THE UTILIZATION OF A COMBINED AUDITORY AND VISUAL TEST OF DISCRIMINATION ABILITY WITH PEOPLE WEARING HEARING AIDS AS A MEASURE OF COMMUNICATION EFFECTIVENESS

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ABSTRACT

THE UTILIZATION OF A COMBINED AUDITORY AND VISUAL TEST OF DISCRIMINATION ABILITY WITH PEOPLE WEARING HEARING AIDS AS A MEASURE OF COMMUNICATION EFFECTIVENESS

by Hinda Kahn

The purpose of this study is to analyze the results obtained from hard-of-hearing persons with sensori-neural losses as they responded with their hearing aids and without their hearing aids to tests of discrimination ability under three methods of stimulus presentation: visual (lipreading), auditory, and combined visual and auditory. This was done in an attempt to determine the potential of including a test of combined auditory and visual discrimination ability in the battery of tests now used in evaluating hearing aids.

The subjects for this study were sixteen people with sensori-neural hearing losses who were wearing hearing aids. They ranged in age from fourteen to seventy-seven years. Sensori-neural, for the purposes of this study, is defined as a hearing loss characterized by an air-bone gap of not more than ten dB in the speech frequencies and at least a ten percent discrimination loss.

A total of seven tests were administered to the subjects, half of whom were tested first without their hearing aids followed by testing with their hearing aids; the other half were tested first with their hearing aids and then without. A colored film of a female speaker presenting list 1A of the Semi-Diagnostic Test in Aural Rehabilitation was administered first to each subject as a test of lipreading ability. Unaided and aided speech reception thresholds were obtained as well as aided and unaided auditory and combined auditory and visual test scores. All the word stimuli for each discrimination test were taken from the Semi-Diagnostic Test. The standardized recording of the CID Auditory Test W-1, lists 1A and 1B, were used in obtaining the speech reception threshclds.

The findings of this study indicate that there was no significant improvement in discrimination scores when the utilization of a hearing aid was supplemented with visual cues.

The conclusions which were drawn from this study suggest that, in the testing situation, the subjects depended more on lipreading without than with their hearing aids. Persons with sensori-neural losses have difficulty in wearing a hearing aid because of discrimination problems as evidenced by their unaided auditory scores which were better than their aided auditory

scores. Aided speech reception thresholds were always improved over the unaided. Thus, it can be concluded that improvement in speech reception thresholds with the addition of a hearing aid does not imply improvement in discrimination ability with the addition of a hearing aid. Results also indicate that the addition of auditory clues with visual clues improves discrimination ability.

The feasibility of the Semi-Diagnostic Test in Aural Rehabilitation as a clinical measure of lipreading ability, auditory discrimination ability, and combined auditory and visual discrimination ability appears favorable although the expense of developing tapes and a sound film is a limiting factor.

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By

Hinda Kahn

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

> A major function of audiological personnel in the rehabilitation of hearing impaired individuals is to assist in the selection of a suitable hearing aid. Such a service of necessity implies a means of determining how well a person may be expected to perform communicatively with a hearing aid.[1]
>
> Obviously, the final criterion of hearing aid excellence is the success with which the instrument functions in everyday situations; thus, selection procedures need to be chosen so as to yield estimates of the future usefulness promised by each hearing aid.[2]

A crucial problem for the audiologist is related to the fact that although hearing aid amplification may provide improvement in sensitivity for speech, it frequently does not improve the finer auditory discrimination on which the understanding for speech is dependent.[3] "Tests of the ability to understand the spoken word are generally recognized as the most realistic, valid, and

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[1]Freeman McConnell, Eileen Silber, and Douglas McDonald, "Test-Retest Consistency of Clinical Hearing Aid Tests," Journal of Speech and Hearing Disorders, 25 (August, 1960), p. 273.

[2]Raymond Carhart, "Tests for Selection of Hearing Aids," Laryngoscope, 56 (1946), p. 780.

[3]McConnell, Silber, and McDonald, loc. cit.

the most sensitive tests of auditory function."[1] However, hearing aid recommendations are based primarily on scores obtained in response to auditory stimuli. A primary objective of a hearing aid is to improve communication effectiveness. For the individual with a sensori-neural hearing loss, a hearing aid, while amplifying sound, does not necessarily improve discrimination ability and more often further distorts it. This capacity for auditory discrimination is in part a physiological function involving an individual's ability to perceive sound stimuli transmitted from auditory nerve endings to the brain. To evaluate this function, the audiologist has at his disposal test materials which can be used to investigate an individual's ability to discriminate speech sounds through hearing alone. Concomitant frequently with a sensori-neural hearing loss is a loss of ability to discriminate; this difficulty in discrimination is not easily improved.

There has been much research on the topic of lip-reading which has indicated the important role that vision plays in face-to-face voice communication. It would appear that the eye plays an important

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[1]H. Davis, et al. "The Selection of Hearing Aids," The Laryngoscope, 56 (1946), p. 144.

supporting role in perception of speech.[1] At lectures, for example, particularly when the speaker speaks indistinctly, the audience tends to watch the speaker's face in order to facilitate understanding. This tendency does not originate in the instinctive desire to amplify the volume of sound.[2] Watching the speaker's face occurs to facilitate the comprehension of speech.[3] Research has indicated that "individuals with normal hearing make appreciable use of the visual cues (lipreading) to gain information in some communication channels."[4]

The implications of the importance of this visual compoment to the hard-of-hearing individual seem obvious. It would appear that an important channel of communication--vision--is being neglected when hearing aids are recommended and communication effectiveness determinded. Very often the audiologist is confronted with the decision of whether or not to recommend a hearing aid. He has, however, no way to measure the amount of success

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[1]Louise Morgenstern Neuschutz (trans.), "Lipreading: Its Psychological Aspects and Its Adaptation to the Individual Needs of the Hard-of-Hearing," American Annals of the Deaf, 73 (1928), p. 237.

[2]Ibid.

[3]Ibid.

[4]John J. O'Neill, "Contributions of Visual Components of Oral Symbols to Speech Comprehension," Journal of Speech and Hearing Disorders, 19 (1954), p. 438.

a candidate for a hearing aid will achieve in everyday situations when visual clues can be utilized. This supplement to amplification could be a determining factor in the final recommendation of an aid.

In an attempt to more completely evaluate the communication effectiveness of a hearing aid user, this study attempts to look at the possibility of a speech discrimination test which would allow the wearer, in the testing situation, to supplement the amplification afforded by the aid with the visual clues he is presumed to be utilizing.

Statement of Problem and Purpose of Study

The problem from which this study arose is one which the audiologist is often confronted--that of recommending a hearing aid to an individual with a sensori-neural hearing loss whose scores on auditory tests show improvement in speech reception but whose discrimination scores are not changed significantly.

The purpose of this study is to analyze the results obtained from a population of hearing aid users with sensori-neural hearing losses as they responded to auditory and combined auditory and visual tests of speech discrimination both with amplification and without. From this analysis it is hoped that implications with regard to the potential of a combined auditory and visual speech

discrimination tests as one of the battery of tests used in the evaluation and recommendation of hearing aids can be determined.

Questions Posed

Within the confines of this study, the following questions were posed:

1. Is the difference between auditory unaided and auditory aided scores significantly different from the difference between the combined auditory and visual unaided scores and the combined auditory and visual aided scores?
2. What are the interrelationships among aided and unaided performance on a visual (lip-reading) test, an auditory discrimination test, and a combined auditory and visual test?

Importance of Study

The most important function of a hearing aid is to allow a hard-of-hearing individual to improve understanding of oral communication. In the evaluation of hearing aids, it is desirable to obtain scores which indicate how well the individual can discriminate speech as it occurs in everyday communication situations. Studies have been conducted relative to the use of combined auditory and visual clues in signal-to-noise ratios and as a test of aural rehabilitation. However, a survey of the

literature revealed no attempts to explore the potential of this as a tool to be included in the battery of tests now used in the evaluation of the communication effectiveness of hearing aid users. This information may have implications for further research and for lipreading training for the acoustically handicapped.

Definition of Terms

For the purpose of this study, the terms used are defined in the following manner:

Sensori-Neural hearing loss.--The subjects with sensori-neural hearing losses used in this study must show at least a ten per cent unaided discrimination loss, and air and bone conduction thresholds must be within ten decibels of each other at frequencies 500cps, 1000cps, and 2000cps.

Discrimination loss.--A discrimination loss is defined as the difference between 100 per cent and the percentage of words of a phonetically balanced list that a listener repeats correctly when the list is presented at an intensity level thirty decibels above threshold.

Speech Reception Threshold (SRT).--The intensity level at which a person can correctly understand and repeat fifty per cent of the stimulus spondaic words presented him.

Phonetically Balanced (PB) Word Lists.--Monosyllabic word lists, chosen such that each list contains samples of speech sounds in the same proportion with which they occur in connected speech. The discrimination function is measured by administering phonetically balanced lists of words at levels above a subject's speech reception threshold.

Intensity Level.--The number of decibels that the sound intensity at any point is above some reference intensity. In accordance with the audiometer used in this study, the reference intensity utilized and referred to in this study is normal audiometric zero.

Lipreading.--An aspect of human behavior in which an individual makes use of visual clues to aid in determining what a speaker says; concentration is on the speaker's lips and other facial expressions.

Organization of the Thesis

Chapter I contains a statement of the problem which led to this study and the purpose for which it has been conducted. It includes an introduction to the topic and has set forth the questions under consideration in this study. The importance of the study is discussed, and the terms which were used within this study are defined.

Chapter II provides a review of the literature which pertains to this study.

Chapter III consists of a discussion of the subjects, materials, equipment, and testing procedure employed in this study.

Chapter IV consists of a presentation of and a discussion of the results.

Chapter V contains a summary and the conclusions of the study.

CHAPTER II

REVIEW OF THE LITERATURE

Because this study is concerned with communication performance under certain unaided and aided conditions and particularly with the role that visual stimuli combined with auditory stimuli plays in that communication, this chapter considers three major areas deemed relative to the study; these include (1) the role of visual and auditory components in communication, (2) procedures commonly used in the evaluation and recommendation of hearing aids, and (3) tests of lipreading ability.

The Role of Visual and Auditory Components in Communication

"The role of the eye as supporting organ for the comprehension of speech is so deeply rooted in common usage that it is considered a transgression against good form to listen with the face turned aside."[1] Children look at the speaking mouth when learning to speak or even touch it with their hands. Children born blind,

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[1]Neuschutz, loc. cit.

under the same conditions, learn to speak later than those who can see.[1]

In addition to the term lipreading, speechreading, and visual hearing have been designated to describe a particular form of nonauditory communication. That the normal hearing individual makes appreciable use of visual clues in communication situations seems apparent. For the individual with a moderate to severe hearing loss, the visual form and movement of a speaker's articulators and his facial expressions become the important communicative components. Thus, the eye becomes the primary receptor, with the ear affording some assistance, and an additional sensory pathway is available to the aurally handicapped.[2]

Oyer and O'Neill[3] discuss the similarity between auditory and visual performance in lipreading. An individual views lip movements with the intent to discern the thoughts of a speaker, and rather than more recognition, attention is directed toward comprehension. Here the term "visual listening" may be applied.

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[1] Ibid.

[2] John J. O'Neill and Herbert J. Oyer, Visual Communication for the Hard of Hearing: History, Research, and Methods (Englewood Cliffs, New Jersey: Prentice Hall, Inc., (1961), p. 1.

[3] Ibid., p. 6.

A study by O'Neill[1] revealed that vision contributed 29.5% to the recognition of vowels, 57% for consonants, 38.6% for words and 17.4% for phrases. Hutton[2] states that visual clues along produce only 35% to 55% speech intelligibility. In another study by Hutton[3] normal hearing subjects showed a mean of 38% for visual scores, a mean of 68% for auditory scores, and a mean of 83% for scores on a combined auditory and visual test. He lists the following conclusion:

1. Although auditory values were generally higher than visual values, combining auditory and visual clues resulted in greater intelligibility than either audition or vision alone.

2. Large differences were observed among the various phonemes in intelligibility gains as a result of combining stimuli.

3. The most frequently occuring speech sounds had relatively low combined values.

4. There did not appear to be a relationship between visual intelligibility and the difference between the combined and the auditory values.

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[1]O'Neill, op. cit., pp. 429-439.

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

[3]Charles Hutton, "Combining Auditory and Visual Stimuli in Aural Rehabilitation," Volta Review, 61, #7.

5. In combined vowel recognition, auditory clues were the primary determinants.

6. There was much variation in the utilization of visual clues in combined stimuli among subjects.

Several studies have utilized combined stimuli under the effects of speech-to-noise ratios. One such study was conducted by O'Neill.[1] He used four classes of oral materials under the following types of perception: visual, auditory, and combined visual and auditory. The following are several conclusions drawn regarding the contribution of lipreading in the discrimination of both simple and more complex information by normal hearing individuals:

1. Visual recognition was always better than non-visual recognition for all materials under the four speech-to-noise ratios utilized in the study.

2. A high level of noise tends to hinder auditory communication; however, when the visual channel supplements the auditory channel there is an increase in understandability of the vowels, consonants, words, and phrases that are transmitted.

In support of the above findings, Sumby and Pollack[2] state that as the signal-to-noise ratio decreases, the

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[1] O'Neill, op. cit., p. 435.

[2] W. H. Sumby and I. Pollack, "Visual Contribution to Speech Intelligibility in Noise," Journal of the Acoustical Society of America, 26 (1954), pp. 212-215.

importance of the visual clues to listener-intelligibility increases. A twenty per cent increase in the intelligibility of received speech was observed by Neely[1] when visual cues were added to auditory cues.

Using phonetically balanced words based on the kindergarten familiarity lists, Josephine Prall[2] obtained average scores for lipreading ability, use of a hearing aid with no visual cues, and lipreading combined with the use of a hearing aid for eight children in elementary schools. She concluded that "in each case the pupil's score is substantially increased when a hearing aid is used to supplement lipreading."

The hearing of speech can be reasonably expected to reinforce speech reading because auditory clues aid in the discrimination of words that seem alike on the lips.[3] "Long-time users of hearing aids generally report that the continuous association of hearing and seeing speech is mutually advantageous."[4] When complete

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[1]Keith K. Neely, "Effect of Visual Factors on the Intelligibility of Speech," Journal of the Acoustical Society of America, 28 (1956), pp. 1275-1277.

[2]Josephine Prall. "Lipreading and Hearing Aids Combine for Better Comprehension," Volta Review, 59 (February, 1957), pp. 64-65.

[3]Hallowell David and Richard Silverman, Hearing and Deafness (New York: Holt, Rinehart, and Winston, Inc., 1960), p. 333.

[4]Ibid.

understanding of speech is not possible because of severe loss of hearing, sufficient auditory clues may be provided by a hearing aid, such as stress patterns, to effectively supplement speech reading.[1]

In conclusion of the foregoing discussion, Heller[2] has the following to say:

> Speech reading can provide assistance to those who have a sufficient loss of hearing regardless of the degree of the loss. The limitations of the hearing aid deny the user complete hearing under all conditions necessary for hearing and discriminating conversational speech. The frequency spectrum of many aids fails to include the highest speech frequencies effectively. Patients with perceptive (sensori-neural) deafness, with or without recruitment, and with discrimination losses do not receive the maximum potential improvement which an aid can yield. The gaps left by the hearing aid must be supplemented and filled in by visual clues. The effectiveness of a hearing aid is roughly inversely proportional to the kind and severity of the deafness. The most severely acoustically impaired patients can expect the least amount of acoustic serviceability from a hearing aid. Speech reading thus serves the purpose of reinforcing the perception of speech.

Procedures Commonly Used in the Evaluation and Recommendation of Hearing Aids

Much discussion has evolved relative to the method of helping the hard-of-hearing person select a

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[1] Ibid.

[2] Morris F. Heller, Functional Otology: The Practive of Audiology (New York: Springer Publishing Company, Inc., 1955), pp. 203-205.

hearing aid which will provide him optimum acoustic assistance. "Some examiners consider the fitting process to be one of careful measurement while to others it is simply a matter of general guidance."[1]

Based on laboratory investigation and clinical experience there have emerged, however, certain principles, techniques and procedures which are generally accepted and used by audiologists in hearing aid selection. It is of utmost importance that procedures be chosen in order to yield estimates of the future usefulness promised by each hearing aid. Thus, Carhart[2] lists various dimensions of hearing aid performance as worthy of exploration: (1) sensitivity, or effective gain, (2) tolerance limit, or psychophysical ceiling, (3) efficiency in background noise, or signal-to-noise ratio, and (4) discrimination, or efficiency in distinguishing small sound differences.

Differences exist in the way hearing aid evaluations are conducted, but Shore, Bilger, and Hirsh[3] indicate

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[1]Heller, op. cit., p. 165.

[2]Raymond Carhart, "Tests for Selection of Hearing Aids," Laryngoscrope, 56 (1956), pp. 381-382.

[3]Irvin Shore, Robert C. Bilger, and Ira Hirsch, "Hearing Aid Evaluations: Reliability of Repeated Measures," Journal of Speech and Hearing Disorders, 25 (May, 1960), p. 152.

that generally they are still done in the manner described by Carhart.[1] The following presentation is based on Carhart's discussion.

To test for sensitivity, the speech reception technique is employed. Bascially, the speech reception threshold procedure consists of determining the sensation level at which a client can hear adequately well to respond correctly to 50% of the test items. Speech reception thresholds obtained through various hearing aids reveal the "residual loss for speech" which the client experiences with each particular instrument.

To test for tolerance limit, the audiologist must estimate the strength of the sound field in which a particular hearing aid becomes intolerable to the client. The hearing aid selected should be the one with the highest tolerance limit, other factors being approximately equal.

Thus far, the hearing aid performance has been assessed in the relative quiet of a sound-treated room. Conditions might be more realistic if testing could be done in an ordinary noise environment; however, because the real life noise level is constantly changing, measurements from hearing aid to hearing aid becomes impossible.[2]

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[1]Carhart, op. cit. pp. 780-794.

[2]Heller, op. cit. p. 170.

Since ordinary listening situations do include varying degrees of background noise, the effectiveness with which hearing aids perform in the presence of noise should be estimated. This is done by determining the maximum amount of noise which can be present without destroying the ability to understand speech. This is called determining the "signal-to-noise ratio." Noise is increasingly presented while speech is presented at a fixed intensity, and the hearing aid is adjusted to the most comfortable loudness (MCL). The procedure is continued until a noise level is reached at which the patient can no longer understand the test items; intensity of the noise is then dropped until understanding returns. Signal-to-noise ratio is then computed with ratio defined as the difference between the sensation level at which speech is presented and the sensation level of the noise at which repetition of test items is possible.

A good estimate of the relative discrimination which the wearer achieves with different hearing aids is necessary because of the importance to the user to be able to discriminate or distinguish small differences in sound. Phonetically balanced word lists are utilized and differences in discrimination scores of 8% or more are taken to be significant. The hearing aid which yields

the highest score is selected. Heller[1] states that

> one should not expect the aided discrimination score to surpass the unaided score; often the aided discrimination score will be poorer since the electro-acoustic characteristics of a hearing aid are far below the quality of the usual evaluation assembly used in obtaining the unaided percentage.

In support of this, Hirsh[2] concludes that:

> it is unusual to find that the discrimination loss for speech through a hearing aid is significantly less than the discrimination loss without a hearing aid, unless the unaided discrimination was measured at an intensity that lay below the patient's ceiling.

Advances in electronics and a growing public acceptance of the hearing aid have increased the need for proven test materials and procedures in evaluating the acoustic reception of various instruments when worn by hearing impaired persons.[3]

Tests of Lipreading Ability

A lipreading test is a specialized educational instrument, designed to measure a viewer's ability to

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[1]Heller, loc. cit.

[2]Ira J. Hirsh, The Measurement of Hearing, (New York: McGraw-Hill Book Company, Inc., 1952), p. 299.

[3]McConnell, Silber, and McDonald, loc. cit.

understand what a speaker is saying by concentrating on his lip movements and other facial expressions; it provides a means of quantifying an aspect of human behavior.[1]

There are several reasons why lipreading tests are desirable:[2]

> (1) they can be used to measure the basic lipreading ability of an individual, (2) they can be employed to measure the effects of lipreading training, (3) to aid in proper placement of individuals within a training program, (4) a lipreading test is helpful in deciding which teaching methods, or combination of methods, are most appropriate for students of various ages and performance levels, and (5) a valid and reliable test of lipreading is also a useful research tool.

As early as 1913, researchers were developing tests of lipreading in an attempt to assess the lipreading skill of the acoustically handicapped. Many types of lipreading tests have been constructed which utilize isolated sounds, syllables, words, sentences, and stories. There are face-to-face lipreading tests and filmed tests in black-and white or color. Oyer and O'Neill[3] present a comprehensive review of formal materials now available. Among the

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[1]Oyer and O'Neill, op. cit., p. 20.

[2]Ibid.

[3]Ibid., pp. 22-28.

most prominent are Conklin's[1] face-to-face test consisting of consonants, words, and sentences; two face-to-face lipreading tests consisting of four sets of ten sentences each developed by Day and Fusfeld;[2] three filmed tests of lipreading ability by Heider and Heider;[3] Utley's[4] motion picture achievement tests of lipreading ability consisting of words, sentences and stories; and a test developed by Kelly[5] to be used for either face-to-face or filmed presentation.

Certainly there are numberous tests available to measure a person's lipreading ability. However, the nature of this study necessitated a test which could measure auditory discrimination ability as well as visual discrimination ability and combined auditory and visual discrimination ability. The Semi-Diagnostic Test in Aural Rehabilitation[6] appeared to be a suitably

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[1] Ibid., p. 22.

[2] Ibid., p. 23.

[3] F. K. Heider and G. M. Heider, "Studies in the Psychology of the Deaf," Psychological Monographs, 52 (1940), pp. 124-133.

[4] J. Utley, "Factors Involved in the Teaching and Testing of Lipreading Ability Through the Use of Motion Pictures," The Volta Review, (1946), pp. 657-659.

[5] Ibid., p. 27.

[6] Charles Hutton, "Directions for Using the Semi-Diagnostic Test in Aural Rehabilitation," (University of Illinois, 1959), 12 pp. (Mimeographed).

constructed test designed to measure all three of these components. Further, because it appears that the test retains its sensitivity in repeated presentations, the implications for its use in multiple testing as in hearing aid evaluations are obvious.[1]

The purpose for its construction, the authors indicate[2], arose from "the need for a systmatic method of analyzing the intelligibility errors of hard of hearing clients as a way of paralleling the 'phonetic analysis' commonly used in speech correction. The results of the error analysis would be used to form, in part, the basis of the therapy program. Retesting after therapy would show not only the amount but also the kinds of improvement." Development of the test is thoroughly described by the authors.[3] Briefly, several aspects taken into consideration in the development of the word list include phonetic occurrence of the key sounds, ease of error analysis, word familiarity, phonetic contrast within the answer sets, and ability to discriminate between good and poor listeners. The resultant test (1959 revision) was presented to normal and hard-of-hearing listeners and compared

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[1]Hutton, Curry, and Armstrong, op. cit., p. 327.

[2]Ibid., p. 319.

[3]Ibid., pp. 323-327.

with other auditory tests, i.e., Psycho-Acoustic Laboratory recordings and W - 22's. The test was found to be sensitive to different kinds of hearing losses and to yield reliable estimates of discrimination ability. The diagnostic implications of the auditory error analysis and the live voice, visual and combined auditory and visual test results are presented in detail.

With regard to the use of isolated words in measuring intelligibility, Hirsh[1] indicates that words are used because of the ease in constructing a list which can be presented to a listener, each word at a given intensity. An important concept to be considered in comparing the intelligibility of different kinds of speech material is the amount of context present in the sample. Each word in a list is presented by itself, affording the listener no additional cues about what the word might be either from preceding or succeeding words. Test materials consisting of sentences may yield more information about what the individual words might be because of the many interactions among the words in a given sentence.

Hirsh concludes:

> The problem of context is a bothersome one, particularly when we consider that a man's ability

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[1]Hirsh, op. cit., pp. 131, 136.

> to understand speech in ordinary communication is aided constantly by the context among the words of conversation. We sometimes wonder about the relation between articulation scores for lists of isolated words and the 'score' a person would obtain for his ability to understand conversational speech. We would like to know the latter, but we can quantify only the former.[1]

With regard to nonsense syllables, Davis[2] states that the nonsense syllable is the most difficult form of test material and is not appropriate for use in the selection of a hearing aid because of the difficulty that an untrained listener has in writing down or repeating the meaningless syllables that he hears.

Various types of speech materials have also been subjected to analysis in experiments involving lipreading. One study which reports on the speechreading of various speech materials is that by John B. Brannon, Jr.[3] Three types of speech materials are utilized: the Utley Lipreading Sentence Test, fifty selected phonetically balanced words, and ten spondee words. These were presented

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[1]Hirsh, op. cit., p. 137.

[2]Davis, loc. cit.

[3]John B. Brannon, Jr., "Speechreading of Various Speech Materials," Journal of Speech and Hearing Disorders, 26 (November, 1961), pp. 348-353.

to normal hearing subjects. The results showed that the subjects identified approximately 50% of the words in the sentence test; approximately 35% of the fifty selected phonetically balanced words and approximately 30% of the spondee words.

In the development of the Semi-Diagnostic Test in Aural Rehabilitation, the use of words as opposed to sentences, paragraphs, etc, developed from initial attempts to discover a rapid and convenient way to analyze errors as are possible with the phonetically balanced (PB) tests. The authors state that these attempts were unsuccessful and that the alternative appeared to be to limit the number of responses by providing a set of answers from which the subject could make his choice.[1] The words finally selected were those which generally met the criteria of A or AA occurence in the Thorndike-Lorge general count[2] in addition to occurrence in the first 2000 words, grades one through four, in Rinsland.[3] The number of items was limited to fifty and two words presented in a series in order to reduce administration time. The list contains eighteen vowel and thirty-two consonant discrimination items; [ð] and [ʒ] are counted as vowels.

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[1]Hutton, Curry and Armstrong, op. cit., p. 317.

[2]E. L. Thorndike and I. Lorge, The Teacher's Word Book of 30,000 Words (New York: Columbia University, 1944).

[3]H. D. Rinsland, A Basic Vocabulary of Elementary School Children (New York: Macmillan, 1947.

In the process of developing discriminating items for a test of visual and auditory discrimination ability, the familiarity of the words chosen as well as the ease or difficulty with which they can be seen and heard are all taken into consideration. Hutton, Curry, and Armstrong[1] attempted to chose familiar words as indicated by their use of the Thorndike-Lorge general count and Rinsland. A year was spent in administering these words to aural rehabilitation clients in an effort to analyze each item to find out how well it was discriminating for auditory and visual stimuli between good and poor listeners; items not proving satisfactory were modified or replaced. Two words (luck and pool) which did not meet the above familiarity criteria in the Thorndike-Lorge general count and seven words (knee, lad, led, pain, seek, vote, wide) which did not meet the Rinsland criteria were included. All of these words met one criteria, and most of them were close to the other. The authors indicate that measurements have indicated that these nine words are useful discrimination items for the purposes of this Semi-diagnostic test. The alternate answers were, as nearly as possible, selected on the basis of the familiarity criterion mentioned previously and which offered little phonemic contrast. In the six forms that are available, the words are presented in various random orders.

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[1]Hutton, Curry, and Armstrong, op. cit., p. 322.

CHAPTER III

SUBJECTS, MATERIALS, EQUIPMENT, TESTING PROCEDURES AND METHOD OF SCORING

A total of seven tests were administered to sixteen subjects. Half of the subjects were tested without their hearing aid first and with their aid secondly; the other half were tested aided first followed by unaided testing. The visual test was always presented first; the speech reception threshold always followed, preceding auditory and combined testing aided or unaided. The auditory and combined auditory and visual tests were presented in random order by consulting a table of random numbers. See Appendix A for the order of test presentation per subject. This was done to randomize the possible effects of practice. Testing time was approximately one hour and fifteen minutes for each subject.

This chapter presents in detail an explanation of the criterion on which selection of subjects was based, the materials and equipment necessary for construction of the tests and their presentation and the procedure involved in administering the tests.

Subjects

For the purpose of this study, subjects were selected between the ages of fourteen and seventy-seven years who had been routinely examined in the Michigan State University Speech and Hearing Clinic or in the Hearing and Speech Department located in the Rehabilitation Medical Center of Edward W. Sparrow Hospital in Lansing. The subject population was restricted to include only those people who met the criteria of a sensori-neural hearing loss as has been defined, and who were wearing a hearing aid. This necessitated an inspection of folders containing audiometric test results which were on file at the two above mentioned facilities. Audiometric test results along with name, age, phone number and address, date of the hearing evaluation, and the specific hearing aid recommended were compiled for each prospective subject. The people on the resulting list were then contacted by phone. Following a brief description of the purpose of the study and what participation in it would entail, they were asked to participate as subjects. Appointments were scheduled at the convenience of the subject. The sample population was composed of fifteen females and one male.

Because of the interest of the investigator in results obtained by hearing aid users in response to visual stimuli, auditory stimuli, and combined auditory and visual

stimuli, the utilization of certain materials and equipment was necessitated.

Materials

The word lists contained in the Semi-Diagnostic Test in Aural Rehabilitation[1] were used in obtaining visual scores and unaided and aided auditory and combined visual and auditory discrimination scores. Essentially the test is a multiple-choice word intelligibility test. Each item contains four answers which are the same except for one sound, e.g. "led, laid, lad, lied." The tests consist of 50 such monosyllabic items.

In order to obtain speech reception thresholds both unaided and aided, the CID Auditory Test W-1 record containing lists 1A and 1B were utilized.

Equipment

In order to test lipreading ability, a filmed test of lipreading was required. Using word stimuli of the Semi-Diagnostic Test, list 1A a female speaker was filmed in color with an 8 mm camera (Yashica U - Matic) at a distance of 10 feet. The film was presented to the subjects using an 8 mm film projector (automatic Bell and Howell, 265 A modified) placed 10 feet from the screen.

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[1]Charles Hutton, loc cit.

An audio tape was made of the word stimuli in lists 1B and 1C of the Semi-Diagnostic Test for presentation to the subjects in order to obtain unaided and aided auditory discrimination scores. The investigator's voice was recorded on audio tape (3M, tenzar 175) utilizing a tape recorder (Ampex, Model 601). A calibration tone was also recorded to facilitate amplifier settings. The tape was played to each subject on a tape recorder (Ampex, Model 601) and presented through the amplifying circuit of a clinical audiometer (Allison, Model 20-A).

Word stimuli contained in the Semi-Diagnostic Test lists 1D and 1E were used in testing subjects' unaided and aided combined auditory and visual discrimination ability. For the auditory live voice presentation, the microphone circuit of the clinical audiometric unit was used, allowing the voice to be heard through a loud speaker in the sound-treated room.

Procedure

1. Test of Lipreading Ability.--Each subject was initially shown a filmed test of lipreading ability. The film was shown in an inside room measuring 13 feet by 13 feet with no windows. The subjects were seated at a table located at a distance of seven feet from the screen. They were provided with a pencil and a blank answer sheet and instructed as follows:

> As you can see by the answer sheet, this is a multiple-choice word test. You will be seeing me on film, but you won't be able to hear me. I will say the phrase, "Number one is . . ." followed by two words. Choose one word from each group of four answers. Draw a line through the words you hear. There will be 25 numbers and every number will be followed by two words. Each time after you have finished marking your answer, look over the following group of words. Then look up at the screen for the next presentation. If you see only a part of the word, make the best guess you can. If you have no idea what the word is, leave that answer blank. The words do not have to be across from each other, and they do not have to mean anything together.

The projector, located ten feet from the screen, was stopped between each presentation to allow the subject to respond on their answer sheet. The projector was started again when the subject looked up at the screen as an indication that he was ready for the next stimulus presentation. A small lamp was placed on the table by the subject to facilitate responding in the darkened room.

Following this test, the subject was taken to the hearing testing suite for the remainder of the testing.

2. Speech Reception Testing.--Both aided and unaided speech reception threshold scores were obtained for each subject. Unaided speech reception thresholds were obtained first on the first eight subjects tested and aided speech reception thresholds first on the remaining eight subjects. For the aided testing, the subjects were asked to set the gain of their aids at the level where it is normally kept

in everyday situations. Employing the CID W-1 recorded lists 1A and 1B, speech reception thresholds were obtained for each subject using the procedure defined in Chapter I. Instructions were to repeat aloud each word as it was heard following the carrier phrase, "Say the word. . ." and to guess even though only a portion of a word might be heard.

3. Discrimination Testing.--Auditory unaided and auditory aided scores were obtained by presenting the taped lists 1B and 1C from the Semi-Diagnostic Test at a a level 30 db above the unaided and aided speech reception threshold levels, respectively. Each subject was again provided with a pencil and a blank answer sheet and instructed as follows:

> You will hear the phrase, "Number one is . . ." followed by two words. Draw a line through the words you hear. If you hear only a part of the word, make the best guess you can. If you hear nothing, leave the answer blank. Again, remember that the words do not necessarily fall across from each other, and they do not have to mean anything together. There will be 25 numbers and each number will be followed by two words.

There was a time allowance of five seconds between each presentation for the subject to record his answers and glance over the next group of words.

4. Combined Auditory and Visual Discrimination Test.--Combined scores were obtained in both aided and unaided situations. Semi-Diagnostic Test lists 1D and 1E

were presented at 30 dB above the speech reception thresholds aided and unaided, respectively. The stimulus material was presented live-voice and delivered to a loud-speaker located in the sound-treated room. The subjects watched the lips of the investigator through a window 32 inches by 22 inches. This window is located in the wall between the sound-treated room and the control room. Additional light was provided from two table lamps located in each corner above the window and focused on the speaker's face. The subjects were instructed as follows:

> This is a test to find out how well you understand words when you can both hear and see the speaker. You will be watching me through this window as well as hearing my voice. I will present a number followed by two words. Do not look away until both words have been presented. Then draw a line through the words you both saw and heard. When in doubt, make the best guess you can, otherwise leave the answer blank. As you finish marking each answer, you may glance over the next number before looking up for the next presentation.

Method of Scoring

A test score was recorded as per cent of the fifty items per test that were correct. In order to obtain each score, it was necessary to use the formula $2(R - \frac{W}{3})$ _____%, where R is the number of right answers and W is the number of wrong answers not including blank answers.

CHAPTER IV

RESULTS AND DISCUSSION

As has been stated, the purpose of this study is to analyze the results obtained from a population of hearing aid users with sensori-neural hearing losses as they respond to auditory and combined auditory and visual tests of speech discrimination both with amplification and without. It is hoped that the results will lead to implications with regard to the potential of a combined auditory and visual speech discrimination test as one of the battery of tests used in the evaluation and recommendation of hearing aids.

With this in mind, two questions were posed:

1. Is the difference between auditory unaided and auditory aided scores significantly different from the difference between the combined auditory and visual aided scores?

2. What are the interrelationships among aided and unaided performances on a visual (lipreading) test, an auditory discrimination test, and a combined auditory and visual test?

The first question has been treated as a null hypothesis which states: There is no significant difference

between the differences in the auditory unaided and the auditory aided scores and the differences in combined auditory and visual unaided and aided scores.

To test this hypothesis, a t-test was employed. The formula utilized for computing the test statistic is the one mentioned by Blalock[1] for dependent samples.

The raw scores for each subject on each test are presented in Table 1. Table 2 presents the differences in scores between the aided and unaided auditory tests of discrimination ability and the aided and unaided combined auditory and visual tests of discrimination ability; the fourth column presents the differences between these differences, and the last column presents the differences between the value in column four and the mean of the column.

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[1]Hubert M. Blalock, Jr., Social Statistics (New York: McGraw Hill Book Company, Inc., 1960) p. 181.

TABLE 1

RAW SCORES FOR EACH TEST
FOR EACH SUBJECT

Subjects	Visual	Unaided			Aided		
		SRT	Auditory	Combined	SRT	Auditory	Combined
1	29%	38dB	95%	97%	33dB	72%	100%
2	24	37	63	82	14	76	84
3	27	35	63	84	28	73	84
4	11	27	77	95	11	81	87
5	53	19	92	92	5	97	97
6	24	40	73	95	30	81	97
7	57	45	92	97	18	87	100
8	36	27	79	83	21	69	97
9	41	54	47	95	15	87	95
10	28	23	89	100	18	84	97
11	27	63	61	81	25	56	87
12	34	45	84	93	20	84	89
13	33	30	95	100	21	91	91
14	52	42	97	95	10	84	90
15	26	50	63	83	40	39	49
16	51	35	84	89	10	65	97

TABLE 2

DIFFERENCES IN SCORES OF AIDED AND UNAIDED TESTS OF DISCRIMINATION

Subjects	Percent Differences			
	D_{1-2}	D_{3-4}	$D_{1-2} - D_{3-4}$	$X_D - \overline{X}_D$
1	23%	- 3%	26	25.5
2	-13	- 2	-11	-11.5
3	-10	0	-10	-10.5
4	- 4	8	-12	-12.5
5	- 5	- 5	0	.5
6	- 8	- 2	- 6	- 6.5
7	5	- 3	8	7.5
8	10	-14	24	23.5
9	-40	0	-40	-40.5
10	5	3	2	1.5
11	5	- 6	11	10.5
12	0	4	- 4	- 4.5
13	4	9	- 5	- 5.5
14	13	5	8	7.5
15	24	34	-10	-10.5
16	19	- 8	27	26.5

Key: 1 is auditory unaided
2 is auditory aided
3 is combined unaided
4 is combined aided
$\overline{X}_D$ is mean of the differences or .5

A plus means that the higher score was obtained in the unaided situation. A minus means that the higher score was obtained in the aided situation. For example minus 13% indicates that this particular subject performed better with his hearing aid than without it.

In both columns, a score of zero means that the subject's scores were the same under both conditions.

With fifteen degrees of freedom, a probability of .01 corresponds to a t of 2.947. The obtained t value is .12; thus the null hypothesis as stated cannot be rejected. This indicates that difference scores are not affected by the addition of amplification of a hearing aid. This may have certain implications with regard to a clinical situation; namely that the battery of tests now utilized by the audiologist are adequate in evaluating hearing aids. Another implication might be that the visual factor does not sufficiently improve discrimination ability in a testing situation to warrant its use in the evaluation of hearing aids.

Table 3 shows the mean discrimination scores for all unaided and aided conditions.

TABLE 3

MEAN DISCRIMINATION SCORES

	Mean Per Cent
Auditory Unaided	78
Auditory Aided	76
Combined Unaided	80
Combined Aided	78

Referring to the raw scores in Table 1, it can be observed that the addition of a hearing aid for the auditory test improved scores for only seven of the sixteen subjects. In all instances the combined unaided scores are better than the auditory unaided which would seem to indicate that without the benefit of a hearing aid, the subjects tended to utilize visual cues. In addition the combined aided scores were better than the auditory aided and for all but one subject the combined unaided scores were better than the auditory aided. Some distortion in auditory discrimination with the addition of a hearing aid and greater dependency on visual cues in the unaided combined situation may provide a possible explanation for this.

Six subjects show higher scores for the unaided combined auditory and visual test than for the aided combined

test. It seemed that these people had a tendency not to watch the speaker's lips as carefully when wearing their hearing aids because they seemed to feel that their hearing aid was providing them enough information without having to rely on lipreading. In many instances, this was not so as is evidenced by the raw scores presented in Table 1.

The above observation may, in part, account for the mean scores presented in Table 2. In both instances the unaided scores for both the auditory and combined auditory and visual tests are slightly higher although not significantly so. However, in referring to Appendix A, there appears to be some rather significant differences in certain individual's aided and unaided scores under both conditions, yet favoring the unaided condition.

A possible explanation for this finding has been presented relative to the combined scores. The discrimination scores favoring the auditory unaided situation are not unusual as the review of the literature pertaining to hearing aid evaluations reveals that for persons with a sensori-neural hearing loss the addition of a hearing aid, while improving the speech reception threshold, may not necessarily improve the discrimination ability. The raw scores, both speech reception thresholds and aided and unaided auditory scores, obtained in this study appear to

confirm this. These findings would seem to indicate the importance of counseling, auditory training and lipreading for persons wearing hearing aids.

Because interest here is focused on the exploratory task of discovering the possible interelationships among aided and unaided performance on a visual (lipreading) test, an auditory discrimination test, and a combined auditory and visual test, the Pearson Product Moment Correlation[1] was utilized as the measure of relationship. The correlations are presented in Table 4.

TABLE 4

CORRELATIONS BETWEEN DISCRIMINATION SCORES UNDER THREE TYPES OF PERCEPTION

	Auditory Unaided	Combined Unaided	Auditory Aided	Combined Aided
Auditory Unaided	0			
Combined Unaided	.59	0		
Auditory Aided	.43	.69	0	
Combined Aided	.43	.51	.69	0
Lipreading	.13	.20	.33	.81

[1]Blalock, op. cit., p. 287.

According to Edwards,[1] in order to be significant from a zero correlation, the coefficient values must be equal to or exceed .50 at the .05 level of significance. Referring to Table 4, five correlations exceed .50; these are the correlations between unaided combined auditory and visual test scores and unaided auditory test scores: aided auditory scores and combined unaided scores, combined aided and combined unaided scores, aided combined scores and aided auditory scores, lipreading scores and aided combined auditory and visual scores.

The almost randomness with which the significant correlations appear makes meaningful analysis difficult. No significant correlation was anticipated between lipreading and auditory performance; other positive correlations, however, such as the correlation between lipreading and aided combined auditory and visual performance appear reasonable, because both involve the use of visual cues.

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[1]Allen L. Edwards, Statistical Methods for the Behavorial Sciences (New York: Holt, Rinehart and Winston, 1961), p. 502.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR FURTHER STUDY

Since the principal function of a hearing aid is amplification of speech, its use if reserved for individuals with diminished ability to hear speech. There are, however, individuals who experience a great deal of difficulty as hearing aid wearers. The use of a hearing

> If there exists a reduced tolerance for high intensity sounds together with a markedly poor ability to discriminate the sounds of speech, then the prognosis for a successful hearing aid is poor.[1]

aid should not be ruled out without an investigation of the benefit visual cues will have in supplementing auditory improvement. Hearing aids, however, are evaluated by the wearer's performance on a test of auditory stimuli and recommendation may be based primarily on improvement in speech reception threshold scores. The recommendation of an aid is usually accompanied by recommendation of auditory training and lipreading training under the assumption that the communication effectiveness of the individual will be improved when lipreading is combined with auditory amplication.

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[1]Heller, op. cit., p. 167.

A clinical impression exists that some clients demonstrating sensori-neural hearing losses perform better communicatively with a hearing aid in a face-to-face communication situation than their auditory scores alone would indicate. Is a visual factor, which is not present when evaluating auditory improvement, supplementing the auditory amplification in a face-to-face speaking situation? Certainly the advantage of visual cues is available in a normal communication situation. If an individual is capable of utilizing visual cues to the extent that auditory amplification combined with visual cues provides improved communication effectiveness, whereas without it, auditory discrimination scores would not indicate a successful prognosis with an aid, then the possibility exists of a more functional test of communication effectiveness in hearing aid evaluations.

The purpose of this study has been to analyze the results obtained from hard-of-hearing persons with sensori-neural losses as they responded to aided and unaided tests of discrimination ability under three types of perception: visual (lipreading), auditory, and combined visual and auditory. This was done in an attempt to determine the potential of including a test of combined auditory and visual discrimination ability in the battery of tests now used in evaluating hearing aids.

The overall communication effectiveness of a hard-of-hearing individual as determined by various hearing aids is now evaluated under varying conditions, i.e., signal-to-noise ratio, tolerance level, threshold for the intelligibility of speech, etc. The individual's ability to utilize visual cues as a supplement to the amplification afforded him by a hearing aid is generally not measured. The importance of this study centers around the possibility of providing another measure of communication effectiveness through the use of combined auditory and visual cues in the evaluation of hearing aids for persons with sensori-neural hearing losses.

A review of the literature concerning the role of visual and auditory components in communication, the procedures for hearing aid evaluations, and the tests of lipreading ability all indicated that, while the role that lipreading plays in the communication of both normal hearing and hard-of-hearing individuals is generally accepted, no attempt has been made to measure this during routine hearing aid evaluations. Several studies have, however, investigated the combined factors in signal-to-noise ratios. The tests of lipreading ability are numerous; however, not until Hutton's development of the Semi-Diagnostic Test in Aural Rehabilitation was there a test designed to measure all three conditions of perception, i.e. visual, auditory, and visual and auditory combined. The potential of the

use of this test as a measure of communication effectiveness in the evaluation of hearing aids is based on Hutton's findingsthat it retains its sensitivity in repeated presentations.

The subjects for this study were sixteen hearing aid users with sensori-neural hearing losses, the subjects ranged in age from fourteen to seventy-seven years. All had been tested previously in the Hearing and Speech Department in Sparrow Hospital in Lansing or at the Michigan State University Speech and Hearing Department, and their audiometric results indicated an air-bone gap of not more than 10dB in the speech frequencies and at least a 10% discrimination loss. These people were tested for lip-reading ability by means of the presentation of a color film of a female speaker using list 1A of the Semi-Diagnostic Test in Aural Rehabilitation. Under both aided and unaided conditions, speech reception thresholds were obtained for each subject and discrimination scores were obtained from the presentation of auditory stimuli and combined auditory and visual stimuli all presented at 30dB above the aided and unaided speech reception threshold scores, respectively. Testing was done individually and lasted approximately one hour and fifteen minutes per subject. The subjects recorded their responses on answer sheets provided with the exception of speech reception threshold testing which was conducted in the conventional manner.

The findings of this study indicate that there was no significant improvement in discrimination scores when the utilization of a hearing aid was supplemented with visual cues.

Conclusions

Within the confines of this study the following conclusions seem warranted:

1. There was no significant improvement in discrimination ability with the addition of a hearing aid in the subject's scores on the combined auditory and visual test. It appeared that in the testing situation, subjects depended upon lipreading to a greater extent when they were not wearing their hearing aids. With the addition of the hearing aid, the subjects seemed to feel that sufficient auditory amplification was provided so as not to warrant dependency on visual cues.

2. The unaided auditory discrimination scores were generally better than the aided discrimination scores. All aided speech reception thresholds were considerably improved over unaided speech reception thresholds. This serves to further confirm the generally accepted notion that persons with sensori-neural hearing losses frequently have difficulty wearing a hearing aid because of distortion problems.

3. The feasibility of the Semi-Diagnostic Test as a clinical measure of lipreading ability, auditory discrimination ability and combined auditory and visual discrimination ability appears favorable. A limitation posed, however, is one of expense due to the tapes and two films, one a sound film, necessary for presentation of the stimulus words.

4. The combined unaided scores were improved over both aided and unaided auditory scores; thus the subjects appeared to be utilizing lipreading to supplement their residual hearing.

5. The combined aided scores were better than the auditory aided as would be expected when a hard-of-hearing person is afforded visual cues to supplement amplification provided by a hearing aid.

6. The unaided combined scores were improved over the visual test scores; thus, the addition of auditory cues with visual cues improves discrimination ability.

7. It would appear that an Aural Rehabilitation program should be provided for those persons who have received the recommendation of a hearing aid.

Implications for Further Study

The possibility of a test of combined auditory and visual discrimination ability as a measure of the communication effectiveness of potential hearing aid

users appears to be an area of study that warrants complete and thorough investigation. Raw data as was collected for this study should be gathered from a larger population, if possible. It might prove worthy of investigation to utilize the Semi-Diagnostic Test on subjects immediately following the recommendation of a hearing aid and then retesting six months later to determine improvement in communication effectiveness. An interesting aspect would be a comparison of types of errors made on each test of discrimination ability and then to determine whether errors in auditory discrimination are improved with the addition of visual cues and whether errors in visual discrimination are improved with the addition of a hearing aid.

The present study also indicates a need for the establishment of norms for the Semi-Diagnostic Test at various age levels.

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APPENDICES

APPENDIX A

ORDER OF TEST PRESENTATION PER SUBJECT

Subjects	Visual	SRT_u	SRT_a	$Auditory_u$	$Auditory_a$	$Combined_u$	$Combined_a$
1	1	2	5	3	6	4	7
2	1	2	5	4	7	3	6
3	1	2	5	4	7	3	6
4	1	2	5	4	6	3	7
5	1	2	5	4	6	3	7
6	1	2	5	3	7	4	6
7	1	2	5	4	6	3	7
8	1	2	5	4	6	3	7
9	1	5	2	7	4	6	3
10	1	5	2	6	3	7	4
11	1	5	2	7	3	6	4
12	1	5	2	6	3	7	4
13	1	5	2	7	3	6	4
14	1	5	2	7	4	6	3
15	1	5	2	6	4	7	3
16	1	5	2	7	4	6	3

Key: SRT is Speech Reception Threshold
U is unaided
A is aided

APPENDIX B

SUBJECT RESPONSE SHEET

Client_____ Score $2(R-\frac{W}{3})$_____%

Date _____ Wrong _____

Right _____

DRAW A LINE THROUGH THE WORD YOU HEAR

1.	fell	*men	10.	at	with	19.	day	wear
	*fill	man		add	will		way	*bear
	feel	mine		am	wish		*lay	pair
	full	mean		*an	win		ray	dare
2.	*fur	play	11.	by	tame	20.	is	seed
	fire	plane		tie	*same		if	*seen
	fair	plate		high	shame		ill	sing
	far	*played		*pie	came		*it	seem
3.	lake	it	12.	she	sat	21.	ice	*won
	lack	*eat		key	*sit		I've	run
	*like	ate		*tea	set		I'd	gun
	luck	at		see	seat		*eyes	fun
4.	boy	lied	13.	get	*wood	22.	such	*then
	low	led		met	what		*some	pen
	go	laid		let	wide		song	ten
	*row	*lad		*yet	word		sun	hen
5.	wool	wipe	14.	boat	*nut	23.	*ten	seed
	we'll	*wife		note	net		pen	seen
	well	wise		*vote	not		when	seat
	*will	white		wrote	night		then	*seek
6.	*led	play	15.	boil	coat	24.	chained	for
	less	plays		bull	*cut		chains	fair
	let	plate		*bowl	cat		*change	*far
	leg	*place		ball	caught		chair	fur
7.	pile	died	16.	*wide	*wing	25.	born	they
	*pool	dead		ride	wind		been	gay
	pull	*did		lied	will		barn	*day
	pole	dad		died	win		*burn	bay

8.	*pain	rise	17.	catch	*knee
	pine	*lies		*cat	be
	pen	wise		can	we
	pan	dies		cap	me
9.	pool	look	18.	bite	see
	fool	lock		light	key
	tool	lake		*night	*he
	*cool	*luck		might	tea

*indicates correct responses