be evaluated periodically and related to reports by the subjects and their associates.

The area of self-reports and rating scales for the most part has been ignored, presumably because of reliability problems. However, this type of research is needed before the validity of speech discrimination tests

can be established. Future research in auditory training should not just study tests or just evaluate rating scales. The two types of measures need to be studied concurrently with as much time and effort spent evaluating the ratings as is spent in the selection and administration of discrimination tests.

Discrimination tests are numerous with many combinations possible. Acoustical instrumentation is at a high level of sophistication. The diagnosis of peripheral and central auditory lesions has received and is receiving extensive study in a number of laboratories. But where are the audiological rating scales, the listening tests and scales, the reports of hearing performance at work and in social situations, and the like? How many laboratories and clinics are actively and consistently engaged in this research and publishing their findings? The development of the Hearing Handicap Scale represents one of the few major efforts in this direction. It and similar scales need evaluation and refinement on a large-scale basis. Psychometrics, research design, and statistical analyses have enough sophistication to make these investigations both feasible and worthwhile.

The thesis of this discussion then is to recommend the following:

1. Research in auditory training should be conducted on as high and extensive a level as possible, and not independent from other interest areas in audiology. Both basic

and applied research with persons enrolled in auditory training can enhance audiology's rehabilitation function and provide a framework in which to advance knowledge regarding impaired auditory performance.

2. Self-reports and rating scales, selective listening, hearing aid characteristics, anxiety and auditory behavior, sensory facilitation between audition and vision, monaural and stereophonic effects in training, and so forth are a few of the directions for auditory training research with both adults and children.

3. The present results need to be substantiated by independent researchers. For comparative purposes, other hearing loss populations should be studied, employing similar and dissimilar tests and procedures. The effects of training on speech discrimination at other than the present average-loudness levels need investigation. Training with materials delivered via ear-receivers and/or transduced by hearing aids also might be studied for effects on speech discrimination.

4. Since auditory training has as its major goal the development of maximum use of residual hearing, long-term studies should be conducted to determine plateaus in speech discrimination performance. Age, sensation levels of training materials, and intelligence are factors that need study in relation to performance in auditory training.

5. The Rhyme and Semi-Diagnostic tests, and/or similar tests, might be modified so that separate forms are available for evaluating vowel, consonant, voiced consonant, and unvoiced consonant discrimination.

6. The "sentence" as a unit for testing and training has value for further research, i.e., the study of closed and open set monitoring performance in auditory training.

7. Variation in talker-types (e.g., dialectal variants, rate of speaking, talker intelligibility, foreign accent, and the like) could be studied for relevance to auditory training.

8. Programmed instruction seems to offer a number of possibilities for evaluating the effects of various types of training procedures. Tape-libraries, emphasizing acoustical and linguistic variations, might be developed and studied for potential use in self-instruction and home-training.

In essence, auditory training represents an area of study where the profession of audiology is uniquely qualified and responsible. The exercise of these qualifications and responsibilities remains a challenge for future researchers.

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APPENDIX A

LETTER SENT

TO

PROSPECTIVE SUBJECTS

MICHIGAN STATE UNIVERSITY East Lansing

College of Communication Arts · Department of Speech

This letter is to describe an Auditory Training Research Program to be conducted soon at the Speech and Hearing Clinic, Michigan State University. We are very eager to have you take part in this program.

Auditory training, basically, is a set of procedures that gives a person with a hearing loss the chance to make better use of his hearing through practice. This practice includes listening to speech in a variety of situations so that the person improves in the ease and ability with which he is able to understand speech in these types of situations. Most people with mild, moderate, and even severe hearing loss can benefit from this training. The amount of improvement depends on the type and degree of hearing loss, the age, motivation, and listening ability of the person, the amount of practice, and so forth.

If you would like to take part in this program, the following is required. First, your hearing must be retested before the training. This testing, to be done sometime during the next few weeks, will take about one hour and will be scheduled at your convenience. Second, you must be able to attend a one-half day training program. At this time, the training sessions are being planned for the month of April.

You will be contacted by phone within the next week to answer any questions you might have and to find out if you will join us for what we believe will be an enjoyable experience for you. There will be no charge to you for either the testing or the training. In addition, the results of this research will be used to increase our ability to help people, like yourself, who have a hearing loss.

Sincerely,

Daniel L. Bode, U.S. Office
of Education Fellow

Herbert J. Oyer, Ph.D., Director
Speech and Hearing Clinics

APPENDIX B

RESULTS OF MONAURAL PURE TONE AND
SPEECH AUDIOMETRY

GROUP 1

Subject	Ear	500 cps	1000	2000	3000	4000	SRT	PB-Max
1	R	0dB	15	50	75	80	5dB	72%@40dB
	L	5	15	50	70	60	10	84%@45dB
2	R	15	25	35	40	30	20	96%@55dB
	L	20	25	35	35	25	20	92%@55dB
3	R	25	55	50	50	45	50	60%@85dB
	L	25	40	40	45	40	35	76%@70dB
4	R	35	25	20	35	30	20	92%@55dB
	L	45	45	45	55	45	40	92%@75dB
5	R	35	65	60	55	50	35	76%@70dB
	L	20	65	55	60	50	35	80%@70dB
6	R	15	35	55	75	65	25	68%@60dB
	L	5	50	45	60	55	35	88%@70dB
7	R	25	25	60	75	65	15	76%@50dB
	L	40	35	65	70	65	40	85%@75dB
8	R	25	35	70	75	60	25	48%@60dB
	L	30	45	75	80	60	35	28%@70dB

GROUP 2

Subject	Ear	500 cps	1000	2000	3000	4000	SRT	PB-Max
9	R	40	35	45	65	60	25	64%@60dB
	L	45	35	60	65	70	35	44%@70dB
10	R	15	40	65	75	65	25	60%@60dB
	L	10	55	65	75	70	35	64%@70dB
11	R	40	45	55	60	60	45	64%@80dB
	L	10	35	65	65	70	30	68%@65dB
12	R	15	20	55	65	55	20	68%@55dB
	L	5	5	50	55	60	15	60%@50dB
13	R	55	40	45	30	20	40	72%@75dB
	L	45	40	30	30	15	35	76%@70dB
14	R	40	10	20	35	40	20	52%@55dB
	L	15	5	20	30	30	20	52%@55dB
15	R	40	50	55	55	55	40	80%@75dB
	L	35	40	45	60	55	35	88%@70dB
16	R	0	0	5	60	65	5	96%@40dB
	L	70	70	85	75	70	-	--------*

*No response at maximum output of the audiometer.

GROUP 3

Subject	Ear	500 cps	1000	2000	3000	4000	SRT	PB-Max
17	R	30dB	25	20	15	25	25dB	96%@60dB
	L	40	40	35	45	40	40	88%@75dB
18	R	40	65	65	60	55	45	40%@80dB
	L	30	70	65	65	55	40	56%@75dB
19	R	20	35	50	65	70	25	76%@60dB
	L	25	45	50	55	55	25	64%@60dB
20	R	5	15	55	80	80	10	52%@45dB
	L	5	20	70	85	80	20	44%@55dB
21	R	15	40	85	95	95	35	40%@70dB
	L	5	40	70	80	85	35	48%@70dB
22	R	20	35	35	55	55	30	72%@65dB
	L	20	50	50	55	55	35	88%@70dB
23	R	0	10	50	60	55	5	88%@40dB
	L	0	5	45	65	75	5	80%@40dB
24	R	30	30	60	50	45	30	80%@65dB
	L	85	90	85	-	-	-	--------*

*No response at maximum output of the audiometer.

GROUP 4

Subject	Ear	500 cps	1000	2000	3000	4000	SRT	PB-Max
25	R	55	55	60	55	60	55	92%@80dB
	L	50	35	30	40	35	25	92%@60dB
26	R	30	40	85	95	100	35	56%@70dB
	L	35	40	55	55	50	30	80%@65dB
27	R	15	55	50	55	60	35	84%@70dB
	L	10	55	65	65	60	30	76%@65dB
28	R	50	35	40	60	65	40	76%@75dB
	L	25	20	25	50	45	15	84%@50dB
29	R	30	5	85	100	105	10	52%@45dB
	L	30	20	95	100	-	35	20%@70dB
30	R	30	45	60	70	70	35	60%@70dB
	L	20	55	70	70	70	20	44%@55dB
31	R	40	50	45	30	20	35	84%@70dB
	L	45	45	65	80	75	55	60%@90dB
32	R	5	0	0	30	50	5	98%@40dB
	L	0	5	10	45	65	10	96%@45dB

APPENDIX C

CRITERION DATA EMPLOYED TO ASSIGN SUBJECTS TO FOUR TRAINING GROUPS

GROUP 1

Subject	DS/Noise* (%)	SRT* (dB)	WAIS Vocab. (raw score)	PB-Max* (%)	Age (years)	Educ. (years)	Male	Female	Hearing Aid
1	52	5	69	68	54	16	x		No
2	56	15	53	88	50	12		x	No
3	48	35	28	80	49	12		x	No
4	86	20	48	96	28	15	x		No
5	36	30	72	84	31	20	x		No
6	38	20	48	60	40	12	x		No
7	42	15	38	84	53	9	x		Yes
8	28	30	47	52	42	12	x		Yes
GROUP 2									
9	48	25	49	88	55	12	x		Yes
10	34	25	44	72	49	12	x		No
11	18	25	46	64	57	8	x		No
12	58	5	60	84	45	18	x		No
13	62	35	59	88	45	12		x	Yes
14	38	20	72	64	60	20	x		No
15	44	35	41	92	36	10	x		Yes
16	70	5	26	94	21	13	x		No

*DS/Noise, SRT, and PB-Max are sound-field measurements.

GROUP 3

Subject	DS/Noise* (%)	SRT* (dB)	WAIS Vocab. (raw score)	PB-Max* (%)	Age (years)	Educ. (years)	Male	Female	Hearing Aid
17	76	25	64	98	30	19	x		No
18	24	35	37	68	26	13		x	No
19	52	25	37	80	39	8	x		No
20	28	10	67	48	60	12	x		No
21	28	30	48	64	32	16	x		No
22	36	25	54	76	46	12	x		Yes
23	54	5	55	88	58	16	x		Yes
24	66	30	18	80	55	10	x		No
				GROUP 4					
25	36	25	32	84	38	12	x		Yes
26	68	30	41	88	36	12	x		Yes
27	40	30	67	82	55	20	x		No
28	60	15	46	88	54	12		x	No
29	16	20	52	52	39	11	x		No
30	28	20	57	60	54	12	x		No
31	62	35	31	88	35	12		x	No
32	72	5	66	96	43	20	x		No

*DS/Noise, SRT, and PB-Max are sound-field measurements.

APPENDIX D

HEARING HANDICAP SCALE

HHS Questionnaire (Form A)
(Copyright Wallace S. High, Grant Fairbanks, and Aram Glorig, 1964)

Name________________________Today's Date______________

Instructions:

Following are a series of questions dealing with activities that depend upon hearing. In each question we want to know how often you are able to perform the activity referred to by the question. To answer each question, please check the scale from one to five. If you wear a hearing aid, answer the questions in terms of your experiences as they would be without the hearing aid. Please be sure to answer all the questions:

---

1. If you are six to twelve feet from the loudspeaker of a radio, do you understand speech well?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

2. Can you carry on a telephone conversation without difficulty?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

3. If you are six to twelve feet away from a television set, do you understand most of what is said?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

4. Can you carry on a conversation with one other person when you are on a noisy street corner?

- _____ 1. Practically always
- _____ 2. Frequently
- _____ 3. As often as not
- _____ 4. Occasionally
- _____ 5. Almost never

5. Do you hear all right when you are in a street car, airplane, bus, or train?

- _____ 1. Practically always
- _____ 2. Frequently
- _____ 3. As often as not
- _____ 4. Occasionally
- _____ 5. Almost never

6. If there are noises from other voices, typewriters, traffic, music, etc., can you understand when someone speaks to you?

- _____ 1. Practically always
- _____ 2. Frequently
- _____ 3. As often as not
- _____ 4. Occasionally
- _____ 5. Almost never

7. Can you understand a person when you are seated beside him and cannot see his face?

- _____ 1. Practically always
- _____ 2. Frequently
- _____ 3. As often as not
- _____ 4. Occasionally
- _____ 5. Almost never

8. Can you understand if someone speaks to you while you are chewing crisp foods, such as potato chips or celery?

- _____ 1. Practically always
- _____ 2. Frequently
- _____ 3. As often as not
- _____ 4. Occasionally
- _____ 5. Almost never

9. Can you carry on a conversation with one other person when you are in a noisy place, such as a restaurant or at a party?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

10. Can you understand if someone speaks to you in a whisper and you can't see his face?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

11. When you talk with a bus driver, waiter, ticket salesman, etc., can you understand all right?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

12. Can you carry on a conversation if you are seated across the room from someone who speaks in a normal tone of voice?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

13. Can you understand women when they talk?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

14. Can you carry on a conversation with one other person when you are out-of-doors and it is reasonably quiet?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

15. When you are in a meeting or at a large dinner table, would you know the speaker was talking if you could not see his lips moving?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

16. Can you follow the conversation when you are at a large dinner table or in a meeting with a small group?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

17. If you are seated under the balcony of a theater or auditorium, can you hear well enough to follow what is going on?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

18. When you are in a large formal gathering (a church, lodge, lecture hall, etc.) can you hear what is said when the speaker does not use a microphone?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

19. Can you hear the telephone ring when you are in the room where it is located?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

20. Can you hear warning signals such as automobile horns, railway crossing bells, or emergency vehicle sirens?

_____ 1. Practically always
_____ 2. Frequently
_____ 3. As often as not
_____ 4. Occasionally
_____ 5. Almost never

APPENDIX E

SPEECH DISCRIMINATION TESTS:

W-22, RHYME, SEMI-DIAGNOSTIC

W-22 TEST ITEMS

List 3

1.	add	26.	may
2.	aim	27.	nest
3.	are	28.	no
4.	ate	29.	oil
5.	bill	30.	on
6.	book	31.	out
7.	camp	32.	owes
8.	chair	33.	pie
9.	cute	34.	raw
10.	do	35.	say
11.	done	36.	shove
12.	dull	37.	smooth
13.	ears	38.	start
14.	end	39.	tan
15.	farm	40.	ten
16.	glove	41.	this
17.	hand	42.	three
18.	have	43.	though
19.	he	44.	tie
20.	if	45.	use
21.	is	46.	we
22.	jar	47.	west
23.	king	48.	when
24.	knit	49.	wool
25.	lie	50.	year

List 4

1.	aid	26.	my
2.	all	27.	near
3.	am	38.	net
4.	arm	29.	nuts
5.	art	30.	of
6.	at	31.	ought
7.	bee	32.	our
8.	bread	33.	pale
9.	can	34.	save
10.	chin	35.	shoe
11.	clothes	36.	so
12.	cook	37.	stiff
13.	darn	38.	tea
14.	dolls	39.	tin
15.	dust	40.	than
16.	ear	41.	they
17.	eyes	42.	through
18.	few	43.	toy
19.	go	44.	where
20.	hang	45.	who
21.	his	46.	why
22.	in	47.	will
23.	jump	48.	wood
24.	leave	49.	yes
25.	men	50.	yet

RHYME TEST ITEMS

List 1

1.	hot	26.	cast
2.	pay	27.	gain
3.	top	28.	nest
4.	peel	29.	gun
5.	wake	30.	heal
6.	law	31.	sin
7.	vile	32.	bust
8.	neat	33.	fine
9.	look	34.	mink
10.	fill	35.	sold
11.	tire	36.	hit
12.	male	37.	led
13.	sent	38.	tend
14.	moon	39.	rid
15.	kick	40.	back
16.	same	41.	tail
17.	wide	42.	fight
18.	rip	43.	torn
19.	sore	44.	rod
20.	bang	45.	dock
21.	men	46.	bump
22.	park	47.	date
23.	coil	48.	well
24.	big	49.	set
25.	rage	50.	luck

List 2

1.	got	26.	past
2.	may	27.	pain
3.	hop	28.	west
4.	reel	29.	nun
5.	take	30.	deal
6.	saw	31.	win
7.	mile	32.	just
8.	seat	33.	mine
9.	cook	34.	link
10.	kill	35.	told
11.	hire	36.	sit
12.	tale	37.	bed
13.	rent	38.	send
14.	noon	39.	bid
15.	sick	40.	lack
16.	fame	41.	sail
17.	tide	42.	light
18.	dip	43.	worn
19.	bore	44.	god
20.	hang	45.	mock
21.	den	46.	pump
22.	bark	47.	rate
23.	foil	48.	fell
24.	wig	49.	let
25.	cage	50.	tuck

SEMI-DIAGNOSTIC LIST 1A

1.	led	an*	2.	I'd	barn
	laid	add		eyes*	burn*
	lad*	at		ice	born
	lied	am		I've	been
3.	pie*	tea*	4.	caught	we
	tie	see		cat	me
	high	she		coat	knee*
	by	key		cut*	be
5.	pen	luck	6.	mean	sun
	pain*	lake		mine	such
	pan	lack		men*	song
	pine	like*		man	some*
7.	wife*	can	8.	pen	set
	white	cap		then*	sat
	wipe	cat*		ten	seat
	wise	catch		when	sit*
9.	tea	net	10.	low	win
	he*	not		row*	will
	key	night		go	wing*
	see	nut*		bow	wind
11.	seen	chains	12.	bowl*	ate
	seat	chair		boil	it
	seek*	chained		ball	at
	seed	change*		bull	eat*
13.	it*	plate	14.	shame	will
	if	plays		came	wish
	is	place*		tame	with*
	ill	play		same*	win
15.	gay	bear*	16.	far	tool
	day*	pair		fire	cool*
	bay	dare		fur*	fool
	they	wear		fair	pool
17.	seen*	pen	18.	wide	did*
	seem	ten*		word	dead
	sing	then		wood*	dad
	seed	hen		what	died
19.	gun	wrote	20.	wise	far*
	fun	boat		rise	for
	run	note		dies	fur
	won*	vote*		lies*	fair

SEMI-DIAGNOSTIC LIST 1A--Continued

21.	full	lied	22.	light	lay*
	feel	wide*		bite	way
	fill*	died		might	ray
	fell	ride		night*	day
23.	will*	lake	24.	let	pole
	we'll	look		yet*	pull
	well	luck*		met	pile
	wool	lock		get	pool*
25.	plate	let			
	play	led*			
	played*	leg			
	plane	less			

---

*Test-item.

SEMI-DIAGNOSTIC LIST 1B

1.	ray	same*	2.	win	seek*
	way	came		with*	seen
	day	shame		will	seed
	lay*	tame		wish	seat
3.	ten*	wool	4.	led*	word
	then	we'll		less	wood*
	pen	well		leg	what
	hen	will*		let	wide
5.	fur	bow	6.	wide*	played*
	far*	go		died	play
	fair	row*		ride	plane
	for	low		lied	plate
7.	plate	night*	8.	pull	won*
	place*	might		pole	fun
	plays	bite		pool*	run
	play	light		pile	gun
9.	lied	be	10.	man	key
	laid	knee*		mine	see
	led	me		mean	she
	lad*	we		men*	tea*
11.	dad	they	12.	lock	fell
	died	bay		luck*	feel
	dead	day*		lake	full
	did*	gay		look	fill*
13.	such	key	14.	by	lake
	sun	see		pie*	luck
	some*	he*		high	like*
	song	tea		tie	lack
15.	it	fair	16.	wipe	am
	eat*	far		wife*	at
	at	fire		white	add
	ate	fur*		wise	an*
17.	dare	ball	18.	cut*	not
	pair	bowl*		coat	net
	wear	bull		caught	nut*
	bear*	boil		cat	night
19.	note	yet*	20.	I've	win
	boat	met		eyes*	wing*
	vote*	let		I'd	wind
	wrote	get		ice	will

SEMI-DIAGNOSTIC LIST 1B--Continued

21.	cap	is	22.	when	burn*
	cat*	it*		ten	been
	catch	ill		then*	born
	can	if		pen	barn
23.	cool*	seed	24.	pine	seat
	pool	seen*		pen	set
	tool	seem		pain*	sit*
	fool	sing		pan	sat
25.	chair	lies*			
	chains	rise			
	change*	dies			
	chained	wise			

*Test-item.

APPENDIX F

WRITE-DOWN TRAINING MATERIAL

CNC (REVISED) LISTS

List 1				List 2			
1.	jar	26.	make	1.	rail	26.	hide
2.	boil	27.	dime	2.	vine	27.	choice
3.	tough	28.	bean	3.	root	28.	met
4.	tooth	29.	thin	4.	fake	29.	red
5.	goose	30.	seize	5.	cob	30.	goal
6.	toad	31.	hate	6.	moon	31.	should
7.	rout	32.	wood	7.	talk	32.	car
8.	mess	33.	check	8.	fern	33.	pave
9.	kite	34.	ditch	9.	this	34.	love
10.	jug	35.	rose	10.	nose	35.	which
11.	pad	36.	merge	11.	ship	36.	bought
12.	salve	37.	lease	12.	leak	37.	soul
13.	van	38.	loop	13.	nurse	38.	gain
14.	home	39.	king	14.	hash	39.	germ
15.	cape	40.	dead	15.	lead	40.	beam
16.	shore	41.	chore	16.	jet	41.	ring
17.	wreck	42.	boat	17.	south	42.	dam
18.	shirt	43.	wish	18.	dire	43.	tire
19.	knife	44.	name	19.	beg	44.	tall
20.	hull	45.	pick	20.	pan	45.	late
21.	yearn	46.	ripe	21.	much	46.	coat
22.	sun	47.	fall	22.	dodge	47.	suck
23.	wheel	48.	lag	23.	weep	48.	choose
24.	fit	49.	gale	24.	wag	49.	puff
25.	patch	50.	sob	25.	sap	50.	hill

List 3

1. jail
2. rat
3. toss
4. soon
5. faith
6. sung
7. keg
8. vote
9. size
10. numb
11. dab
12. what
13. room
14. kid
15. dike
16. mate
17. well
18. rig
19. four
20. bush
21. dip
22. gap
23. perch
24. sheep
25. house
26. fade
27. lake
28. gull
29. rouge
30. bar
31. tone
32. chin
33. piece
34. purge
35. bell
36. work
37. life
38. pod
39. shine
40. toll
41. joke
42. head
43. with
44. keen
45. more
46. leave
47. hut
48. noise
49. man
50. yam

List 4

1. sock
2. pool
3. chief
4. pause
5. give
6. lap
7. write
8. serve
9. bone
10. said
11. tower
12. wig
13. chum
14. thumb
15. loan
16. take
17. birch
18. dose
19. him
20. deal
21. net
22. job
23. wail
24. read
25. shake
26. rice
27. cash
28. hire
29. gas
30. phone
31. can
32. mop
33. rage
34. long
35. nice
36. till
37. youth
38. when
39. pack
40. war
41. mill
42. hoof
43. void
44. date
45. shut
46. loud
47. mirth
48. foot
49. keep
50. bug

List 5				List 6			
1.	veil	26.	good	1.	whip	26.	door
2.	worm	27.	nag	2.	bud	27.	niece
3.	half	28.	wire	3.	shone	28.	cat
4.	gaze	29.	robe	4.	rug	29.	move
5.	limb	30.	thought	5.	cheese	30.	cool
6.	juice	31.	beach	6.	chain	31.	web
7.	light	32.	dim	7.	look	32.	knock
8.	zeal	33.	purse	8.	dull	33.	jot
9.	town	34.	tell	9.	pope	34.	cage
10.	chalk	35.	coal	10.	calf	35.	mode
11.	bathe	36.	cup	11.	fire	36.	search
12.	food	37.	dock	12.	turn	37.	gone
13.	mean	38.	care	13.	raise	38.	rush
14.	boot	39.	sore	14.	sour	39.	pole
15.	yoke	40.	five	15.	bed	40.	dig
16.	tease	41.	myth	16.	lawn	41.	bad
17.	hot	42.	match	17.	sit	42.	live
18.	peg	43.	cab	18.	tube	43.	map
19.	then	44.	sing	19.	veal	44.	wife
20.	rough	45.	sail	20.	get	45.	fan
21.	raid	46.	knit	21.	pace	46.	birth
22.	dawn	47.	shop	22.	night	47.	team
23.	pull	48.	lean	23.	hiss	48.	howl
24.	luck	49.	hush	24.	shock	49.	hike
25.	nudge	50.	back	25.	wing	50.	jam

List 7

1.	note	26.	reach
2.	doom	27.	face
3.	coke	28.	bet
4.	hole	29.	caught
5.	join	30.	laugh
6.	third	31.	shall
7.	mouth	32.	geese
8.	sure	33.	tape
9.	vague	34.	sack
10.	big	35.	ridge
11.	far	36.	cheek
12.	gun	37.	dumb
13.	pearl	38.	top
14.	loot	39.	young
15.	save	40.	led
16.	side	41.	rib
17.	heat	42.	pass
18.	bun	43.	wit
19.	fish	44.	did
20.	have	45.	call
21.	mole	46.	neck
22.	pine	47.	such
23.	nap	48.	lose
24.	mine	49.	gem
25.	was	50.	tar

List 8

1.	moss	26.	rot
2.	daze	27.	touch
3.	loathe	28.	calm
4.	road	29.	gin
5.	muff	30.	some
6.	vowel	31.	real
7.	tip	32.	bite
8.	thing	33.	near
9.	week	34.	gag
10.	wheat	35.	cheap
11.	foam	36.	wake
12.	poor	37.	hurl
13.	wet	38.	tin
14.	seek	39.	noose
15.	lash	40.	dive
16.	hail	41.	rain
17.	page	42.	sad
18.	lock	43.	cub
19.	gear	44.	shoot
20.	hoop	45.	den
21.	learn	46.	bag
22.	guide	47.	bath
23.	fuss	48.	there
24.	jerk	49.	cough
25.	pose	50.	shawl

List 9

1. lack
2. watch
3. power
4. mire
5. nail
6. thine
7. word
8. tool
9. mob
10. hen
11. got
12. sane
13. shout
14. pill
15. both
16. shade
17. jazz
18. lathe
19. catch
20. white
21. chair
22. loaf
23. pun
24. ham
25. lip
26. wrong
27. yes
28. sin
29. curve
30. haze
31. girl
32. time
33. book
34. reap
35. fudge
36. voice
37. rag
38. mud
39. ball
40. deck
41. cut
42. need
43. cheer
44. soap
45. feet
46. tick
47. roof
48. dog
49. beat
50. dish

List 10

1. sub
2. lot
3. din
4. death
5. chill
6. coin
7. cause
8. burn
9. loose
10. palm
11. judge
12. wash
13. rob
14. fine
15. while
16. chat
17. bit
18. nick
19. neat
20. hair
21. safe
22. hit
23. jade
24. hurt
25. pile
26. shack
27. cone
28. sell
29. your
30. term
31. mood
32. deep
33. meek
34. rope
35. witch
36. ride
37. bake
38. gore
39. fool
40. guess
41. mouse
42. lung
43. load
44. path
45. peak
46. run
47. sag
48. cave
49. thatch
50. towel

APPENDIX G

MULTIPLE-CHOICE TRAINING MATERIAL

KELLY'S LISTS

1.	shovel	shuffle*	hovel	2.	gauge*	cage	age
	pear	bear	tear*		peril	barrel*	carol
	ton	tongue	tub*		rival	rifle	trifle*
	anger	anchor*	hanker		cheer*	jeer	sheer
3.	stag	stack	tack*	4.	singe	cinch*	inch
	whisker	whisper	whimper*		ether*	either	heater
	choose	shoes	shoot*		glue	clue*	blue
	ladder*	latter	batter		muzzle	muscle*	tussle
5.	buzz*	bus	bun	6.	worse	worth*	work
	jump*	chump	hump		eyes*	ice	light
	pose*	post	boast		slide	slight*	light
	fence	sense*	tense		leave	leaf	lease*

1.	hard	heart*	harp	2.	chief	cheek*	cheap
	cable	gable*	able		bag*	back	bank
	gain*	cane	pane		game	came*	aim
	ankle	angle*	tangle		steam	steed	steep*
3.	stung*	stun	spun	4.	town	down*	gown
	weed*	wheat	weep		truck*	trunk	drug
	lunge*	lunch	lump		veal	feel*	seal
	wait	wake	wade*		prove	proof*	prude
5.	degree*	decree	debris	6.	phone	foam*	home
	cash	gash*	dash		list*	lift	left
	bunch*	punch	hunch		laws	loss	loft*
	beach*	peach	teach		seat	seed	seek*

1.	wig	wing	wick*	2.	rag*	rack	rank
	flash	flesh*	lash		pig*	pink	pick
	neck*	knack	nick		gem*	jam	gym
	mint	minute	meant*		rain	range	rage*
3.	surface	service*	surplus	4.	sang	sack	sag*
	stack*	slack	stag		tribe*	trite	tripe
	vender	fender	sender*		grime	crime	grind*
	drab*	grab	crab		grim	grin	brim*

*Stimulus-word.

5.	paste*	taste	haste	6.	stable*	staple	table
	time	dime*	dine		scene	seam*	seed
	save*	safe	sane		raise*	race	raid
	dug	dunk	duck*		seize	cease	tease*
1.	lift	list*	live	2.	rice	rise	right*
	gum*	come	gun		lamp*	land	lamb
	seal	zeal*	feel		truce	truth	roost*
	crop	drop*	prop		blame	claim*	plane
3.	green	greed	greet*	4.	rudder	runner*	rubber
	trill	drill*	thrill		still	spill	skill*
	ridge*	rich	rib		ample	amble*	camel
	lime*	line	lion		fleas*	fleece	fleet
5.	lose*	loose	loot	6.	zinc	sink*	sing
	bug*	buck	bunk		herd	hurt	her*
	drag	brag*	track		mean*	meet	bean
	skim	skin	spin*		stir	spur	slur*
1.	breathe	breeze*	breed	2.	goat	coat*	coke
	graft*	craft	grass		plaque*	black	plank
	broom	groom*	prune		chair*	share	air
	skill	spill*	still		string*	spring	sprig
3.	vowel	fowl*	howl	4.	vast*	fast	fat
	vault	fault*	salt		smug	snug*	mug
	spar	star*	scar		search	surge*	purge
	simple	symbol*	single		scare	spare*	stair
5.	vase	face*	fate	6.	van	fan*	sand
	vale	fail*	sale		smack*	snack	stack
	preach	breach*	reach		post	boat	boast*
	paint*	faint	taint		cone*	comb	code
1.	bride*	pride	bright	2.	back	bag*	pack
	crew*	grew	brew		bigger	bicker*	picker
	phase*	face	fade		plank	blank*	clank
	dues	deuce*	tooth		coal	goal*	go
3.	think*	thing	thick	4.	five*	fife	vise
	grime	crime*	grind		bounce*	pounce	bouts
	packing*	backing	tacking		bulb	bulk*	pulp
	view*	few	new		zoo	sue*	due

*Stimulus-word.

5.	pill*	bill	till	6.	tame*	dame	game
	moon	noon*	mood		budge*	bunch	punch
	pays	pace*	paste		start	stark*	spark
	true	drew*	grew		neat*	meet	beet
1.	knit	mit*	lit	2.	knob	mob*	mop
	chuck*	chunk	chug		blank*	black	plank
	place*	plays	plate		fame	vein	same*
	dumb*	done	dug		chin	shin*	gym
3.	raise	race*	rage	4.	view	few*	feud
	blend	bled*	lend		grab	crab*	drab
	fan*	fad	sad		his	hiss*	hid
	door	tore*	bore		prize*	price	pride
5.	sack	sag*	sank	6.	crutch	crunch*	crux
	lose*	loose	loot		tack	tag*	tank
	vast	fast*	last		racer*	razor	raider
	dent*	tent	bent		rag*	rack	rank
1.	news	noose*	moose	2.	sky*	spy	sty
	sum*	sun	sung		cause*	gauze	cost
	brief	grief*	reef		etch	edge	itch*
	cane*	game	pane		blame	plane*	fame
3.	graze*	grace	gray	4.	brim	grin*	grim
	nice*	knife	night		case	cape	cane*
	burn*	bird	burr		cave	gave*	pave
	plume	bloom*	loom		smear	sneer*	spear
5.	broad	brought*	bought	6.	jade	shade*	chain
	bored	poured*	toward		splint	sprint*	print
	trench*	drench	wrench		scant	scamp	camp*
	spoke	smoke*	soak		pin	bin*	din
1.	parrot	parent*	pennant	2.	joke*	choke	show
	bale*	pale	rail		last	lest*	list
	job*	chop	shop		gape	cape	cake*
	chair	share*	care		trance*	prance	plants
3.	mice	nice*	ice	4.	clean	gleam	lean*
	raid	rate*	rake		case	gaze*	gave
	class*	glass	last		push*	bush	wish
	pride	bride*	bright		plug*	pluck	plunk

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*Stimulus-word.

5.	crag	crack*	crank	6.	peak	beak*	beet
	blaze*	place	plate		pan	ban*	fan
	crew	grew*	brew		blunder	plunder*	thunder
	grudge*	crutch	drudge		flash	slash*	clash

1.	girl	curl*	cur	2.	motto*	model	bottle
	ridden*	written	ribbon		came*	game	gain
	flute	fluke*	flew		triple*	cripple	trickle
	groove	groom	group*		brink	drink*	brick
3.	wick*	wink	wig	4.	might	night	light*
	patch	batch*	catch		loose	lose	loom*
	tug*	tuck	tub		crow	grow*	groan
	graze*	grace	great		dug*	duck	dunk
5.	shack	shank*	shag	6.	dare	bare*	pear
	tangle*	tango	dangle		tooth	toot*	tube
	waif	wave*	wade		sag	sack	sank*
	bug*	buck	bunk		meal	kneel*	deal

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*Stimulus-word.

LARSEN'S LISTS

f and ch		p and b		m and l		sh and f	
fin*	chin	pin	bin*	mine*	line	show	foe*
few*	chew	pie*	buy	mast*	last	shore*	four
filed	child*	pole	bowl*	moan*	loan	shade	fade*
calf*	catch	cap*	cab	name	nail*	cash*	calf
four	chore*	rope*	robe	home*	hole	leash*	leaf

f and k		b and m		n and v		d and n	
fit	kit*	bill*	mill	nice*	vice	dot	not*
four*	core	boast	most*	nurse*	verse	die	nigh*
find	kind*	bake	make*	nine	vine*	deed*	need
cliff	click*	robe	roam*	loans*	loaves	ode*	own
laugh*	lack	tab*	tam	lean	leave*	did*	din

k and g		m and v		t and th		p and f	
coal*	goal	mice	vice*	tie	thigh*	pour*	four
came	game*	ham	have*	tin*	thin	pile*	file
coat	goat*	glum*	glove	trill	thrill*	par	far*
luck*	lug	mine*	vine	mit*	myth	cap*	calf
rack*	rag	mile	vile*	pat*	path	cup	cuff*

v and z		l and v		l and z		v and f	
live	lies*	lane*	vane	lip	zip*	five*	fife
have	has*	lie	vie*	loan*	zone	vase*	face
rave*	raise	lace	vase*	lisle	lies*	leave	leaf*
view	zoo*	lull*	love	dole	does*	view	few*
wives*	wise	rail*	rave	male	maze*	loaves*	loafs
						vine*	fine

l and n		b and d		s and sh		f and b	
lame*	name	bid	did*	lease*	leash	fun*	bun
light	night*	big*	dig	sew*	show	fig*	big
loan	known*	buy	die*	sign	shine*	fan	ban*
dial*	dine	rob*	rod	sip	ship*	cuff*	cub
pail*	pain	bell*	dell	save*	shave	calf*	cab
rail	rain*	robe*	road	lass	lash*	graph	grab*

k and t		m and n		b and v	
kick	tick*	mine*	nine	bet	vet*
kite*	tight	mew	knew*	bow*	vow
code*	toad	time*	tine	bile*	vile
shirk	shirt*	dime	dine*	bigger	vigor*
park*	part	dumb	done*	robe	rove*
kin	tin*	loam*	lone	boat*	vote

*Stimulus-word

th and v

than	van*
thy*	vie
that*	vat
thine*	vine
loathes	loaves*

f and t

four*	tore
fall	tall*
fan	tan*
fill*	till
free*	tree
fry	try*

k and p

pike	pipe*
car*	par
core*	pore
coke	poke*
cock*	cop
crock	crop*
cry	pry*
coal*	pole

d and g

door*	gore
dot*	got
doe	go*
date*	gate
drove*	grove
bud	bug*
dye*	guy
dad	gag*

s and z

ice	eyes*
seal*	zeal
sip*	zip
loose	lose*
bus*	buzz
lice	lies*
juice	Jews*
fuss*	fuzz

t and p

tore*	pore
tine	pine*
tail	pail*
cat*	cap
cut*	cup
tar*	par
toll	pole*
coat	cope*

f and s

fine*	sign
fur*	sir
four	soar*
flat	slat*
cuff*	cuss
knife	nice*
lift	list*
loft*	lost

th and s

theme	seam*
thin*	sin
thumb	sum*
truth	truce*
path*	pass
myth	miss*
thing*	sing
thank*	sank

ch and sh

chop	shop*
chip*	ship
chair*	share
chew*	shoe
watch	wash*
catch*	cash
which	wish*
cheap	sheep*

th and f

thin*	fin
thirst	first*
three*	free
Thor	for*
thought	fought*
throw*	fro
thrill	frill*

word endings

store	stores*	stored
close*	closes	closed
will*	wills	willed

f and ch

fin	chin*
few*	chew
filed*	child
calf	catch*
four	chore*

p and b

pin	bin*
pie	buy*
pole*	bowl
cap	cab*
rope*	robe

m and l

mine*	line
mast*	last
moan*	loan
name	nail*
home	hole*

sh and f

show*	foe
shore	four*
shade	fade*
cash*	calf
leash*	leaf

f and k

fit*	kit
four*	core
find	kind*
cliff*	click
laugh	lack*

b and m

bill	mill*
boast	most*
bake	make*
robe*	roam
tab	tam*

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*Stimulus-word.

n and v		d and n		k and g		m and v	
nice*	vice	dot	not*	coal	goal*	mice	vice*
nurse	verse*	die	nigh*	came	game*	ham*	have
nine	vine*	deed*	need	coat*	goat	glum*	glove
loans*	loaves	ode	own*	luck*	lug	mine	vine*
lean*	leave	did*	din	rack*	rag	mile	vile*

t and th		p and f	
tie*	thigh	pour	four*
tin*	thin	pile	file*
trill	thrill*	par*	far
mit	myth*	cap	calf*
pat*	path	cup*	cuff

*Stimulus-word.

APPENDIX H

PRE-TRAINING, POST-TRAINING, AND DIFFERENCE-SCORES; HEARING HANDICAP SCALE SELF-RATINGS

GROUP 1

	Pre-Training			Post-Training			Difference-Score*			HHS**
Subject	W-22	Rhyme	Semi-Diag.	W-22	Rhyme	Semi-Diag.	W-22	Rhyme	Semi-Diag.	
1	48%	70%	92%	62%	84%	86%	14%	14%	- 6%	55
2	56	98	88	64	94	90	8	- 4	2	57
3	42	94	86	50	84	86	8	-10	0	64
4	84	98	96	92	98	98	8	0	2	59
5	46	86	80	54	88	70	8	2	-10	39
6	52	86	84	60	88	88	8	2	4	49
7	54	72	80	50	80	90	- 4	8	10	50
8	16	54	80	36	60	74	20	6	- 6	63
GROUP 2										
9	40	70	80	62	94	94	22	24	14	69
10	42	64	78	52	76	78	10	12	0	76
11	32	48	56	34	48	66	2	0	10	52
12	58	72	90	74	88	88	16	16	- 2	55
13	48	96	96	58	98	96	10	2	0	65
14	28	78	90	22	76	90	- 6	- 2	0	65
15	54	96	86	62	86	98	8	-10	12	71
16	44	74	82	52	80	86	8	6	4	45

*Difference-scores were the dependent measures in this study.

**Hearing Handicap Scale self-ratings (raw score).

GROUP 3

	Pre-Training			Post-Training			Difference-Score*			HHS**
Subject	W-22	Rhyme	Semi-Diag.	W-22	Rhyme	Semi-Diag.	W-22	Rhyme	Semi-Diag.	
17	66%	98%	98%	82%	96%	100%	16%	- 2%	2%	33
18	24	32	60	32	38	48	8	6	-12	57
19	52	86	90	68	92	94	16	6	4	61
20	32	46	68	40	56	76	8	10	8	71
21	38	46	64	40	50	60	2	4	- 4	33
22	40	82	68	42	72	78	2	-10	10	50
23	60	92	86	72	100	92	12	8	6	58
24	46	68	72	56	68	76	10	0	4	48

GROUP 4

25	44	90	92	40	88	90	- 4	- 2	- 2	68
26	68	92	94	62	92	98	- 6	0	4	63
27	44	74	84	62	92	90	18	18	6	47
28	56	98	94	58	94	86	2	- 4	- 8	54
29	30	36	58	36	34	50	6	- 2	- 8	77
30	40	52	72	54	72	70	14	20	- 2	61
31	62	94	92	56	88	96	- 6	- 6	4	60
32	74	100	98	82	98	100	8	- 2	2	29

*Difference-scores were the dependent measures in this study.

**Hearing Handicap Scale self-ratings (raw score).