DOCUMENT RESUME

ED 024 207 40 EC 003 376

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Evaluation of Two Measures of Speech Hearing for Hearing Impaired Children. Final Report.
Pennsylvania State Univ., University Park. Speech and Hearing Clinic.
Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No-BR-6-1159
Pub Date Jun 68
Grant-OEG-32-48-0720-6012
Note-98p.
EDRS Price MF-$0.50 HC-$5.00
Descriptors-Auditory Discrimination, Auditory Evaluation, Auditory Tests, Auditory Visual Tests, *Aurally Handicapped, Correlation, Evaluation Techniques, *Exceptional Child Research, Hard of Hearing, Hearing Loss, Testing, Test Reliability, Test Results, *Tests, Test Validity
Identifiers-DIP, Discrimination by Identification of Pictures Test, Threshold by Identification of Pictures Test, TIP

The Threshold by Identification of Pictures (TIP) Test and the Discrimination by Identification of Pictures (DIP) Test were evaluated. Test cards used pictures of items from the first 500 words of Basic Vocabulary for Elementary Children, and the children pointed to the article named. After each item, the tester's voice was reduced 5 decibels. In the DIP test, pictures were arranged in rhymed pairs with a distinction in consonants between the two word items. Of the 202 subjects, a random selection of 138 was used for final data analysis. Subjects were grouped by year (age range 4-10 to 12-10 years), had an IQ over 90, and included a variety of degrees, types, and patterns of hearing loss. All were screened for significant visual, neurological, motor, and emotional problems. It was concluded that the TIP and DIP tests were satisfactory measures, with a threshold correlation of .88 to .98 with pure tone thresholds for the TIP test and a test reliability of .60 to .84 for the DIP test. Twenty-six references and 21 tables are given. (Author/SN)

FINAL REPORT

PA 40

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JUNE 1968

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education

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EVALUATION OF TWO MEASURES OF SPEECH HEARING FOR HEARING IMPAIRED CHILDREN

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June 1968

(The research reported herein was performed pursuant to a grant with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.)

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

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ACKNOWLEDGEMENTS

The authors wish to extend their appreciation to the many individuals and agencies whose participation in this project and whose encouragement made it possible to accomplish the results described herein.

We are particularly grateful for the contributions of time given by the hearing impaired children of Centre County, Lancaster, Philadelphia, and Montgomery County, all in Pennsylvania. We also wish to recognize the support of the administrators of the various school districts and of the teachers who so willingly cooperated in explaining our project to the children involved.

The graduate students who served as research assistants both at the Penn State facility and at the various locations where data were collected committed their time and effort enthusiastically to make this study possible.

Our special appreciation is extended to Dr. Jack Sparks, formerly Assistant Professor in the Department of Educational Psychology at the Pennsylvania State University, who served as statistical consultant. We also wish to thank Mr. Ken Deagman, who gave most generously of his time and skills as statistician and computer specialist. Their advice and imagination were invaluable in the computation and interpretation of results.

B.M.S.
G.S.H.

SUMMARY

The purpose of this research was to investigate the usefulness of the Threshold by Identification of Pictures (TIP) and of the Discrimination by Identification of Pictures (DIP) tests for testing the speech hearing ability of hard-of-hearing children.

The TIP and DIP tests, developed by previous research of the present authors require the subject to point to pictures of common objects. The TIP test follows the usually accepted criteria for threshold tests, although the procedure is adapted for children. The DIP test is based upon the phonetic factors of contrasts in voicing of consonants, continuant-plosive patterns of consonants, and contrasts in transitional patterns (influence) among phonemes in words.

In the present study 202 subjects were tested, and from this pool 138 were used for the final experimental group. The age range was five to thirteen years. Subjects presented a variety of types of hearing losses (conductive, sensori-neural, mixed), degrees of reduction in hearing acuity (mild to profound), and audiometric configurations (flat, rising, marked and gradually falling, and trough).

Testing of subjects included an otological inspection, pure tone audiometrics by AC and BC, TIP test threshold (test and retest) and DIP test at the levels of individual SRT + 5dB, SRT + 10dB, and SRT + 25dB.

Statistical analysis included a numerical taxonomic procedure to identify naturalistic subject sub-groups on

the basis of test performance. Subjects were also divided into sub-groups according to type, degree and pattern of hearing loss, followed by analysis of variance procedure for comparing the performance of groups, and product moment and other correlational methods for estimating test reliability.

The general conclusions drawn from this study are:

1. The TIP test is appropriate for measuring air conduction speech reception threshold among hearing impaired children with a variety of types, degrees and patterns of hearing loss. TIP test scores had coefficients of correlation with pure tone threshold average of .88 to .98 for most subject sub-groups, but with coefficients of correlation as low as .51 (significant at .01) in some cases.
2. The TIP test forms A and B are essentially equivalent for hard-of-hearing children, having a test score correlation of .89 to .99 across subject sub-groups.
3. The DIP test is appropriate for measuring speech hearing discrimination among hard-of-hearing children with a variety of types, degrees, and patterns of hearing loss.
4. DIP test scores have satisfactory reliability (reliability coefficients of .60 to .84).
5. DIP test discrimination curve slope between SRT + 5dB and SRT + 10dB is 1.14 items (2.4 per cent) per dB for hearing impaired children.

CHAPTER I. INTRODUCTION

The measurement of speech-hearing ability in the young school-age and preschool-age child has been of concern to the audiologist and to educators of the hearing handicapped for many years. Recently this concern has heightened because of the gains in knowledge concerned with the habilitation needs of the very young deaf child. It has become increasingly more important to identify hearing impairment as early as possible and to assess speech-hearing ability in order to mount appropriate therapy and educational programs. The development of the Threshold by Identification of Pictures (TIP) test and the Discrimination by Identification of Pictures (DIP) test (Siegenthaler and Haspiel, 1966) has made it possible to describe the speech-hearing function in the normal child at least as young as three years of age. This previous study demonstrated that the TIP and DIP tests were valid and reliable measures for young normal children and that they could be administered easily in the usual audiologic facility. It showed also that both threshold and discrimination scores improved as a function of age.

It was the purpose of the present study to investigate the usefulness of the TIP and DIP tests with a group of young hearing impaired children with no major difficulties other than hearing impairment. The research effort was designed to answer questions concerning the relationship between audiogram shape, etiology of hearing loss, severity and hearing for speech discrimination and for speech reception threshold using the TIP and the DIP tests.

The previous succes ful application of these two measures with normal children permits them now to be evaluated with hearing impaired children. The knowledge gained in the present study may permit categorization of hearing impaired children by DIP and TIP scores into groups which can be treated using various remediation procedures. Eventually, it is hoped that it will be possible to describe specific therapy and educational measures which are appropriate for individuals whose TIP and DIP scores classify them as children who would benefit from particular treatment measures.

Eventually, the procedures will be investigated for use with multiply handicapped children whose problems include mental retardation, neuromuscular difficulty, cerebral dysfunction, and emotional adjustment.

CHAPTER II. BACKGROUND OF THE PRESENT STUDY

While many facets of auditory function can be described as being important for the individual's ability to hear speech, two dimensions of hearing appear to be of primary importance. These are sensitivity and discrimination. These factors play fundamental roles in auditory behavior and require detailed investigation if we are to understand the limitations imposed by the presence of a hearing impairment upon an individual's behavior.

The clinical audiologist is often called on to measure hearing functions in children of school and preschool ages. Such factors as short attention span, shyness, lack of interest, and inability to comprehend the task make child-testing a problem even for children who do not have hearing losses and who are able to respond.

In the examination of hearing impaired children these same problems exist, usually in an exaggerated form, and are accompanied by others such as reduced vocabulary, lack of experimental development, and unintelligible speech. All of these factors combine to make the audiological testing of the hearing impaired child a difficult task, and the interpretation of responses often more of an art than a science.

Adequate tests of speech-hearing capacity contribute to improved descriptions of the ability of a given child to function in a particular educational situation. To place a child with good residual hearing in a deaf education program, or to place a deaf child in a hard-of-hearing class can do irreparable harm to the educational achievements of both. Similarly, to put an inappropriately high or low gain hearing aid on a child can cause difficulty in his school adjustment. Unfortunately, the audiologist is frequently required to make decisions and recommendations on the basis of inadequate information, or on the basis of misinformation, in part, because he does not have speech-hearing measures which are standardized for use with the hearing impaired child.

Place of Speech-Hearing Tests in Audiological Practice and Research

The place of speech reception testing has become firmly established in audiological research and in audiology clinic practice. Fry (1964) indicated that speech audiometry enables the audiologist to gain an estimate of how far the linguistic processing ability is able to compensate for faults in the acoustic processing apparatus. In his work on auditory localization among clinic patients and normal hearing subjects, Hochberg (1966) used speech stimuli for studying median-plane localization. As an extension of this research, Aungst (1966) studied the sound localization ability in normal children using speech stimuli in order to provide an audiological base line for this type of behavior.

Speech stimuli also have found use in recent studies on the cerebral dominance for the hearing of speech (Kimura, 1963; Dirks, 1964). As a result of these research efforts there is the strong possibility of a cerebral dominance for speech, namely that the left cerebral hemisphere, associated with stimuli from the right ear, is the dominant hemisphere.

The use of speech audiometry, often with special modifications, in the assessment of central nervous system problems has seen considerable development in the last few years. Quist-Hanssen (1960) studied patients with brain atrophy, and found that especially with frequency filtering there was a marked reduction in the intelligibility of speech stimuli. Goldstein (1961) was able to test a patient with a left hemispherectomy. The patient showed reduction, especially for the right ear, of speech reception-discrimination. Kimura (1961) in testing the speech hearing ability of subjects with epileptic lesions in various areas of the brain, found reductions in hearing ability associated with the pathology. Other authors (Feldman, 1962; Groen, 1962) used binaural speech audiometry in attempts to investigate the hearing dysfunction caused by central nervous system problems. Other representative studies (although by no means a complete listing of such) are those by Groen, (1963), Davis (1964), and Gray, D'Asaro and Aklar (1965). All of these authors were interested in the diagnosis of central auditory problems.

Speech reception tests, both for threshold and for discrimination, are considered basic procedures for the clinical audiologist (O'Neill and Oyer, 1966). The good agreement between pure tone hearing and speech reception threshold, especially for conductively impaired audiology patients is well known to the clinical audiologist. The less good agreement in the case of the sensori-neural client is also observed by the audiologist, who also utilizes speech materials to observe such symptomatology as phonemic regression in the presbycusic patient and reduction in intelligibility for high intensity signals as in the patient with cochlear impairment.

From the viewpoint of the audiologist interested in aural rehabilitation, especially when he uses acoustic remediation, the ability to hear speech is one of the primary indicators both of the degree of handicap, and the degree to which the rehabilitation measures are effective. That is, the aural rehabilitation audiologist looks upon ability to hear speech as the primary measure of the patient's disability, and of the effectiveness of remediation. When measuring the effectiveness of hearing aids the speech audiometry techniques of the audiologist are his most commonly used procedures. The rationale, as indicated above, is that the main measure of a client's hearing disability is his inability to hear and understand speech. Therefore, the effectiveness of a hearing aid is indicated by restoration of speech-hearing ability. In the more recent audiological literature such use of speech audiometry has been discussed by Decroix and Dehaussy (1964) and Reddell and Calvert (1966). Miller and Niemoeller (1967) demonstrated by intensive study of a single case the use of speech audiometry for hearing aid advisement.

Among the newer developments in hearing aid advisement is the CROS type of fitting (Dodds and Harford, 1968). In the research on this type of hearing aid fitting, speech audiometry is the major method for evaluating the effectiveness of the instrument.

Previous Work on Present Test Procedures

The present authors have completed a two year test development project sponsored by the U. S. Office of Education (Siegenthaler and Haspiel, 1966b). These tests for threshold (TIP) and discrimination (DIP) are especially adapted for use with children. The DIP test is based upon distinctive phonetic features rather than upon the concept of phonetic balance. Because of their underlying rationale and construction, the TIP and DIP tests are believed to be significant improvements over the currently available threshold and discrimination tests for children. The need for speech-hearing tests specifically designed for hearing impaired children is best indicated by the following statements:

> During the past decade, measurement of hearing in children has resulted in more quantifiable information than perhaps in any preceding ten year period. In spite of this, paedo-audiology remains in its infancy. . . Speech audiometry with non-handicapped children has not been systematically pursued to any great extent. Many problems exist in utilization of speech materials as the stimulus for the measurement of hearing. . . Standard or modified forms of speech audiometry to date have not been shown to be good predictors of academic and/or speech and language success (in children) . . . (Frisina, 1963).

The previous research (Siegenthaler and Haspiel, 1966a) demonstrated the essential equivalence of forms A and B of the TIP test, and of the three forms of the DIP test. In addition, test reliability is satisfactory. An important finding of the research is that there is a significant age effect, with older children receiving better threshold scores and higher discrimination test scores, especially until the age of approximately eight years.

Description of the TIP test. Form A of this test is composed of a set of six cards, 8 1/2 x 11 inches in size carrying five colored pictures per card (for example: fish, dog, house, ball, comb). The specific test items were chosen by previous research for familiarity to children, to be unambiguous in name, and to have specific degrees of audibility. All appear among the first 500 words of Basic Vocabulary for Elementary School Children, H. A. Rinsland, New York: MacMillan, 1945. The first card is for practice, and the remainder are test cards. The child is presented one card at a time, and told "Point to the __________," according to the prepared test protocol using the tape playback of the speech audiometer. Five responses are obtained using the pictures on the card. After each item the tester's voice level is reduced five decibels. The first item on each card is at the original beginning level, 10-15 decibels above estimated threshold. The test obtains 25 responses from the five cards and permits the obtaining of the decibel level for a 50% threshold using either the graphic or the tabular method. Form B protocol is the same as Form A but the picture items are different. See Table 1 for the TIP test items.

Description of the DIP test. The DIP Test is composed of 52 cards (four practice and 48 test items) 8 1/2 by 11 inches in size, with two pictures per card, in color. The subject is told to indicate one of the items on each card by the phrase "Poirt to the __________," according to the prepared test protocol, using the tape playback of the speech audiometer. After each item, the card is turned down exposing the next pair of pictures. The pictures are of things familiar to children, unambiguous in name, and arranged in pairs to be different in the distinctive features of voicing of consonants (for example, pear-bear), of transition (for example, peas-keys) or pressure pattern of consonants (for example, hat-cat), or of combinations of these phonetic factors. All words appear in The Teacher's Word Book of 30,000 Words (B. Thorndike and I. Lorge, Teacher's College, Columbia University, New York, 1944) among the "most familiar" category. Scoring is according to correct and incorrect selection of the item called for in each pair, and provides an overall per cent correct. On the average, chance factors produce a fifty per cent correct score; the critical score is per cent correct in excess of fifty per cent. Three forms (sets of call words) of the DIP have been developed from the basic pool of 52 items. Form II is an opposite form of Form I, while Form III is a random grouping of the 52 items. See Table 2 for the DIP test items.

Table 1. Word-pictures on the TIP test cards.

TIP Form A					
Practice Card A	Card A1	Card A2	Card A3	Card A4	Card A5
bread	dog	house	top	house	key
cap	hand	bus	horse	comb	train
chair	cake	dress	ball	cup	milk
car	stove	kite	cat	clock	eyes
shoe	truck	flag	fish	drum	stone
TIP Form B					
Practice Card B	Card B1	Card B2	Card B3	Card B4	Card B5
shoe	plane	gum	fish	clown	blocks
car	cow	hand	lamb	skates	watch
swing	pie	hat	top	man	doll
chair	socks	boat	frog	comb	tree
dog	door	bed	corn	gun	knife

Table 2. Word-pictures appearing on DIP test cards.

Card	Word Pair		Card	Word Pair	
Practice A	cat	dog	VI-23	pot	dot
Practice B	chair	boat	VI-24	cone	bone
Practice C	key	kite	VI-25	key	bee
Practice D	kite	coat	VP-26	nail	sail
			VP-27	pen	men
V1	bear	pear	VP-28	gun	sun
V2	dear	tear	VP-29	feet	beet
V3	peas	bees	IP-30	bat	cat
V4	fan	man	IP-31	fire	tire
V5	goat	coat	IP-32	horn	corn
I-6	key	pea	IP-33	pear	hair
I-7	pup	cup	IP-34	log	dog
I-8	boat	goat	IP-35	fan	can
I-9	tea	pea	IP-36	cheese	peas
P-10	meat	beet	IP-37	shoe	two
P-11	saw	paw	VIP-38	light	kite
P-12	chain	cane	VIP-39	bees	cheese
P-13	seal	wheel	VIP-40	toes	rose
P-14	cheese	keys	VIP-41	rain	cane
P-15	ring	wing	VIP-42	bat	hat
P-16	bat	rat	VIP-43	thumb	gum
P-17	tail	sail	VIP-44	log	hog
VI-18	coat	boat	VIP-45	door	four
VI-19	toe	bow	VIP-46	can	man
VI-20	toy	boy	VIP-47	suit	boot
VI-21	tack	back	VIP-48	hair	bear
VI-22	cat	bat			

V - indicates voicing difference of initial consonants.
P - indicates pressure pattern differences of initial consonants.
I - indicates influence pattern differences of initial consonants.

Cards 18-48 are of items differing in more than one phonetic factor, as indicated. All cards are numbered consecutively.

Purpose of Present Project

The first step in a longer range research plan by the present authors has been accomplished by the development of the TIP and DIP test materials, and their standardization by the obtaining of norms on normal hearing children. This research also provides a base line of normalcy against which to judge the behavior of hearing impaired children seen in the audiology clinic; however, the test procedures require validation both through use and through test response analysis, on representative hearing impaired children.

Therefore, the present study utilized the TIP and DIP test with peripherally hard-of-hearing children between the ages of five to thirteen years inclusively. Performance with these tests was studied with subjects having a variety of types of impairment, degrees of loss, and audiometric patterns.

Several reasons exist for selecting the peripherally hearing impaired child for study at this time, and as the second step in our research program with the TIP and DIP tests. There is a need for tests which are suitable for hearing impaired children; these children form the largest single group with auditory dysfunction, and there are fewer problems present other than auditory dysfunction among them so that there are fewer variables to control when experimenting with such children. As we acquire more knowledge about the less complex groups from an audiological point of view we will be better able to assess the performance of children who are considered to be more difficult test subjects.

The general objective of this research is to determine the behavior of peripherally hearing impaired children, using TIP and DIP tests. This behavior is in terms of numerical test scores (dB threshold for TIP test and per cent items correct for DIP test, reliability of test scores, interrelationships among test scores, and relationships between TIP and DIP test performance and usual audiological-otological classifications). These purposes did not easily lend themselves to the usual formulation of hypotheses.

However, the statement of objectives is closely interwoven with the experimental strategy used for this research, as follows:

1. The experimental test performance scores for each subject were entered into a correlational matrix and a follow-up numerical taxonomic procedure (inverted factor analysis) was done. From this was obtained natural subgroups, which were inspected for commonalities and differences according to standard audiological-otological criteria.

2. These subgroups (from one above) were compared on the basis of standard audiological-otological data, including pure tone audiogram average loss, audiogram shape, and type of etiology, TIP test threshold, DIP score at SRT + 5dB, SRT + 10dB, SRT + 25dB, and articulation function slope.

3. A third analysis of the data was done following a more conventional procedure. That is, the subjects were divided into subgroups according to standard audiological-otological aspects (pure tone audiogram average, audiogram shape, type of etiology, and so forth). The available subgroups were compared on experimental test scores according to the following experimental questions:

    a. What is the relationship between scores obtained with the TIP test and pure tone averages through the speech range for children with various types, degrees, and patterns of hearing loss?

b. What is the reliability of TIP test scores by children with various types, degrees, and patterns of hearing loss?

c. What is the slope and level of the intelligibility curve for the DIP test scores at presentation levels of SRT + 5dB and SRT + 10dB for children with various types, degrees, and patterns of hearing loss?

d. What is the relationship between maximum intelligibility score on the DIP test (at SRT + 25dB) and types, patterns, and degrees of hearing loss?

e. What is the reliability of scores obtained on the DIP test for types, degrees, and patterns of loss?

f. What are the relationships among TIP threshold scores, DIP scores at each presentation level, and DIP intelligibility function slope for children with various types, degrees, and patterns of hearing loss?

In this report the term intelligibility and the term discrimination are used interchangeably when referring to subject performance on the DIP test. The original plan used the term intelligibility but because of the nature of the subjects' task on the DIP test, namely choosing one of two items, to many readers the term discrimination may seem more appropriate. In the latter parts of this report discrimination is commonly used.

Hearing loss and hearing level will also be used interchangeably when referring to levels of hearing acuity or severity of loss. Both terms will refer to threshold deviation from audiometric 0dB (as for normal hearing subjects).

CHAPTER III. PROCEDURES

Subjects

For this study children who were normal, with the exception of varying degrees of peripheral hearing impairment, and who were between the ages of four years, ten months and twelve years, ten months were tested.

The sample of subjects was obtained in the following manner:

1. Audiologic records of children seen recently in the Audiology Program of the Pennsylvania State University Speech and Hearing Clinic were screened to find subjects who satisfied the following criteria for inclusion (these criteria also were applied for inclusion of subjects from other areas of the state):
   a. Appropriate age (four years, ten months to twelve years, ten months)
   b. Peripheral hearing loss between 15dB and 90dB ISO (two frequency average through the speech range)
   c. Psychological tests indicating at least normal intelligence (IQ over 90).
   d. No significant visual, neurological, motor, or emotional problems.

e. Recent otological diagnosis of conductive, sensori-neural or mixed peripheral hearing loss.

2. Permission was obtained from the parents to permit their children to participate in the study.

3. A testing schedule was arranged which coincided with the time when the children would normally be seen for re-evaluation at the Penn State facility. This schedule was occasionally modified to bring children at a time when they could be included in a particular desired age range.

4. In order to obtain additional subjects and to obtain a representative geographic and sociologic sampling, children were selected from Centre County and Montgomery County, Pa., and from Lancaster and Philadelphia, Pa. Education and hearing centers in these areas were contacted and were asked to provide the names of children who satisfied our criteria for subjects.[1] Permission was obtained from the parents to test their children for this project.

5. For every child a recent otological examination report describing etiology was obtained. (The report was no more than one month old, and the otological diagnosis was supported by the current air and bone conduction audiograms.) School

[1]The sources of subjects were public school rolls of Centre County, the Special Education School of Montgomery County, the Lancaster Hearing Center case load, and the Pennsylvania School for the Deaf in Philadelphia.

administered psychological test scores were obtained for nearly all subjects. In some instances, valid intelligence quotient measurements were not available and children were accepted for inclusion in this study when their teachers described them as performing at appropriate levels as compared to children of similar chronological age. In addition, evidence for lack of emotional instability was determined from case history information, interviews with the parents and/or educational personnel familiar with the child. For children not presenting recent otological examinations, a medical examination of the ears was done by the Penn State Audiology Program consultant.

6. Each child was given a pure tone threshold test in each ear by air conduction for the audiometric octave frequencies 250-4000 Hz. Bone conduction tests were performed for each ear for frequencies 250-4000 Hz, with masking used as needed. All tests were done using a descending-ascending-descending series of threshold estimates at 5dB intervals, with threshold recorded as the lowest level at which two of three tones presented were heard. Either a Maico MA-2 or Beltone Model 15-C audiometer was used for all testing. Weekly calibration checks were made with a Bruel and Kjaer audiometer calibration system model 158. ISO 1964 calibration values were used.
7. An analysis of the otological report and relationships between air conduction and bone conduction

results was done to classify the subjects as having conductive impairments (air-bone gap of at least 20dB, and otological diagnosis), sensori-neural impairments (air-bone gap no more than 10dB, and otological diagnosis), or a mixture of the two.

8. The audiogram was classified by severity of hearing level and audiometric configuration. The following categories were used:

   a. Severity:

      Class 1, 15.6-30.5 dB (mild)

      Class 2, 30.6-50.5 dB (moderate)

      Class 3, 50.6-70.5 dB (severe)

      Class 4, 70.6-90.5 dB (profound)

      (Severity was determined by the two frequency method, for frequencies 500, 1000, and 2000 Hz. The same dB levels were used to classify bone conduction pure tone threshold two frequency average, and TIP thresholds.)

   b. Configuration (pattern between 250-4000 Hz)

      Flat: No more than 15dB difference between 250 and 4000 Hz, with no difference greater than 10dB between adjacent octave points.

      Rising: Minimum difference of 20dB between 250 and 4000 Hz, with 250 poorer than 4000 Hz.

      Gradual falling: Minimum difference of 20dB between 250 and 4000 Hz, with average difference between adjacent octave points of

10 to 15dB; audiogram slope downward toward higher frequencies.

Marked Falling: minimum difference of 25dB between 250 and 4000 Hz, with average difference between adjacent octave points more than 15dB; audiogram slope downward toward higher frequencies.

Trough: U-shaped configuration with depression at 1000 Hz or 2000 Hz, and a minimum difference between the center portion of the trough and 250 and 4000 Hz of 15dB.

An original sample of 202 children was tested. Of this group, subsequent inspection of the data indicated 28 did not meet all of the criteria even though at the time of testing, some of which was done in the field, it appeared that all were satisfactory subjects. From the remaining pool of 174 subjects, 138 were randomly drawn to provide the final experimental sample. This final number was used because of limitations in the library of computer programs available to handle various subject sample sizes.

Table 20 shows the distribution of the 138 subjects in the final test sample for the factors of age, severity, audiometric configuration, and otological classification.

Experimental Test Environment

A quiet room of the Chambers Building on the Pennsylvania State University campus was assigned for this project. The room was equipped with a two-room IAC suite, series 600. The control room was 4 x 6 ft. with an adjoining subject sound room which was 6 x 8 ft. All testing done at the Penn State facility was performed in these rooms. Measurements made of the noise levels within the sound room were obtained with a Bruel-Kjaer sound level meter with octave band level attachment Model 2203/1613 (audiometer calibration system for free field measurements). All noise band measurements were better than the ASA standard S 3.1-1960 background requirements for audiometric rooms.

The control room contained a Panasonic Model RQ706S Tape transport, which led into a Grason-Stadler Model 1160-A speech audiometer terminating in matched pair of TDH-39 earphones The speech audiometer was calibrated in sound pressure levels for earphone testing re .0002 dy/cm^2 as measured on the Bruel-Kjaer Model 2203/1613 artificial ear system. The speech audiometer calibration was monitored at weekly intervals and adjusted as necessary throughout experimental testing. The tester was provided with an earphone and a switch to control stop and start of the tape transport in order to pace the rate of test word stimulus to the subjects.

Experimental testing was done binaurally under phones using tape recorded materials. The outer room provided waiting space for parents, record keeping and record processing as well as work space for the experimenters.

When field testing was done at the various locations away from the Penn State campus similar audiometric test rooms were available. The rooms were within the ASA requirements for audiometric testing. Taped stimuli were delivered from a Panasonic Model No. RQ706S tape transport and amplifier to a 10dB and 1dB Daven attenuator set and to matched TDH 39 earphones. The system was comparable to that used at the Penn State facility in frequency response characteristics, maximum output, attenuation characteristics and signal-to-noise ratio of the end signal. The system was calibrated before each day's use with the Bruel-Kjaer sound level meter. The tester was provided with a monitor phone from the tape recorder. Testing was done binaurally and was identical to that which was done at the Penn State facility.

Preparation of Experimental Test Recordings

The recording of TIP and DIP test words, preceded by the carrier phrase "Point to the __________," was done in a quiet sound treated room, with all words monitored at VU zero. The tape recorder was an Ampex 600 series with amplifier, and Electro Voice Model 633 dynamic microphone. Re-recording of each word was done to bring it within plus or minus 1dB of zero VU. The final equalized tape was copied back onto the Ampex 600 series recording equipment to produce a master tape with a 1000 Hz tone at the beginning, at the same VU meter level as the test words. TIP tests were made with progressive five decibels attenuation for the five items of a test card. Each test card series began at the standard beginning level of zero attenuation. DIP items were all recorded without attenuation.

Because the DIP tests were to be given at intensities which were relative to the SRT values determined with TIP tests, either TIP form A or form B was recorded at the beginning of test tapes. This TIP form was then followed by three DIP test forms. The last DIP form was followed by the TIP test form not used at the beginning of the tape. The order of the TIP forms A and B and DIP forms 1, 2, and 3 was rotated among several tape recordings, but without DIP forms 1 and 2 adjacent to each other. Four test sequences were generated and were selected randomly for use with the various subjects. The sequences of the tests on the final tape recording were:

Sequence 1

TIP A

DIP 1 (SRT + 10dB)

DIP 3 (SRT + 25dB)

DIP 2 (SRT + 5dB)

TIP B

Sequence 2

TIP B

DIP 1 (25dB)

DIP 3 (SRT + 10dB)

DIP 2 (SRT + 5dB)

TIP A

Sequence 3

TIP A

DIP 2 (SRT + 25dB)

DIP 3 (SRT + 5dB)

DIP 1 (SRT + 10dB)

TIP B

Sequence 4

TIP B

DIP 2 (SRT + 10dB)

DIP 3 (SRT + 25dB)

DIP 1 (SRT + 5dB)

TIP A

(The notations in parenthesis after each DIP list, e.g., SRT + 10dB, indicates the level relative to the child's initial speech reception threshold with the TIP test at which the DIP test form was administered.)

When a child was tested at the Penn State facility the 1000 cycle tone at the beginning of a given test list was monitored to 0 VU on the speech audiometer and the starting level for a given test list was adjusted by use of the speech audiometer attenuators. Each succeeding test list for a child was checked for 1000 cycle tone calibration. When the portable unit was used away from the Penn State facility the 1000 cycle tone was adjusted to a voltage setting determined by previous calibration to give a known sound pressure level of test word, and attenuation was done from that reference point.

Attenuation was accomplished by the 10dB and 1dB step attenuators. Each succeeding test list was checked for 1000 cycle tone calibration at the same voltage point.

For SRT and discrimination testing, the child was seated comfortably before a small table with the test materials placed before him and the tester beside him with scoring sheet, earphone, and tape transport switch in hand. The child was instructed to respond to a given test item by pointing to the picture of the word he thought he heard. No items were repeated during the testing. (A stand-by tape transport and amplifier unit were available as back-up equipment if needed.)

Test Series

Each child was given an air conduction and bone conduction test using clinical audiometers which were calibrated as described before. In almost all instances prior otological information was available. In those cases where this was not possible, the children were sent to our staff otologist for otologic evaluation and categorization. As described before, there was intelligence level information available on each child, together with descriptions of his social, emotional, and educational performance.

Each child was given the complete experimental test series. The sequence below is an example of one of the four sequences used during this procedure.

1. TIP test form A was administered. SRT values were recorded in sound pressure level re .0002 dy/cm^2. The tabular method of scoring was possible for nearly all children. For the few for whom this was not possible, the graphic method was used for each test independently.
2. A short rest was given.
3. DIP form 1 at SRT + 10dB was given followed by a short rest.
4. DIP form 3 at SRT + 25dB was given, followed by a rest of a few minutes
5. DIP form 2 was given at SRT + 5dB and again a short rest was given.
6. TIP form B was given.

Data Tabulation

The following information was obtained for each child and was entered on IBM cards, verified, and together with appropriate computer program cards entered into the Penn State IBM Computer System 360, Model 67.

1. Identification Number
2. Birthdate
3. Date of examination
4. Age group: The age groups were formed at yearly intervals with the first age group (age 5) being four years ten months to five years nine months, the second group was five years ten months to six years

nine months, and so forth. The final group (age 12) was eleven years ten months to twelve years nine months. There were eight such year-interval groups formed for this study.

5. Sex
6. Otological category
   a. conductive
   b. sensori-neural
   c. mixed loss
7. Audiogram shape
   a. flat
   b. rising
   c gradually falling
   d. markedly falling
   e. trough
   f. X (unclassifyable; very irregular)
8. Severity group
   a. 15.6 dB - 30.5 dB ISO
   b. 30.6 dB - 50.5 dB ISO
   c. 50.6 dB - 70.5 dB ISO
   d. 70.6 dB - 90.5 dB ISO
9. Two-frequency decibel pure tone binaural average for air conduction, and for bone conduction
10. TIP form A test threshold
11. TIP form B test threshold
12. DIP score at SRT + 5dB
13. DIP score at SRT + 10dB

14. DIP score at SRT + 25dB

15. DIP scores by acoustic category at SRT + 5, SRT + 10, and at SRT + 25dB. Acoustic categories on the DIP test are voicing, influence, pressure, voicing and influence, voicing and pressure, influence and pressure, voicing influence and pressure.

In addition to the above information each child's air conduction and bone conduction threshold at each frequency was recorded.

CHAPTER IV. DATA AND ANALYSIS

The data collected on the 138 subjects finally selected are shown in Appendix A. For each subject, 56 measures were obtained, although not all were independent. For example, the pure tone air conduction thresholds were obtained for audiometric frequencies 500, 1000, and 2000 Hz (as well as other frequencies), and these three thresholds contributed to the better ear two frequency pure tone average hearing level, which was used to classify each subject into a severity group.

Analysis Related to Objective 1
(Derivation of Naturalistic Subject Sub-groups)

For this analysis all data available on the 138 subjects were used, across all 56 measures shown in Appendix A.

A numerical taxonomic procedure (inverted factor analysis) was followed (Sokol and Sneath, 1963; Deagman, 1968).

Several coefficients of resemblance are available; however, in the final analysis the methods most generally used are familiar correlation and distance methods. For this study, correlation was chosen because more data are available using this procedure. Conceptually, however, it is expedient to discuss the technique as if the distance method were employed. The conceptual description which follows will be based on the distance method. The conceptual steps and rationale for this procedure were:

1. A Coefficient of Distance Resemblance matrix was formed between subjects, across the 56 variables.
2. Each subject was plotted on all 56 variables, as if in a 56 dimensional space. (The mathematical model employed uses the correlational values in place of plotting.)
3. All 138 subjects were entered into the same set of 56 dimensional coordinates.
4. The analysis identified subjects who were highly similar in location in the 56 dimension space. Such clusters of subjects formed a highly inter-related group. A conservative version of the procedure, namely the complete linkage method of clustering, was used. That is, two highly associated subjects were identified, and a mathematical search was done for another subject who was highly associated with each of these. (As many initial pairs of subjects were identified as feasible, in this case pairing subjects with correlations of .961.) A search was made for a fourth subject highly related with each of the three subjects. This process of searching for additional subjects to join each cluster was continued until all subjects joined into a single cluster. Within this single cluster, coherent sub-clusters often with low or negative correlations could be identified. For the purposes of the

present study, this complete linkage method is superior to the single linkage method for indentifying sub-clusters because it produces more coherent and compact clusters. The serpentine clusters which often result from the single linkage method may group subjects who are at the extremes of the cluster, and therefore, individually relatively unrelated.

5. Identification of natura_ taxonomic groups was done. The coefficients of correlation were inspected to identify and isolate sub-clusters. These subclusters were characterized by high within cluster correlations and low or negative between cluster correlations. The separation value is arbitrary, but the indicator of loss of sub-group identity is a sudden change in within group correlation as new members are added. (See Appendix B for a further discussion of this procedure.)

Four clusters of subjects were identified. The lowest within-group correlation (either between individual subjects or between one subject and the rest of the group) for each cluster was as follows:

Cluster I	.643	(31 subjects)
Cluster II	.797	(71 subjects)
Cluster III	.899	(28 subjects)
Cluster IV	.527	(8 subjects)

Cluster IV, having a relatively low correlation and composed of only eight subjects, probably is a group of miscellaneous, isolated subjects. Table 3 lists the experimental subjects contained in each cluster.

To identify commonalities and differences among the clusters, the means and standard deviations for selected acoustic and otological variables were inspected. For this descriptive analysis the variables of age, sex, type of loss (medical diagnosis), audiogram shape, severity of hearing loss, binaural average air conduction, binaural average bone conduction initial TIP threshold[2], and DIP test total score are of interest because these measures are of audiological concern. Table 4 lists the means and standard deviations for each of these variables. In this Table, a numerical value has been assigned to each level or category, as follows:

Sex: male = 1

female = 2

Type of loss:

conductive = 1

sensori-neural = 2

mixed = 3

Audiogram shape:

flat = 1

rising = 2

gradual falling = 3

marked falling = 4

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[2]Subjects received either TIP A or TIP B threshold test initially in the testing sequence. The correlation between scores on TIP A and TIP B was between .88 and .97 for various subject sub-groups. For the present, these test forms will be considered equivalent.

Table 3. Subjects in each cluster. (Raw score data on subjects are in Appendix A.)

Cluster	Subject Number
I (N 31)	1, 3, 5, 7, 11, 13, 17, 26, 29, 34, 66, 75, 76, 77, 78, 82, 84, 85, 88, 89, 90, 110, 111, 112, 113, 120, 121, 122, 123, 124, 125
II (N 71)	2, 4, 6, 8, 9, 10, 16, 19, 20, 21, 22, 23, 24, 25, 27, 30, 31, 32, 36, 39, 40, 41, 43, 44, 45, 50, 55, 56, 57, 58, 59, 60, 61, 64, 67, 68, 69, 70, 71, 72, 73, 74, 81, 86, 87, 91, 94, 95, 96, 97, 98, 99, 100, 105, 106, 107, 108, 109, 116, 117, 118, 119, 127, 128, 129, 130, 132, 133, 135, 136, 137
III (N 28)	12, 14, 15, 18, 28, 35, 37, 38, 42, 46, 47, 49, 52, 54, 62, 63, 65, 79, 80, 92, 93, 101, 102, 103, 104, 131, 134, 138
IV (N 8)	33, 48, 51, 53, 83, 114, 115, 126

Table 4. Mean items correct and standard deviation (in parentheses) by subject sub-groups for selected test variables.

	Subject Cluster			
	I	II	III	IV
Age (in yrs., mos.)	9.2 (1.90)	9.5 (1.80)	9.5 (2.00)	9.6 (2.00)
Sex	1.5 (.50)	1.5 (.06)	1.7 (.09)	1.5 (.50)
Type of Loss	1.5 (.60)	2.1 (.30)	2.1 (.30)	2.1 (.30)
Audiogram Shape	1.6 (1.30)	3.3 (1.30)	3.5 (.74)	2.3 (1.30)
dB bin. P.T. Av., A.C.	28.7 (10.70)	60.48 (13.30)	37.4 (13.80)	33.1 (8.90)
dB bin. P.T. Av., B.C.	4.97 (6.70)	54.6 (13.50)	34.5 (13.70)	29.1 (12.70)
TIP threshold (dB)	34.3 (13.40)	66.4 (13.80)	41.3 (12.80)	43.0 (14.50)
DIP Score Items Correct*				
at SRT + 5dB	32.5 (12.50)	30.7 (6.80)	34.3 (6.90)	36.3 (2.50)
at SRT + 10dB	40.8 (6.40)	34.8 (6.80)	38.0 (5.40)	38.8 (3.90)
at SRT + 25dB	46.5 (1.90)	38.6 (6.60)	43.0 (4.00)	47.4 (1.10)

*DIP items correct may be converted to per cent correct by multiplying by 2.1.

trough = 5

unclassifiable = 6

(Pure tone averages, TIP scores, DIP scores, and age are given in numerical values for the function.)

The Table 5 data indicate the following subject cluster characteristics: (No age or sex difference among the clusters.)

Group I:

a. Mixture of conductive and sensori-neural type of loss as follows:

conductive	74.8 %
sensori-neural	0.0 %
mixed	26.0 %

b. Audiogram shape predominately flat and rising, distributed as follows:

flat	71.0 %
rising	12.9 %
gradually falling	6.4 %
marked falling	0.0 %
trough	9.7 %
unclassifiable	0.0 %

c. Air conduction pure tone 2 frequency average: mild.

d. Bone conduction pure tone 2 frequency average: normal, large AC-BC gap.

e. TIP threshold: mild.

f. DIP score at SRT + 5dB: 68.25%

g. DIP score at SRT + 25dB: 97.65%

h. DIP slope between SRT + 5 and SRT + 10dB: 5.48% per dB

Table 5. One way analysis of variance summary tables for standard audiological-otological aspects of subject clusters.

Source	ss	ms	df	F	p
Audiogram Shape:					
Between Clusters	75.02	25.01	3	16.52	.001
Error	201.38	1.51	133		
Total	276.40		136		
Type of Loss:					
Between Clusters	8.29	2.76	3	10.94	.001
Error	33.60	.25	133		
Total	41.89		136		
dB P.T. Av. AC:					
Between Clusters	27206.40	9068.59	3	56.12	.001
Error	21491.60	161.59	133		
Total	48698.00		136		
dB P.T. Av. BC:					
Between Clusters	54080.30	18026.80	3	119.22	.001
Error	20109.60	151.20	133		
Total	74189.90		136		
TIP Threshold:					
Between Clusters	28058.90	9352.96	3	50.83	.001
Error	24473.60	184.01	133		
Total	52532.50		136		
DIP at SRT + 5:					
Between Clusters	406.14	135.38	3	2.91	.05
Error	6194.13	46.57	133		
Total	6600.27		136		
DIP at SRT + 10:					
Between Clusters	851.80	283.93	3	6.23	.001
Error	6058.17	45.55	133		
Total	6909.97		136		
DIP at SRT + 25:					
Between Clusters:	1662.13	554.04	3	21.03	.001
Error	3503.55	26.34	133		
Total	5165.68		136		

i. DIP score at SRT + 25dB: ~~46.5~~ 96.7%

Group II:

a. Predominately sensori-neural type of loss, distributed as follows:

conductive	0.0 %
sensori-neural	90.1 %
mixed	9.9 %

b. Audiogram shape predominately gradually falling, distributed as follows:

flat	16.9 %
rising	2.8 %
gradually falling	33.8 %
marked falling	26.8 %
trough	16.9 %
unclassifiable	2.8 %

c. Air conduction pure tone 2 frequency average: severe

d. Bone conduction pure tone 2 frequency average: severe, small AC-BC gap

e. TIP threshold: severe

f. DIP score at SRT + 5dB: 64.47%

g. DIP score at SRT + 10dB: 73.08%

h. DIP slope between SRT + 5 and SRT + 10dB: 1.72% per dB

i. DIP score at SRT + 25dB: 81.06%

Group III:

a. Predominately sensori-neural type of loss, distributed as follows:

conductive	0.0 %
sensori-neural	89.0 %
mixed	11.0 %

b. Audiogram shape predominately marked falling, distributed as follows:

flat	3.6 %
rising	3.6 %
gradual falling	28.6 %
marked falling	64.3 %
trough	0.0 %
unclassifiable	0.0 %

c. Air conduction pure tone 2 frequency average: moderate

d. Bone conduction pure tone 2 frequency average: moderate, small AC-BC gap.

e. TIP threshold: moderate

f. DIP score at SRT + 5dB: 72.03%

g. DIP score at SRT + 10dB: 79.80%

h. DIP slope between SRT + 5 and SRT + 10dB: 1.55% per dB

i. DIP score at SRT + 25dB: 90.30%

Group IV:

a. Predominately sensori-neural type of loss, distributed as follows:

conductive	0.0 %
sensori-neural	87.5 %
mixed	12.5 %

b. Audiogram shapes mixed, but with lack of marked falling shape, distributed as follows:

flat	25.0 %
rising	37.5 %
gradual falling	25.0 %
marked falling	0.0 %
trough	12.5 %
unclassifiable	0.0 %

c. Air conduction pure tone 2 frequency average: moderate

d. Bone conduction pure tone 2 frequency average: mild, small AC-BC gap

e. TIP threshold: moderate

f. DIP score at SRT + 5dB: 76.23%

g. DIP score at SRT + 10dB: 81.48%

h. DIP slope between SRT + 5 and SRT + 10dB: 1.05% per dB

i. DIP score at SRT + 25dB: 99.54%

In summary of this analysis for naturalistic sub-grouping or clusters of subjects, the four identifiable sub-groups may be characterized as follows:

Group I: largely conductive type disorders, mild degree of hearing level, flat audiogram shape, generally high speech discrimination (DIP socres), especially in comparison to Group II and III for the higher intensity levels (SRT + 10 and SRT + 25dB).

Group II: largely sensori-neural type disorders, severe degree of hearing level, a variety of audiogram shapes but predominately gradual or marked falling, lowest speech discrimination (DIP scores) of the four groups.

Group III: predominately sensori-neural type disorders, moderate degree of hearing level, predominately marked and gradual falling audiograms, distinguished from Group II by higher speech discrimination (DIP scores), higher proportion of marked falling audiograms, and less severe hearing level.

Group IV: largely sensori-neural type of disorder, moderate degree of hearing level, wider distribution of audiogram shapes (no marked falling audiograms) and with highest proportion of rising audiograms than other types or in comparison with the other groups, and generally high discrimination (DIP scores).

These sub-groups are divided most obviously on a conductive-sensori neural basis, on a degree of hearing loss basis, on a shape of audiogram basis, and on a speech discrimination level basis. (Group IV, with only eight subjects, is the least well-defined sub-group). Because the group differences also appear in both TIP test thresholds and in DIP test scores, the validity of the tests as measures of differences among hearing impaired subjects is supported.

Analysis Related to Objective 2
(Comparisons Among Subject Clusters)

The four subject clusters identified above were compared on each of several audiological and otological aspects of interest, namely type of loss, audiogram shape, dB binaural pure tone two frequency average by AC and BC, TIP threshold, and DIP test scores. The comparisons involved one way analysis of variance, followed by a multiple contrasts procedure. The results for the analyses of variance are shown in Table 5.

Noticeable are the significant F ratios, indicating clear differentiation among the clustered subjects with respect to the various test scores and hearing aspects. Scheffé (1967) described a procedure for making comparisons among sets of means, such as those compared by the analyses of variance. According to his procedure, although there may be an overall significant F ratio, when individual group means are compared a difference may not be verified. (Lack of homogeneity of variance, for example, may produce such a result.) The group means shown in Table 4 for each cluster and for each of the aspects of interest were compared using the Scheffé technique. Table 6 indicates the pattern of significant differences (at the .05 level) for these comparisons. While the data in Table 6 are somewhat scattered as to pattern of significant differences, Cluster I appears to be most frequently noticeably different from the other clusters. Cluster IV is somewhat of an enigma, being small in size and of diverse characteristics.

Table 6. Pattern of significant differences (.05 level) between group means of subject clusters.

Aspect	Group Clusters Compared
Type of Loss	no significant differences
Shape of Audiogram	Cluster I sig. diff. from Cluster II
	" I " " " " III
dB 2 freq. Av., AC	Cluster I sig. diff. from Cluster II
	" II " " " " III
	" II " " " " IV
dB 2 freq. Av., BC	Cluster I sig. diff. from Cluster IV
	" II " " " " III
	" II " " " " IV
TIP test threshold	Cluster I sig. diff. from Cluster II
	" II " " " " III
	" II " " " " IV
DIP test at SRT + 5dB	no significant differences
DIP test at SRT + 10 dB	no significant differences
DIP test at SRT + 25 dB	Cluster I sig. diff. from Cluster II
	" II " " " " IV

Analysis Related to Objective 3 (Comparisons Among Standard Otological-Audiological Sub-Groups)

The group of 138 subjects was divided into a number of sub-groups according to their otological reports and audiograms. (These sub-groupings were independent of the previous work to obtain clusters of subjects according to the numerical taxonomy procedure.) The same subjects were grouped (e.g., on the basis of pure tone average) for a given analysis, and then regrouped for a subsequent analysis (e.g., on the basis of audiogram shape).

Relationship between TIP test threshold and type, degree and pattern of hearing loss. Subjects were divided into the traditional otological categories on the basis of their medical reports and as supported by the air-bone gap as seen on the audiogram. For the medical etiology sub-groups (types of loss) product moment correlations were computed between TIP test thresholds and air conduction pure tone two frequency average, and between TIP test thresholds and bone conduction pure tone two frequency averages. The results are shown in Table 7. Also shown are the correlations between TIP A and TIP B test thresholds. Noticeable in Table 7 are the highly significant r values for the relationship between TIP tests and air conduction threshold averages, and between TIP tests and bone conduction threshold averages for the sensori-neural and mixed type of loss subjects, but not for the bone conduction average threshold for the conductive subjects. Such an

Table 7. Product moment correlations between TIP test thresholds and pure tone audiogram average by air conduction (AC) and by bone conduction (BC) for type of loss sub-groups.

	TIP A and AC	TIP B and AC	TIP A and BC	TIP B and BC	TIP A and TIP B
Conductive (N 23)	.916**	.890**	.137N S	.057N S	.975**
Sensori-Neural (N 96)	.924**	.917**	.872**	.859**	.975**
Mixed (N 19)	.909**	.928**	.842**	.853**	.984**

N S Not significant at .05
* Significant at .05
** Significant at .01

outcome is not surprising because the TIP tests were given binaurally by air conduction and the air conduction pure tone average reflects binaural acuity. For the sensori-neural and mixed subject groups, the audiogram AC-BC gap tended to be small, but for the conductive group it was large; hence, the observed pattern of correlations for bone conduction audiogram average. Also of interest are the very high correlations between TIP A and TIP B test thresholds, supporting the equivalence of the two test forms. The pattern of highly significant correlations between TIP test thresholds and pure tone air conduction audiogram threshold averages indicates the essential validity of the TIP test as a measure of acuity to hear speech.

Subjects were re-grouped according to degree of hearing loss (hearing level) displayed by their two frequency air conduction audiogram averages, and for each of the four severity groups product moment correlations were computed between TIP test threshold and audiometric thresholds. The results are shown in Table 8. Noticeable in Table 8 are the significant correlations between the TIP test thresholds and the audiometric two frequency averages by air conduction, and the lower (although often significatn) correlations by bone conduction. The non-significant correlations between TIP test thresholds for the severe and profound groups and bone conduction audiogram averages probably are accounted for by the data processing procedure of assigning a value to a bone conduction threshold of the dB value which was the maximum output of the audiometer by BC for that frequency as the "threshold" even though the

Table 8. Product moment correlation between TIP test thresholds and pure tone audiogram average by air conduction (AC) and by bone conduction (BC) for severity of loss sub-groups.

	TIP A and AC	TIP B and AC	TIP A and BC	TIP B and BC	TIP A and TIP B
Mild: 15.5 - 30.5 dB (N 29)	.707**	.590**	.131NS	.249NS	.888**
Moderate: 30.6 - 50.5 dB (N 43)	.708**	.690**	.518**	.504**	.910**
Severe: 50.6 - 70.5 dB (N 42)	.546**	.526**	.353*	.275NS	.923**
Profound: 70.6 - 90.5 dB (N 24)	.719**	.508**	.051NS	.150NS	.898**

NS Not significant at .05.
* Significant at .05.
** Significant at .01.

loss was so severe that hearing responses could not be obtained. This procedure obviously could lead to some large errors in bone conduction two frequency averages. The high correlations between TIP A and TIP B thresholds for this subject grouping also supports the equivalence of the test forms, and the significant correlations between TIP thresholds and severity group supports the TIP test as a valid measure of hearing acuity.

The 138 subjects were again divided into sub-groups, but on the basis of pattern or shape of pure tone audiogram. Table 9 shows the audiometric pattern sub-groups, the product moment correlations between audiometric two frequency average and TIP test thresholds, and the correlations between the TIP form A and form B thresholds. The correlations in Table 9 are uniformly high, all significant at the .01 level, but with those dealing with bone conduction a little lower than those dealing with air conduction. The general conclusion to be drawn from Table 9 is that the TIP test measure is highly related to hearing acuity for subjects with various audiogram shapes, especially for air conduction hearing.

Reliability of TIP test scores for type, degree and pattern of hearing loss. For each subject, the TIP test was administered twice: at the beginning of the speech hearing test series, and again after the testing with the three DIP lists. Our previous work with the TIP test demonstrated a test-retest reliability coefficient of .731 for form A and .725 for form B. Although there was a small difference in thresholds obtained with form A and with form B (form A

Table 9. Product moment correlations between TIP test thresholds and pure tone audiogram averages by air conduction (AC) and by bone conduction (BC) for audiometric pattern sub-groups.

	TIP A and AC	TIP B and AC	TIP A and BC	TIP B and BC	TIP A and TIP B
Flat (N 37)	.962	.960	.887	.879	.988
Rising (N 10)	.941	.957	.805	.803	.982
Gradually Falling (N 36)	.934	.920	.887	.872	.981
Marked Falling (N 37)	.905	.894	.873	.844	.975
Trough (N 16)	.952	.975	.709	.771	.971

Note: Two subjects had unclassifiable, very irregular audiograms, and are not included in this table.

All r values in this table are significant at the .01 level.

produces thresholds about 1.5 dB lower sound pressure level than form B) the difference is well within the ±3dB standard error of estimate for each form, and the form A-form B correlation was .859 (Siegenthaler and Haspiel, 1966a). Because of these correlations, for the present purposes it was considered appropriate to interpret the correlations between TIP form A and form B thresholds as indicators of TIP test reliability.

Tables 7, 8, and 9 include the TIP form A-form B correlations for the three methods of sub-grouping the experimental subjects.

These correlations are all high, with two exceptions being over .91 (the exceptions were .888 and .898), and all over .97 for the type of loss and the pattern or shape of audiogram sub-grouping. Correlations of this magnitude indicate very satisfactory test-retest reliability for the various audiometric and type of loss subjects.

<u>DIP test slope and discrimination levels at SRT + 5dB and SRT + 10dB for type , degree and pattern of loss</u>. For the analysis according to type of hearing loss the 138 subjects were grouped as before into types of hearing loss as shown in Table 10, which includes the mean DIP test scores and slopes between SRT + 5 and SRT + 10dB. Tables 11 and 12 summarize analyses of variance for DIP test scores and slopes according to type of hearing loss category. The special interest in Tables 11 and 12 is that although the DIP test scores are significantly different among types of subjects, the absolute test score mean differences are

Table 10. Mean DIP test scores (items correct) at each dB level, and discrimination curve slopes between SRT + 5dB and SRT + 10dB test levels, for type of hearing loss sub-groups.

	DIP Score at SRT + 5dB	DIP Score at SRT + 10dB	DIP Score at SRT + 25dB	Slope* between SRT + 5dB and + 10dB
Conductive (N 23)	31.91	35.85	40.45	.79 (1.65)
Sensori-Neural (N 96)	33.22	41.13	46.89	1.58 (3.32)
Mixed (N 19)	32.58	37.84	42.58	1.05 (2.2)

*Slope is number of items per dB change in level. Number of items is converted to per cent items per dB (values in parentheses) by multiplying by 2.1.

2

Table 11. Analysis of variance summary table for DIP test scores by type of loss sub-groups.

	df	ss	ms	F	P
Between Subjects	137				
Type (T)	2	1075.02	537.51	5.704 ($F_{T/b}$)	.01
error (b)	135	12721.20	94.24		
Within Subjects	276				
DIP Level (L)	2	6351.37	3175.68	47.08 ($F_{L/TxL}$)	.01
T x L	4	269.77	67.44	4.03 ($F_{TxL/w}$)	.01
error (w)	276	4615.53	16.72		

Table 12. Analysis of variance summary table for DIP test slopes from SRT + 5 to SRT + 10dB by type of loss sub-groups.

	df	ss	ms	F	P
Between Subjects	137				
Type (T)	2	2.95	1.47	2.88 ($F_{T/b}$)	N S
error (b)	135	69.47	.51		
Within Subjects	138				
Slope (S)	1	30.20	30.20	56.98 ($F_{S/w}$)	.01
T x S	2	2.90	1.45	2.74 ($F_{TxS/w}$)	N S
error (w)	135	71.44	.53		

less than expected test variability ($\pm$ 5 DIP test items, which is approximately ten per cent in test score as the standard error of estimate according to Siegenthaler and Haspiel, 1966a), and the non-statistically significant difference in DIP discrimination slope among subject types. The within-subjects significant F ratios and interaction F ratios are not judged to be of special significance for the present purposes because inspection of Table 10 indicates that the differences among means at each dB level are relatively modest. The mean DIP test slope over all subjects was found to be 1.4 items per dB change in level (2.9% per dB). This value is close to previous data showing that for normals the slope is 1.8 items (Siegenthaler and Haspiel, 1966a).

Table 13 contains the DIP test scores and slopes for the 138 subjects divided according to degree of hearing level. Tables 14 and 15 are analyses of variance summaries for DIP test scores and slopes. In Table 13 the DIP test scores decrease for the more severe degrees of hearing level; in Table 14 the significant F ratio for Hearing Level indicates a statistical significance to this change. Also shown in Table 13 is a decrease in slope of discrimination function as hearing level increased. However, this decrease was not of statistical significance according to the Hearing Level F ratio shown in Table 15. The implication of the DIP score means in Table 13 is that DIP test scores decrease for subjects with more severe degrees of hearing loss (even though the DIP test is administered at comparable sensation

Table 13. Mean DIP test scores (items correct) at each dB level, and discrimination curve slopes between SRT + 5dB and SRT + 10dB test levels for degrees of hearing level sub-groups.

	DIP Score at SRT + 5dB	DIP Score at SRT + 10dB	DIP Score at SRT + 25dB	Slope* Between SRT + 5dB and SRT + 10dB
15 - 30.5dB (N 29)	32.83	39.17	45.86	1.27 (2.66)
30.6 - 50.5 (N 43)	34.05	39.[illegible]4	45.00	1.10 (2.31)
50.6 - 70.5 (N 42)	30.98	35.45	39.05	.89 (1.77)
70.6 - 90.5 (N 24)	30.38	32.58	36.04	.44 (.924)

*Slope is number of items per dB change in level. Number of items is converted to per cent items per dB (values in parentheses) by multiplying by 2.1.

Table 14. Analysis of variance summary table for DIP test scores for degrees of hearing level sub-groups.

Source	df	ss	ms	F	P
Between Subjects	137				
Hearing Level (H)	3	2858.14	952.71	11.67 ($F_{H/b}$)	.01
error (b)	134	10938.10	81.63		
Within Subjects	276				
DIP Level (L)	2	6351.37	3175.68	41.65 ($F_{L/HxL}$)	.01
H x L	6	457.40	76.23	4.61 ($F_{HxL/w}$)	.01
error (w)	268	4427.90	16.52		

Table 15. Analysis of variance summary table for DIP test slopes from SRT + 5dB to SRT + 10dB for degrees of hearing level sub-groups.

	df	ss	ms	F	P
Between Subjects	137				
Hearing Level (H)	3	2.86	.95	1.83 ($F_{H/b}$)	N S
error (b)	134	69.55	.52		
Within Subjects	137				
Slope (S)	1	30.20	30.20	56.98	.01
H x S	3	2.74	.91	1.72 ($F_{HxS/w}$)	N S
error (w)	134	71.61	.53		

levels), but the discrimination curve slope remains relatively constant for subjects with various degrees of hearing loss, even though more steep for subjects with lesser degrees of hearing acuity reduction.

For the analysis of DIP discrimination level and discrimination curve slope according to pattern of audiogram, subjects were redivided into sub-groups as shown in Table 16, which also has the mean DIP test scores for the sub-groups, and DIP discrimination curve slopes. Tables 17 and 18 show the analyses of variance summaries for DIP test scores and for DIP test slopes, respectively, the significant (at .05 level) F ratio for pattern of audiogram in Table 17 appears to be accounted for at least by the relatively high DIP test scores at all dB levels by the rising audiogram subjects. Excluding this sub-group, all of the other mean differences among subject sub-groups are no more than five items, the standard error of estimate for the test. According to Table 18, the difference in DIP test discrimination curve slope is not significant between pattern of audiogram subject sub-groups.

Relationship between maximum DIP discrimination score (at SRT + 25dB) and type, degree and pattern of hearing loss. The necessary data for this analysis are contained in Tables 10, 13, and 16. These tables show the mean DIP test scores at SRT + 25dB for the subjects divided into sub-groups according to type of loss (Table 10), degree of hearing loss (Table 13), and pattern or shape of audiogram (Table 16). Our earlier research on the DIP test with normals indicated

Table 16. Mean DIP test scores (items correct) at each dB level, and discrimination curve slopes between SRT + 5dB and SRT +10dB test levels for pattern (shape) of audiogram sub-groups.

	DIP Score at SRT + 5dB	DIP Score at SRT + 25dB	DIP Score at SRT + 25dB	Slope* between + 5dB and + 10dB
Flat (N 37)	31.76	37.30	44.13	1.11 (2.33)
Rising (N 10)	37.90	42.60	46.30	.94 (1.97)
Gradually Falling (N 36)	32.42	32.67	41.22	.05 (.11)
Marked Falling (N 37)	32.11	35.73	39.65	.72 (1.51)
Trough	30.62	37.63	41.87	1.40 (2.94)

Two subjects had unclassifiable, very irregular audiograms, and are not included in this table.

*Slope is number of items per dB change in level. Number of items is converted to per cent items per dB (values in parentheses) by multiplying by 2.1.

Table 17. Analysis of variance summary table for DIP test score for pattern (shape) of audiogram sub-groups.

	df	ss	ms	F	P
Between Subjects	135				
Pattern (P)	4	1041.35	260.34	2.83 ($F_{P/b}$)	.05
Error (b)	131	12037.60	91.89		
Within Subjects	274				
DIP Level (L)	2	6386.80	3193.40	86.87 ($F_{L/PxL}$)	.01
P x L	8	294.05	36.76	2.15 ($F_{PxL/w}$)	.05
error (w)	264	4513.15	17.10		

Table 18. Analysis of variance summary table for DIP test slopes from SRT + 5dB to SRT + 10dB for pattern (shape) of audiogram sub-groups.

	df	ss	ms	F	P
Between Subjects	135				
Pattern (P)	4	2.41	.60	1.13 ($F_{P/b}$)	N S
Error (b)	131	69.72	.53		
Within Subjects	136				
Slope (S)	1	29.98	29.98	54.53 ($F_{S/w}$)	.01
P x S	4	2.35	.59	1.07 ($F_{[illegible]/w}$)	N S
error (w)	131	71.72	.55		

a test reliability of about five items (standard error of measurement). Initial inspection of Tables 10, 13, and 16 suggested that differences among subject sub-groups within each Table were mostly less than five items (especially in Tables 10 and 16) or in two cases about 6.5 items. In Table 13 the differences between the lesser hearing loss groups and the greater hearing loss groups were as high as about nine items, with the greater hearing loss being associated with lesser DIP test scores.

In summary of this inspection of scores, apparently DIP test scores at SRT + 25dB are not related systematically to type of hearing loss or to shape of audiogram, but are related to degree of hearing loss. That is, greater hearing loss subjects tend to have smaller DIP test scores at SRT + 25dB (which for the present is interpreted as the intensity level producing maximum DIP test discrimination score).

Reliability of DIP test scores for type , degree and pattern of hearing loss. Although in the original research plan it was intended to estimate DIP test scores for the various types, degrees and patterns of hearing loss subjects, the preceding analyses did not indicate significant differences in DIP test scores for subject sub-groups or test levels. Therefore, the reliability analysis was done only with the subjects as a total group, and using the test scores at SRT + 5, + 10, and + 25dB intensity level.

A subject could be tested at each dB level only once, so that test-retest data were not available. Split-half techniques were not appropriate because the DIP test word list is intended to be composed of independently different categories of items, with relatively small numbers of items per category.

Therefore, for this analysis, the Kuder-Richardson formula was used to indicate DIP test reliability. This computation (based on the DIP test scores for the 138 subjects) gave a reliability value of .596 for the DIP test at SRT + 5dB, .844 for the DIP test at SRT + 10dB, and .933 for the DIP test at SRT + 25dB. All of these values, especially at SRT + 5 and + 10 indicate acceptable DIP test reliability.

As a further area of interest, the mean intra-item correlations for the DIP test were computed, and found to be as follows:

at SRT + 5dB	.030
at SRT + 10dB	.102
at SRT + 25dB	.092

These values show the great degree of independence among DIP test items retained in the present version of the test procedure.

<u>Relationships among TIP thresholds, DIP test scores, and DIP discrimination curve slope for type, degree and pattern of hearing loss</u>. To investigate the relationships suggested for subjects with various types, degrees, and patterns of hearing loss, product moment correlations were computed between the pairs of variables, as shown in Table 19.

A noticeable feature of the Table is the lack of significant correlations relative to the discrimination curve slope. This finding is important because it supports the use of the same DIP discrimination curve slope for the various

Table 19. Product moment correlations between TIP test threshold and DIP test scores and slope for subject sub-groups according to type, degree, and pattern of hearing loss.

	DIP Slope +5 to +10	DIP at SRT +25	DIP at SRT +10	DIP at SRT +5
TIP A threshold by type of loss:				
Conductive (N 23)	.119	.180	.111	.042
Sensori-neural (N 96)	-.131	-.614**	-.451**	-.316**
Mixed (N 19)	-.223	-.555**	-.099	.117
TIP A threshold by degree of loss:				
15 - 30.5 (N 29)	-.100	.162	.097	.115
30.6 - 50.5 (N 43)	-.072	-.132	-.216	.025
50.6 - 70.5 (N 42)	.166	-.572**	-.501**	-.451**
70.6 - 90.5 (N 24)	.059	-.263	-.355	-.314
TIP A threshold by pattern of loss:				
Flat (N 37)	-.216	-.715**	-.383*	-.211
Rising (N 10)	-.263	-.462	-.507	.182
Gradually Falling (N 36)	-.241	-.596**	-.448**	-.334*
Marked Falling (N 37)	.019	-.567**	-.274	-.150
Trough (N 16)	-.429	-.673**	-.713**	-.199

* Significant at .05
** Significant at .01

types and degrees of hearing loss subjects who might be tested with the TIP and DIP test series and according to the earlier data analysis the same conclusion may be drawn regarding degrees of pure tone hearing acuity.

With respect to the correlations between TIP test thresholds and DIP test scores, no clear pattern is evident in Table 19. That is, there is a mixture of significant and non-significant correlations for DIP test levels, and for the various subject sub-groups.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

This project had as its general purpose the investigation of the behavior of peripherally hearing impaired children when given the Threshold by Identification of Pictures (TIP) test and the Discrimination by Identification of Pictures (DIP) test.

Involved in the accomplishment of this purpose was the statistical analysis of subject test responses (binaural testing either sound field or under earphones) to identify subject sub-groups, and comparing these sub-groups on the basis of their audiological behavior. As a companion but independent analysis the subjects were divided into sub-groups on the basis of standard otological and audiological aspects, and compared for TIP and DIP test performance.

Conclusions

Based upon these analyses, the following conclusions are appropriate for children with peripheral hearing loss:

1. Children with peripheral hearing loss are divided into the following sub-groups on the basis of hearing test performance:

   Group I: largely conductive type disorders, mild degree of hearing level, flat audiogram shape, generally high speech discrimination (DIP) scores, especially in comparison to Group II and III for the higher intensity levels (SRT + 10 and SRT +25dB)

Group II: largely sensori-neural type disorders, severe degree of hearing level, a variety of audiogram shapes but predominately gradual or marked falling, lowest discrimination (DIP) scores of the four groups.

Group III: predominately sensori-neural type disorders, moderate degree of hearing level, predominately marked and gradual falling audiograms, distinguished from Group II by higher speech discrimination (DIP) scores, higher proportion of marked falling audiograms, and less severe hearing level.

Group IV: largely sensori-neural type of disorder, moderate degree of hearing level, wider distribution of audiogram shapes (but no marked falling audiograms) and with highest proportion of rising audiograms in comparison with the other groups, and generally high discrimination (DIP) scores.

2. These subject sub-groups differ with statistical confidence, especially regarding audiogram configuration, degree of hearing loss, type of hearing loss and TIP threshold.
3. These groups have clinically small differences in DIP test discrimination scores, especially at test levels five and ten decibels above their individual speech reception thresholds.
4. The TIP test speech reception thresholds by air

conduction are highly correlated (.89 to .98) with pure tone air conduction two frequency better ear average for children with conductive, sensori-neural and mixed hearing losses, and highly correlated for sensori-neural and mixed hearing loss children with two frequency pure tone threshold average by bone conduction. (The AC-BC gap for conductive hearing loss subjects accounts for the non-significant correlation between bone conduction pure tone thresholds and TIP thresholds by air conduction for these subjects.)

5. The TIP test speech reception thresholds by air conduction are significantly correlated with pure tone air conduction two frequency average for children with hearing losses ranging from mild to profound, but less strongly related to bone conduction threshold two frequency average.

6. The TIP test speech reception thresholds by air conduction are significantly related to two frequency pure tone thresholds average for all audiometric configurations (air conduction thresholds) including flat, rising, gradually and marked falling, and trough (correlation values .89 to .98).

7. TIP test form A thresholds are significantly correlated with TIP test form B thresholds (correlation .89 to .99) for all of the subject sub-groupings according to type, degree, and pattern of hearing loss.

8. DIP test discrimination curve slope between scores

at SRT + 5dB and SRT + 10dB are not significantly different among subgroups of subjects divided according to type, degree, or pattern of hearing loss. Our over-all best estimate average slope is 1.14 items per dB (2.4 per cent per dB). This value is less than for the previous research on normals, namely 1.8 items per dB (3.8 per cent per dB).

9. DIP test scores, although of statistically significantly different levels among subject sub-groups according to type, degree, and pattern of hearing loss, are generally not different across subject sub-groups according to a clinical standard. That is, test scores generally are less than five test items different (the test reliability estimate found previously for normal children).

10. Although direct comparisons were not possible with the results of our previous data on normal children, our impression is that on hearing impaired subjects at SRT + 5dB intensity level the hearing loss subjects had DIP test scores approximately five items fewer than with normals, and at SRT + 10dB intensity level the hearing impaired subjects had DIP test scores approximately seven items fewer than did normals. (Data are not available on normals for the level SRT + 25dB because a pilot study indicated normals nearly all had perfect test scores at that level, which was not extensively tested.

In the present study the subjects had test scores of two to seven items incorrect at SRT + 25dB).

11. The DIP test reliability is satisfactory for hearing loss subjects, (reliability coefficients of .60 to .84).

12. TIP test threshold is not significantly related to DIP test discrimination curve slope, and not consistently related to DIP test scores at the levels tested.

Recommendations

The above conclusions drawn from the data, need to be translated into recommendations for implementation of test procedures. The general, overall outcome of this study is to demonstrate the validity and reliability of the TIP and DIP test procedures with hearing impaired children having a variety of types of hearing loss, degrees of hearing loss, and pattern of pure tone air conduction audiograms. This leads to recommendations that:

1. The TIP test is appropriate for measuring speech hearing threshold among hearing impaired children.
2. The DIP test is appropriate for measuring speech hearing discrimination among hearing impaired children.
3. TIP test form A and TIP test form B are essentially equivalent, and may be used interchangeably with hearing impaired children.
4. When DIP test slope is an important consideration,

we recommend use of 1.4 items (2.4 per cent) per dB change in intensity between the levels of SRT + 5dB and SRT + 10dB for testing hearing impaired children.

5. Because nothing from the present study contradicts the concept of change in TIP threshold or DIP test score as a function of age, the age normative data developed in our previous research (Siegenthaler and Haspiel, 1966b) should be applied when testing hearing impaired children.

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APPENDIX A. RAW SCORE DATA AND DERIVED SCORES FOR 138 EXPERIMENTAL SUBJECTS

In these Tables, column headings are abbreviated as follows:

Subject: subject identification number

Age: age to nearest year

Sex: F female; M male

Tape: sequence of TIP and DIP test administration

Loss Type: C conductive; SN sensori-neural; M mixed

Audiogram Shape: F flat; R rising; GF gradually falling; MF markedly falling; T trough; U unclassifiable

Severity: (two frequency better ear average)

1 15.6 to 30.5 dB

2 30.6 to 50.5 dB

3 50.6 to 70.5 dB

4 70.6 to 90.5 dB

AC 250 Rt: right ear air conduction threshold at 250 Hz

AC 500 Rt: " " " " " " 500 "

AC 1000 Rt: " " " " " " 1000 "

AC 2000 Rt: " " " " " " 2000 "

AC 4000 Rt: " " " " " " 4000 "

AC 8000 Rt: " " " " " " 8000 "

BC 500 Rt: " " bone " " " 500 "

BC 1000 Rt: " " " " " " 1000 "

BC 2000 Rt: " " " " " " 2000 "

AC 250 Lft: left ear air conduction threshold at 250 Hz

AC 500 Lft: " " " " " " 500 "

AC 1000 Lft: " " " " " " 1000 "

AC 2000 Lft: " " " " " " 2000 "

AC 4000 Lft: " " " " " " 4000 "

AC 8000 Lft: " " " " " " 8000 "

BC 500 Lft: " " bone " " " 500 "

BC 1000 Lft: " " " " " " 1000 "

BC 2000 Lft: " " " " " " 2000 "

AC Bin Av: air conduction binaural average

BC Bin Av: bone conduction binaural average

AC 2 Freq Rt: right ear air conduction 2 frequency average

AC 2 Freq Lft: left ear " " " " "

BC 2 Freq Rt: right ear bone " " " "

BC 2 Freq Lft: left ear " " " " "

TIP A SRT: TIP A Speech Reception Threshold

TIP B SRT: TIP B Speech Reception Threshold

DIP Score SRT + 5: DIP score at SRT + 5dB

DIP Score SRT + 10: " " " " " 10dB

DIP Score SRT + 25: " " " " " 25dB

V @ SRT + 5: Voicing at SRT + 5dB

I @ SRT + 5: Influence at SRT + 5dB

P @ SRT + 5: Pressure at SRT + 5dB

VI @ SRT + 5: Voicing-Influence at SRT + 5dB

VP @ SRT + 5: Voicing-Pressure at SRT + 5dB

IP @ SRT + 5: Influence-Pressure at SRT + 5dB

VIP @ SRT + 5: Voicing-Influence-Pressure at SRT + 5dB

V @ SRT + 10: Voicing at SRT + 10dB

I @ SRT + 10: Influence at SRT + 10dB

P @ SRT + 10: Pressure at SRT + 10dB

VI @ SRT + 10: Voicing-Influence at SRT + 10dB

VP @ SRT + 10: Voicing-Pressure at SRT + 10dB

IP @ SRT + 10: Influence-Pressure at SRT + 10dB

VIP @ SRT + 10: Voicing-Influence-Pressure at SRT + 10dB

V @ SRT + 25: Voicing at SRT + 25dB

I @ SRT + 25: Influence at SRT + 25dB

P @ SRT + 25: Pressure at SRT + 25dB

VI @ SRT + 25: Voicing-Influence at SRT + 25dB

VP @ SRT + 25: Voicing-Pressure at SRT + 25dB

IP @ SRT + 25: Influence-Pressure at SRT + 25dB

VIP @ SRT + 25: Voicing-Influence-Pressure at SRT + 25dB

Table 20. Experimental test data and derived scores on 138 subjects; Part A.

Subject	Age	Sex	Tape	Loss Type	Audio Shape	Severity	AC 250 Rt	AC 500 Rt	AC 1000 Rt	AC 2000 Rt	AC 4000 Rt	AC 8000 Rt	BC 500 Rt	BC 1000 Rt	BC 2000 Rt	AC 250 Lft	AC 500 Lft	AC 1000 Lft	AC 2000 Lft	AC 4000 Lft	AC 8000 Lft	BC 500 Lft	BC 1000 Lft	BC 2000 Lft	AC Bin Av	BC Bin Av
1	7	F	2	C	GF	1	45	50	50	45	55	55	0	0	5	30	15	15	25	30	35	0	0	0	15	0
2	12	F	1	SN	MF	4	45	70	95	110	110	90	65	75	75	45	65	110	110	90	90	75	75	75	80	75
3	10	F	3	C	F	2	50	50	50	40	40	50	0	5	0	50	40	50	40	50	45	0	0	0	40	0
4	9	F	3	SN	GF	2	30	85	85	75	85	90	25	60	55	15	45	45	50	70	60	35	40	55	45	37
5	11	M	4	M	R	2	60	65	70	75	110	90	15	25	35	55	60	40	40	55	90	20	15	35	40	15
6	7	M	2	SN	MF	3	35	35	75	70	65	75	30	75	60	75	85	85	85	85	90	75	75	75	57	45
7	11	M	2	M	F	2	20	30	35	35	45	40	15	15	25	45	45	45	40	30	50	20	25	25	33	15
8	10	F	2	SN	MF	2	55	60	60	55	70	80	40	65	60	20	35	55	75	80	75	30	55	65	45	43
9	10	F	2	SN	MF	3	30	50	60	80	75	70	35	65	70	45	70	85	100	95	85	45	60	60	55	47
10	9	F	2	SN	MF	3	40	55	70	85	75	65	55	70	75	45	50	60	85	75	65	50	60	75	55	55
11	9	F	1	M	F	2	35	50	50	45	50	25	35	25	30	30	45	30	50	60	30	40	15	25	37	20
12	12	F	1	SN	MF	3	35	50	80	85	85	90	50	75	75	35	50	80	90	80	90	50	75	75	65	62
13	12	F	1	C	T	3	45	60	65	60	35	40	5	0	5	40	50	55	60	55	50	5	5	10	53	0
14	6	F	4	SN	MF	1	5	10	45	55	65	65	15	50	55	10	10	45	45	65	65	15	50	55	27	33
15	12	F	2	SN	MF	2	10	15	65	80	80	80	5	60	75	10	55	70	85	85	75	30	60	75	40	33
16	5	F	2	SN	MF	3	35	50	65	75	85	90	30	60	75	50	65	65	80	85	90	45	55	75	57	43
17	11	F	4	M	T	2	35	40	55	30	40	65	5	35	25	30	45	55	30	25	65	15	30	25	35	15
18	10	F	2	M	MF	3	25	40	75	90	110	90	20	55	75	25	60	60	80	95	90	45	70	75	57	33
19	11	M	2	SN	F	4	75	75	70	80	75	75	75	75	75	70	80	85	85	75	75	70	75	75	73	75
20	9	F	3	SN	GF	3	35	45	70	60	50	65	45	60	60	35	55	60	55	55	70	45	60	55	53	50
21	6	F	1	SN	T	3	40	50	65	70	65	45	40	60	75	45	50	65	75	40	45	45	60	75	57	50
22	9	F	4	SN	GF	3	60	75	75	70	80	90	45	65	75	60	65	75	70	80	90	55	55	65	67	50
23	10	M	3	SN	F	2	35	40	50	45	55	35	35	50	45	45	55	55	65	65	60	35	50	50	43	40
24	7	M	3	M	GF	3	60	65	75	65	80	80	50	55	50	60	65	80	65	80	85	50	65	50	65	50
25	8	M	3	SN	GF	3	35	55	65	75	80	65	40	55	75	35	50	50	80	75	70	45	50	75	50	45
26	8	F	3	C	F	1	35	45	40	35	55	40	5	10	0	15	20	20	15	40	25	0	10	0	17	0
27	12	M	2	SN	GF	4	45	75	75	90	110	90	60	75	75	50	70	95	85	95	90	50	60	75	72	55
28	8	M	2	SN	GF	1	15	20	25	45	50	75	20	25	35	20	25	15	45	65	70	20	15	35	17	17

Table 20. Experimental test data and derived scores on 138 subjects; Part A (cont.)

Subject	Age	Sex	Tape	Loss Type	Audio Shape	Severity	AC 250 Rt	AC 500 Rt	AC 1000 Rt	AC 2000 Rt	AC 4000 Rt	AC 8000 Rt	BC 500 Rt	BC 1000 Rt	BC 2000 Rt	AC 250 Lft	AC 500 Lft	AC 1000 Lft	AC 2000 Lft	AC 4000 Lft	AC 8000 Lft	BC 500 Lft	BC 1000 Lft	BC 2000 Lft	AC Bin Av	BC Bin Av
29	6	M	3	C	F	1	30	30	30	40	40	30	0	5	10	20	20	30	25	40	35	0	0	0	23	0
30	11	M	4	SN	R	4	85	85	80	75	70	50	75	75	75	65	85	80	75	70	50	75	75	75	80	75
31	11	M	4	SN	GF	3	25	45	60	60	65	80	40	50	65	25	40	60	60	60	70	30	30	65	50	30
32	8	F	4	SN	T	2	25	45	65	50	60	35	35	60	45	35	50	70	55	55	55	35	60	50	47	40
33	8	F	2	SN	T	2	30	45	50	45	20	0	30	50	30	25	45	45	30	20	10	45	40	25	37	27
34	7	M	2	C	R	1	30	30	30	15	20	30	10	10	15	35	35	30	25	25	50	5	0	10	23	3
35	8	F	2	M	MF	2	30	50	60	55	110	90	20	35	45	20	40	45	55	85	90	30	35	45	43	33
36	8	F	1	SN	GF	2	35	50	65	65	55	30	50	65	65	20	40	55	55	65	60	40	50	55	47	45
37	12	M	1	SN	MF	1	10	15	60	85	70	55	5	60	65	10	35	35	55	75	50	15	30	45	25	17
38	10	F	2	SN	GF	2	35	20	30	40	45	50	20	25	40	25	25	35	40	40	45	20	25	40	25	22
39	12	F	3	SN	GF	4	60	75	75	85	100	90	70	75	75	60	70	70	75	90	90	60	70	75	70	65
40	12	M	3	SN	MF	2	30	55	65	75	60	15	55	65	70	35	55	55	60	55	50	20	55	60	43	37
41	9	M	3	M	T	4	65	95	110	90	80	70	65	65	65	50	75	90	75	75	60	65	65	65	75	65
42	11	F	1	SN	MF	3	35	40	60	95	110	90	50	65	75	30	50	65	85	90	80	35	70	75	50	43
43	9	M	4	SN	GF	2	30	35	45	55	60	55	25	45	45	25	40	45	60	65	60	35	45	45	40	35
44	12	F	4	SN	MF	3	20	50	80	75	65	75	40	75	75	25	40	65	70	65	50	45	75	60	53	50
45	7	F	2	SN	R	3	45	55	70	70	95	90	35	55	75	35	45	60	70	85	90	35	50	75	53	43
46	8	M	4	SN	F	2	35	35	35	35	70	75	35	35	35	35	45	50	45	85	70	45	50	45	35	35
47	12	F	4	SN	MF	3	25	45	65	80	110	90	40	50	75	25	85	85	100	110	90	75	75	75	55	45
48	7	F	4	SN	F	2	35	40	40	40	45	65	45	45	40	60	80	75	70	85	60	75	75	75	40	43
49	9	F	4	SN	R	2	20	30	35	35	45	65	10	30	40	20	30	35	35	60	65	10	35	30	33	20
50	7	M	4	M	F	3	65	70	70	65	70	90	55	60	40	60	70	70	65	70	90	50	45	40	65	43
51	11	M	4	SN	GF	2	20	35	40	45	40	55	25	35	35	20	25	35	35	45	55	30	35	30	30	30
52	10	F	4	SN	MF	1	5	15	30	50	55	75	20	25	35	10	20	25	50	55	70	20	30	35	20	23
53	10	M	4	M	R	1	25	35	30	5	0	0	15	30	5	50	55	55	40	30	0	25	35	20	27	10
54	12	M	4	SN	GF	1	15	20	40	30	50	60	20	40	30	10	15	25	35	55	50	20	25	35	20	23
55	12	M	4	SN	T	3	15	35	70	70	60	50	35	75	65	10	35	70	65	60	45	30	65	70	50	47
56	12	M	2	SN	GF	4	55	70	80	95	85	90	75	75	75	50	65	80	85	80	85	75	75	75	73	75

Table 20. Experimental test data and derived scores on 138 subjects; Part A (cont.)

Subject	Age	Sex	Tape	Loss Type	Audio Shape	Severity	AC 250 Rt	AC 500 Rt	AC 1000 Rt	AC 2000 Rt	AC 4000 Rt	AC 8000 Rt	BC 500 Rt	BC 1000 Rt	BC 2000 Rt	AC 250 Lft	AC 500 Lft	AC 1000 Lft	AC 2000 Lft	AC 4000 Lft	AC 8000 Lft	BC 500 Lft	BC 1000 Lft	BC 2000 Lft	AC Bin Av	BC Bin Av
57	12	F	3	SN	T	3	40	70	80	65	70	55	50	75	75	45	60	0	70	60	50	50	75	75	63	63
58	9	M	2	M	T	4	70	90	85	85	65	85	55	65	65	35	65	75	80	70	65	55	65	65	70	60
59	11	M	1	SN	T	2	50	65	55	35	40	55	65	55	30	30	45	65	50	45	60	45	60	50	40	37
60	10	F	1	SN	T	3	35	45	70	75	65	45	45	75	75	45	55	70	75	75	60	45	75	75	57	60
61	5	F	2	SN	T	3	40	45	75	80	60	90	60	75	75	40	45	90	80	65	70	60	65	75	60	67
62	9	M	3	SN	MF	3	20	40	60	75	100	90	40	80	75	25	50	50	60	110	90	50	55	70	45	47
63	9	F	4	M	MF	2	60	65	60	60	95	90	25	60	60	45	35	45	85	100	90	10	35	75	35	23
64	9	F	4	SN	GF	3	40	60	75	80	65	65	55	75	75	45	60	75	75	70	75	60	75	75	67	65
65	10	F	2	SN	MF	1	5	0	35	55	75	75	0	40	50	15	15	35	45	75	75	15	35	60	17	17
66	12	M	4	C	R	2	35	45	40	30	25	45	10	5	0	35	45	45	40	55	60	15	0	0	35	0
67	12	F	2	SN	MF	4	35	65	85	90	95	90	50	75	75	35	70	85	85	90	85	55	75	75	75	63
68	11	M	2	SN	F	3	65	75	85	85	85	90	75	75	75	50	60	70	35	40	55	30	40	35	35	35
69	8	M	3	SN	GF	2	35	50	55	55	55	55	45	55	50	35	30	40	70	70	65	50	65	75	65	63
70	10	F	3	M	F	3	60	75	75	70	80	90	45	65	75	40	65	70	75	75	90	55	55	75	63	60
71	9	F	3	M	GF	2	35	50	55	45	60	45	30	40	50	30	55	50	45	65	55	35	45	50	47	35
72	11	F	3	SN	GF	3	50	60	65	75	95	90	50	75	75	50	60	60	85	100	90	50	75	75	60	63
73	11	M	2	SN	GF	2	35	40	55	60	75	65	55	55	60	55	60	55	70	85	80	50	50	50	47	50
74	10	F	3	SN	F	2	35	45	70	60	50	65	45	60	55	40	45	60	55	50	70	55	60	55	50	50
75	7	F	3	C	F	1	25	35	35	20	35	15	10	25	20	15	20	20	15	15	15	5	20	0	17	3
76	12	M	1	C	F	2	40	50	55	45	50	50	5	10	15	45	50	60	40	50	50	10	10	25	45	10
77	8	F	3	C	R	1	20	30	35	15	20	45	0	0	0	20	15	35	15	20	40	0	0	0	15	0
78	10	M	1	C	F	1	20	20	25	15	20	20	0	10	5	20	30	35	25	40	45	0	5	5	17	3
79	6	F	3	SN	GF	2	25	40	45	65	90	90	35	50	65	35	40	55	60	90	90	40	45	60	43	40
80	10	F	1	SN	MF	1	20	0	35	40	55	75	10	25	40	0	0	35	40	65	80	5	25	40	17	15
81	7	F	1	SN	T	2	25	35	55	35	40	20	25	45	45	20	40	50	55	55	65	10	45	30	35	20
82	12	M	4	C	F	1	70	70	70	60	55	25	5	20	15	20	20	25	15	25	35	0	25	5	17	3
83	10	M	4	SN	F	3	60	55	65	55	45	55	55	60	55	75	75	70	65	65	55	75	65	60	50	50
84	8	F	3	C	F	1	30	25	20	25	20	20	0	5	0	30	40	30	25	30	20	0	0	0	23	0

Table 20. Experimental test data and derived scores on 138 subjects; Part A. (cont.)

Subject	Age	Sex	Tape	Loss Type	Audio Shape	Severity	AC 250 Rt	AC 500 Rt	AC 1000 Rt	AC 2000 Rt	AC 4000 Rt	AC 8000 Rt	BC 500 Rt	BC 1000 Rt	BC 2000 Rt	AC 250 Lft	AC 500 Lft	AC 1000 Lft	AC 2000 Lft	AC 4000 Lft	AC 8000 Lft	BC 500 Lft	BC 1000 Lft	BC 2000 Lft	AC Bin Av	BC Bin Av
85	8	F	4	M	F	2	30	30	30	30	40	35	10	15	25	30	30	30	30	40	40	5	10	25	30	7
86	8	M	3	M	GF	3	65	80	85	70	90	90	25	75	75	55	60	70	80	90	90	20	75	75	65	47
87	10	F	3	SN	F	2	35	45	50	45	45	55	45	40	40	35	35	45	35	45	55	35	40	40	35	37
88	11	F	4	M	F	3	55	55	55	60	60	65	20	25	30	50	65	60	55	60	60	20	25	25	55	20
89	10	M	4	M	F	1	25	25	25	30	20	30	0	0	10	35	30	30	35	35	25	0	0	10	25	0
90	10	M	4	C	F	1	25	25	40	20	30	25	0	0	0	40	40	35	35	35	40	0	0	0	23	0
91	10	F	2	SN	GF	4	55	60	80	80	70	80	55	70	75	50	70	70	80	85	90	60	75	75	70	60
92	9	M	1	SN	GF	3	35	45	65	70	70	90	45	70	70	45	50	70	85	110	90	50	70	75	55	60
93	6	F	1	SN	MF	3	40	50	65	100	110	90	50	75	75	40	50	60	100	110	90	50	65	75	55	57
94	7	F	1	SN	GF	3	40	65	85	85	70	65	55	75	75	35	50	65	70	60	85	40	65	60	57	50
95	10	M	3	SN	MF	4	55	55	85	85	110	90	75	75	75	65	85	95	100	110	90	75	75	75	70	67
96	9	F	3	SN	MF	4	55	70	95	100	110	90	60	75	75	30	45	90	95	110	90	45	75	75	80	60
97	9	F	3	SN	F	3	60	70	60	60	45	90	60	55	55	55	60	60	60	45	90	75	55	45	60	50
98	12	F	2	SN	MF	3	40	50	70	90	90	90	75	75	75	40	55	75	75	110	90	50	75	75	60	67
99	11	M	2	SN	GF	3	80	100	100	110	110	90	75	75	75	45	55	55	45	60	65	35	45	55	50	40
100	12	M	2	SN	MF	3	60	65	65	90	90	90	40	65	75	75	35	95	90	110	90	45	75	75	65	52
101	11	F	2	SN	MF	3	30	45	55	75	85	90	50	65	75	25	45	60	80	80	90	35	65	75	50	50
102	9	F	4	SN	MF	2	25	30	95	110	110	90	25	75	75	25	25	60	110	110	90	25	65	75	43	45
103	6	M	2	SN	GF	1	25	35	20	50	50	55	35	20	50	20	30	30	50	60	60	25	25	50	27	25
104	12	F	2	SN	GF	2	20	35	60	65	70	80	40	60	65	30	50	55	65	75	75	50	60	65	47	50
105	7	M	3	SN	GF	4	50	70	70	80	90	90	75	75	75	50	65	90	90	90	90	75	75	75	70	75
106	11	M	3	SN	GF	3	55	60	85	80	90	90	50	75	75	45	55	70	65	70	70	55	65	70	60	60
107	9	F	2	SN	F	4	60	85	85	90	85	80	60	75	75	60	85	70	80	85	80	60	75	75	75	67
108	11	F	3	SN	F	4	65	80	75	70	80	90	50	75	75	65	70	75	70	80	70	45	75	75	75	67
109	8	F	1	SN	T	4	70	75	75	65	55	55	75	75	75	55	65	75	75	60	45	75	75	75	70	75
110	10	M	3	C	T	1	25	25	40	35	20	20	0	0	0	15	25	35	30	25	15	0	0	0	27	0
111	8	M	3	C	F	1	20	15	20	20	15	20	0	0	0	20	20	25	20	30	30	0	0	0	17	0
112	10	F	3	C	F	1	10	20	20	25	20	30	0	0	0	15	20	25	20	25	25	0	0	0	20	0

Table 20. Experimental test data and derived scores on 138 subjects; Part A. (cont.)

Subject	Age	Sex	Tape	Loss Type	Audio Shape	Severity	AC 250 Rt	AC 500 Rt	AC 1000 Rt	AC 2000 Rt	AC 4000 Rt	AC 8000 Rt	BC 500 Rt	BC 1000 Rt	BC 2000 Rt	AC 250 Lft	AC 500 Lft	AC 1000 Lft	AC 2000 Lft	AC 4000 Lft	AC 8000 Lft	BC 500 Lft	BC 1000 Lft	BC 2000 Lft	AC Bin Av	BC Bin Av
113	8	F	3	C	F	1	40	35	35	25	35	40	0	0	0	25	30	30	25	35	30	0	0	0	27	0
114	12	F	1	SN	R	1	40	35	30	20	10	20	30	30	15	75	90	75	70	60	20	50	75	65	25	23
115	12	M	1	SN	GF	1	15	20	25	30	70	55	15	25	30	70	110	110	110	110	90	75	75	75	23	20
116	12	F	1	SN	U	4	60	80	85	110	110	90	50	75	75	60	80	90	110	110	90	50	75	75	83	67
117	8	M	1	SN	F	4	75	90	90	80	85	90	50	75	75	65	75	85	80	75	90	50	75	75	77	67
118	8	F	1	SN	U	4	85	90	110	110	110	90	55	75	75	70	80	95	110	110	90	50	75	75	87	63
119	8	F	1	SN	GF	4	45	55	75	75	80	75	55	75	75	45	65	75	80	90	85	55	75	75	70	67
120	6	M	1	C	F	1	30	30	30	25	25	35	10	15	10	10	25	30	20	15	15	10	5	10	23	7
121	9	M	3	C	F	2	50	60	55	50	25	25	25	20	25	15	35	25	35	35	25	15	15	10	30	13
122	9	F	3	C	F	1	20	25	30	25	30	45	0	0	0	15	30	30	20	20	25	0	0	0	25	0
123	6	F	4	C	F	2	45	45	35	35	50	45	0	0	0	30	35	30	35	35	20	0	0	0	33	0
124	11	M	1	C	F	2	50	60	50	55	50	90	10	5	10	35	35	45	45	50	80	10	10	5	40	5
125	7	F	1	M	GF	2	25	30	30	50	55	55	20	15	15	50	55	45	60	45	55	25	30	30	30	15
126	7	F	1	SN	R	2	35	40	40	25	40	50	35	35	25	60	65	60	45	40	60	60	45	45	33	30
127	8	M	1	SN	GF	4	75	85	95	110	110	90	75	75	75	65	70	110	110	110	90	75	75	75	90	75
128	10	M	4	SN	MF	2	50	55	60	60	75	80	40	55	60	30	30	65	55	65	75	30	65	50	43	40
129	8	M	3	SN	MF	4	40	65	70	95	110	90	75	75	75	30	65	95	90	85	90	75	75	75	70	75
130	11	M	2	SN	MF	4	60	65	90	90	110	90	65	75	75	40	75	100	110	110	90	75	75	75	77	67
131	11	M	1	SN	MF	2	35	35	35	75	65	60	35	35	75	35	50	40	70	65	65	45	40	75	35	35
132	9	M	1	SN	MF	3	0	50	75	70	60	60	75	75	75	0	45	75	70	60	50	50	75	75	61	75
133	10	M	3	SN	MF	3	45	55	85	90	110	90	50	75	75	25	50	70	75	100	90	50	75	75	60	61
134	11	M	3	SN	MF	1	10	30	35	55	70	70	25	35	55	10	30	25	65	85	90	25	35	55	27	30
135	12	M	1	SN	MF	3	35	45	65	85	90	75	50	75	75	60	85	110	110	110	90	75	75	75	55	62
136	11	M	4	SN	F	2	45	50	50	45	55	55	35	50	40	40	45	45	45	60	55	40	35	35	40	35
137	7	M	2	SN	T	4	65	75	85	75	65	70	55	75	75	70	70	85	85	75	90	60	60	75	75	60
138	7	F	3	SN	GF	2	15	30	50	50	55	90	20	45	50	35	55	85	85	85	90	15	50	75	40	33

Table 21. Experimental test data and derived scores on 138 subjects; Part B.

Subject	AC 2 Freq Rt	AC 2 Freq Lft	BC 2 Freq Rt	BC 2 Freq Lft	TIP A SRT	TIP B SRT	DIP Score SRT +5	DIP Score SRT +10	DIP Score SRT +25	V @ SRT +5	I @ SRT +5	P @ SRT +5	VI @ SRT +5	VP @ SRT +5	IP @ SRT +5	VIP @ SRT +5	V @ SRT +10	I @ SRT +10	P @ SRT +10	VI @ SRT +10	VP @ SRT +10	IP @ SRT +10	VIP @ SRT +10	V @ SRT +25	I @ SRT +25	P @ SRT +25	VI @ SRT +25	VP @ SRT +25	IP @ SRT +25	VIP @ SRT +25
1	47	15	0	0	7.5	11.5	31	39	43	1	0	3	3	1	4	5	1	1	1	3	0	1	2	0	2	1	0	1	0	1
2	83	83	75	75	83.5	75.5	41	39	40	0	1	4	0	0	2	0	0	2	4	0	0	1	0	2	2	2	0	0	0	0
3	47	40	0	0	43.5	46.5	37	45	48	3	2	3	0	0	1	2	0	0	3	0	0	0	0	0	0	2	0	0	0	0
4	80	45	40	37	42.5	39.5	34	48	44	2	1	4	2	0	1	3	0	0	0	0	0	0	1	0	0	0	2	1	0	0
5	67	40	20	17	64.5	62.5	37	44	48	0	2	1	3	1	3	1	0	0	1	0	0	1	2	0	0	0	0	0	0	0
6	57	85	45	75	50.5	52.5	36	39	42	1	2	3	1	0	3	2	1	3	4	0	0	1	0	2	2	0	2	0	0	0
7	33	43	15	23	37.5	39.5	28	44	47	3	2	4	4	1	2	4	0	0	3	0	0	1	1	0	0	1	0	0	0	0
8	57	45	47	43	51.5	51.5	39	44	45	2	2	2	1	1	2	0	1	0	1	0	1	1	0	0	1	2	0	0	0	0
9	55	77	47	52	64.5	66.5	33	28	40	1	3	2	3	0	3	5	1	1	4	2	1	4	7	1	1	2	1	0	2	1
10	62	55	62	55	71.5	71.5	26	44	43	3	2	1	3	3	4	6	1	1	1	0	0	1	0	0	0	2	1	0	1	1
11	47	37	27	20	44.5	43.5	28	41	47	3	0	2	4	2	4	4	0	1	1	1	0	2	2	0	0	1	0	0	0	0
12	65	65	62	62	54.5	55.5	42	46	45	1	1	0	2	1	1	0	0	0	2	0	0	0	0	1	1	1	0	0	0	0
13	60	53	3	3	67.5	65.5	20	38	47	3	2	3	4	3	6	7	2	2	0	1	2	1	2	0	0	1	0	0	0	0
14	27	27	33	33	29.5	31.5	32	34	38	2	3	2	1	2	4	2	1	0	5	3	0	3	3	0	0	3	2	1	1	2
15	40	63	33	45	32.5	29.5	40	44	43	1	1	0	0	1	4	1	0	1	2	0	1	0	0	0	1	2	0	0	1	0
16	57	65	45	50	74.5	77.5	19	32	40	2	4	5	5	3	4	6	2	1	4	3	0	3	3	0	0	3	0	0	1	0
17	35	37	15	20	37.5	36.5	35	47	47	3	1	1	2	1	3	2	0	1	0	0	0	0	2	2	0	0	0	1	2	2
18	57	60	33	57	45.5	46.5	36	40	42	1	1	3	0	0	6	1	1	1	2	1	0	1	2	0	1	3	1	0	1	0
19	73	83	75	75	65.5	71.5	32	42	43	4	3	3	2	1	1	2	2	1	2	0	0	0	0	0	0	1	1	0	1	2
20	53	55	53	50	53.5	58.5	35	40	44	2	2	1	1	1	3	3	1	2	2	1	0	0	2	1	1	1	0	0	1	0
21	57	57	50	53	58.5	61.5	23	37	41	3	2	3	5	2	5	5	1	1	3	1	1	3	1	0	1	4	0	2	1	0
22	73	67	55	55	68.5	67.5	35	37	39	1	2	2	1	1	2	4	1	2	3	2	1	1	1	1	1	3	2	1	0	0
23	43	60	40	50	51.5	52.5	39	41	46	1	2	3	0	0	2	1	1	1	2	1	0	1	1	1	0	0	0	0	1	0
24	65	65	50	50	76.5	76.5	22	29	26	3	0	5	3	1	4	8	2	2	2	3	1	2	7	3	2	4	6	2	4	6
25	60	50	47	47	62.5	68.5	37	41	42	0	2	2	0	1	5	1	2	1	2	1	0	1	0	2	2	2	1	0	1	0
26	37	17	3	0	25.5	26.5	37	46	47	1	1	2	1	0	1	4	0	0	2	0	0	0	0	1	0	0	0	0	0	0
27	75	77	67	55	79.5	80.5	34	40	43	0	3	3	1	0	3	4	1	1	3	2	0	0	1	0	2	1	1	0	0	1
28	22	20	22	17	21.5	24.5	40	41	48	0	0	5	1	0	2	0	1	2	2	0	0	1	1	0	0	0	0	0	0	0

Table 21. Experimental test data and derived scores on 138 subjects; Part B.(cont.)

Subject	AC 2 Freq Rt	AC 2 Freq Lft	BC 2 Freq Rt	BC 2 Freq Lft	TIP A SRT	TIP B SRT	DIP Score SRT +5	DIP Score SRT +10	DIP Score SRT +25	V @ SRT +5	I @ SRT +5	P @ SRT +5	VI @ SRT +5	VP @ SRT +5	IP @ SRT +5	VIP @ SRT +5	V @ SRT +10	I @ SRT +10	P @ SRT +10	VI @ SRT +10	VP @ SRT +10	IP @ SRT +10	VIP @ SRT +10	V @ SRT +25	I @ SRT +25	P @ SRT +25	VI @ SRT +25	VP @ SRT +25	IP @ SRT +25	VIP @ SRT +25
29	30	23	0	0	39.5	39.5	42	45	46	1	0	1	0	2	1	1	0	1	1	0	0	0	1	0	0	1	0	0	0	1
30	80	80	75	75	91.5	91.5	41	38	44	1	1	2	0	0	1	2	0	1	2	3	1	2	1	0	1	1	2	0	0	0
31	53	50	45	30	49.5	54.5	37	43	48	1	2	3	0	1	3	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0
32	47	53	40	43	56.5	53.5	26	35	45	3	3	3	4	1	5	1	1	2	3	1	1	1	4	1	0	1	0	1	0	0
33	40	37	30	33	34.5	46.5	40	43	48	1	2	0	1	2	1	1	1	1	2	0	0	1	0	0	0	0	0	0	0	0
34	23	27	10	3	37.5	38.5	38	47	48	1	1	2	2	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
35	53	43	27	33	37.5	40.5	38	35	44	1	3	2	0	0	3	1	1	1	5	3	1	2	0	0	1	2	0	0	1	0
36	57	47	57	45	61.5	57.5	31	42	46	3	0	3	4	1	2	4	0	1	1	1	0	1	2	0	0	2	0	0	0	0
37	37	35	32	22	37.5	33.5	35	39	46	2	0	5	2	0	3	1	1	2	2	0	1	2	1	0	0	1	0	0	1	0
38	25	30	22	22	37.5	39.5	33	43	47	3	2	3	1	1	2	3	1	1	1	0	0	1	1	0	1	0	0	0	0	0
39	75	70	73	65	60.5	62.5	35	38	48	1	1	0	3	2	2	4	1	2	1	0	1	2	3	0	0	0	0	0	0	0
40	43	45	37	37	48.5	49.5	28	43	46	2	2	3	3	3	4	3	0	2	1	0	1	0	1	0	1	0	0	0	1	0
41	93	75	65	65	84.5	83.5	40	42	43	1	1	2	1	1	1	1	0	2	1	2	0	0	1	1	0	0	1	0	1	2
42	50	57	63	53	43.5	41.5	27	37	40	2	2	4	4	4	2	3	1	3	4	3	0	0	1	0	0	4	2	0	1	1
43	40	85	35	40	54.5	54.5	39	37	48	0	2	4	1	1	0	1	3	2	2	1	0	3	0	0	0	0	0	0	0	0
44	63	53	55	53	49.5	54.5	40	43	45	0	2	3	1	1	1	0	0	1	1	1	0	1	1	0	2	1	0	0	0	0
45	63	53	45	43	59.5	64.5	33	35	38	1	2	3	2	1	4	2	0	1	1	3	2	3	3	1	2	3	0	0	2	2
46	35	45	35	45	40.5	38.5	26	36	45	4	4	4	3	1	2	4	1	4	2	1	2	0	2	1	1	1	1	0	0	0
47	55	85	45	63	42.5	60.5	39	43	42	0	2	4	0	1	2	0	0	2	1	0	0	2	0	0	2	4	0	0	0	0
48	40	75	43	75	60.5	58.5	30	15	47	2	3	3	3	1	2	4	1	2	6	1	1	2	0	0	0	0	0	0	0	1
49	33	33	20	20	46.5	43.5	40	45	48	2	1	0	1	2	0	2	1	0	0	0	1	0	1	0	0	0	0	0	0	0
50	65	67	47	43	77.5	82.5	34	43	44	2	3	5	3	0	1	0	0	1	2	0	1	0	1	1	1	0	1	1	0	0
51	40	30	30	30	42.5	48.5	45	45	48	0	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0
52	23	23	23	25	25.5	25.5	37	41	46	0	3	5	1	0	1	1	0	3	1	0	0	2	1	1	1	0	0	0	0	0
53	27	47	10	13	33.5	30.5	42	42	48	0	0	2	3	0	0	0	1	0	2	1	0	1	1	0	0	0	0	0	0	0
54	25	20	25	23	25.5	29.5	40	37	47	1	3	3	1	0	1	0	1	2	1	3	0	4	0	0	0	0	0	0	0	1
55	53	50	50	47	48.5	55.5	42	45	48	0	2	3	0	0	1	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
56	75	73	75	75	62.5	62.5	36	36	45	1	3	0	3	0	4	1	1	2	4	1	1	1	3	0	0	0	0	1	0	1

Table 21. Experimental test data and derived scores on 138 subjects; Part B. (cont.)

Subject	AC 2 Freq Rt	AC 2 Freq Lft	BC 2 Freq Rt	BC 2 Freq Lft	TIP A SRT	TIP B SRT	DIP Score SRT +5	DIP Score SRT +10	DIP Score SRT +25	V @ SRT +5	I @ SRT +5	P @ SRT +5	VI @ SRT +5	VP @ SRT +5	IP @ SRT +5	VIP @ SRT +5	V @ SRT +10	I @ SRT +10	P @ SRT +10	VI @ SRT +10	VP @ SRT +10	IP @ SRT +10	VIP @ SRT +10	V @ SRT +25	I @ SRT +25	P @ SRT +25	VI @ SRT +25	VP @ SRT +25	IP @ SRT +25	VIP @ SRT +25
57	67	65	63	63	70.5	71.5	36	31	35	1	0	4	2	0	3	2	2	2	4	2	1	3	3	3	1	3	3	1	1	3
58	85	70	60	60	67.5	71.5	32	36	41	2	2	4	0	2	4	2	2	0	0	3	1	3	3	1	2	2	0	1	0	1
59	45	47	43	47	37.5	38.5	34	41	45	0	1	3	3	3	2	2	1	1	1	1	0	1	2	1	1	0	0	1	0	0
60	57	63	60	60	60.5	62.5	27	38	43	1	2	5	1	2	6	4	1	2	3	1	1	0	2	0	0	3	1	0	1	0
61	60	60	67	67	73.5	70.5	22	28	34	2	3	5	5	3	4	5	2	0	3	3	2	4	6	0	2	3	2	1	3	3
62	50	50	50	53	65.5	67.5	33	26	34	2	0	2	2	1	3	5	1	3	6	2	0	3	7	2	1	3	4	1	3	1
63	60	35	43	23	43.5	38.5	35	37	45	0	3	4	0	1	1	4	2	2	1	1	2	2	1	0	0	0	0	2	0	1
64	67	67	65	67	74.5	75.5	32	32	35	2	3	5	1	0	1	4	3	2	2	3	2	3	1	1	3	4	0	0	0	0
65	17	25	20	25	23.5	30.5	41	44	42	1	0	3	1	0	1	1	1	1	0	0	0	2	0	0	2	1	0	0	0	1
66	35	43	3	0	37.5	42.5	41	43	46	1	0	2	1	0	2	2	0	0	1	1	1	1	1	0	0	4	2	0	1	2
67	75	77	63	65	85.5	90.5	31	36	37	1	0	3	2	0	4	7	1	2	1	3	0	4	1	0	2	1	1	0	0	1
68	52	35	50	35	41.5	45.5	39	32	44	1	0	3	1	0	2	2	2	3	5	2	2	1	1	0	1	3	2	1	1	2
69	80	65	65	63	72.5	72.5	19	32	34	4	0	7	4	3	5	6	2	1	4	2	2	3	2	3	2	4	1	0	2	1
70	73	63	60	60	69.5	67.5	40	36	38	2	1	2	0	0	1	2	0	3	1	1	2	2	4	[illegible]	1	1	1	2	2	3
71	50	47	35	43	51.5	53.5	29	34	41	2	1	4	4	1	3	5	0	3	1	3	2	3	1	1	1	2	1	0	1	0
72	63	60	63	63	76.5	75.5	34	32	26	2	2	2	3	2	3	5	1	1	6	1	0	1	4	2	2	0	2	1	4	7
73	47	57	53	50	59.5	59.5	35	41	40	1	1	2	2	1	4	2	1	3	3	1	1	3	4	3	1	4	1	2	1	0
74	53	50	53	50	60.5	61.5	28	35	42	2	1	2	3	1	5	0	1	0	2	0	1	1	3	0	1	3	0	0	1	3
75	27	17	17	3	20.5	19.5	24	19	45	2	1	3	4	2	5	7	4	4	2	6	1	5	6	0	0	1	0	0	1	1
76	47	45	13	10	53.5	48.5	39	44	48	0	0	3	1	1	3	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0
77	25	15	0	0	23.5	26.5	38	42	47	0	1	3	2	1	2	1	0	1	2	0	0	1	2	0	0	1	0	0	0	0
78	17	3	27	3	18.5	22.5	35	44	48	1	2	3	0	1	4	2	1	0	1	1	0	1	0	0	0	0	0	0	0	0
79	43	47	43	43	44.5	51.5	35	37	37	0	2	2	3	0	2	4	0	2	4	1	1	1	2	1	2	3	1	1	2	1
80	17	17	17	15	19.5	20.5	18	29	41	2	2	7	4	3	5	7	1	2	5	3	2	3	3	1	0	2	0	2	1	1
81	35	45	35	20	34.5	35.5	30	40	45	1	1	2	1	4	6	3	1	4	3	2	0	0	0	0	1	2	0	0	0	0
82	65	17	10	3	18.5	25.5	43	47	48	0	1	2	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
83	50	67	50	63	67.5	63.5	40	45	47	4	3	1	0	0	0	0	1	0	2	0	0	0	0	1	0	0	0	0	0	0
84	23	27	0	0	26.5	29.5	36	43	48	2	1	2	3	2	1	1	2	1	0	0	0	1	1	0	0	0	0	0	0	0

Table 21. Experimental test data and derived scores on 138 subjects; Part B. (cont.)

Subject	AC 2 Freq Rt	AC 2 Freq Lft	BC 2 Freq Rt	BC 2 Freq Lft	TIP A SRT	TIP B SRT	DIP Score SRT +5	DIP Score SRT +10	DIP Score SRT +25	V @ SRT +5	I @ SRT +5	P @ SRT +5	VI @ SRT +5	VP @ SRT +5	IP @ SRT +5	VIP @ SRT +5	V @ SRT +10	I @ SRT +10	P @ SRT +10	VI @ SRT +10	VP @ SRT +10	IP @ SRT +10	VIP @ SRT +10	V @ SRT +25	I @ SRT +25	P @ SRT +25	VI @ SRT +25	VP @ SRT +25	IP @ SRT +25	VIP @ SRT +25
85	30	30	12	7	27.5	29.5	31	37	46	3	2	3	3	1	2	3	4	1	0	1	2	1	2	0	0	2	0	0	0	0
86	80	65	50	47	67.5	73.5	25	26	34	1	2	3	2	1	3	2	3	3	2	3	1	5	7	2	3	5	3	2	3	4
87	45	35	40	37	40.5	34.5	30	30	40	2	1	3	4	1	3	4	3	2	3	3	2	1	4	2	1	0	1	1	2	1
88	55	57	20	25	57.5	59.5	37	39	40	2	0	2	2	1	2	2	2	1	1	2	0	1	2	2	0	3	2	1	0	2
89	25	30	0	0	28.5	23.5	29	31	44	0	3	3	4	2	3	4	3	2	1	2	1	4	4	0	0	0	0	0	0	0
90	23	35	0	0	34.5	38.5	39	46	48	2	3	0	0	0	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
91	70	70	60	67	76.5	77.5	27	29	33	4	1	4	4	1	2	5	2	1	2	2	1	5	6	2	2	5	1	0	2	3
92	55	60	60	60	53.5	51.5	34	32	40	1	2	3	1	1	3	3	2	1	3	3	0	3	4	0	1	3	2	0	0	2
93	57	55	63	57	65.5	59.5	25	36	39	2	2	2	5	3	4	5	1	3	4	1	0	0	3	1	1	2	2	1	2	0
94	75	57	65	50	66.5	60.5	34	48	41	1	0	4	2	2	2	3	0	2	3	1	1	1	2	2	0	4	1	0	0	0
95	70	90	67	67	75.5	81.5	27	32	32	2	1	4	2	2	3	6	2	3	3	2	3	2	1	1	1	4	0	1	6	3
96	83	80	67	60	82.5	84.5	30	29	32	4	1	1	3	1	3	5	2	3	4	2	1	3	4	3	1	3	3	3	2	2
97	60	60	50	57	68.5	67.5	24	32	42	2	2	3	4	2	5	5	1	3	4	5	0	0	2	2	0	3	0	0	0	1
98	60	65	67	67	71.5	65.5	18	17	25	3	2	7	4	1	3	8	2	3	2	5	2	4	7	4	0	3	6	1	4	5
99	99	50	75	40	58.5	62.5	28	37	40	4	1	1	2	2	4	4	1	1	1	1	0	2	5	2	0	2	0	0	1	2
100	65	90	52	75	69.5	79.5	27	33	37	4	0	3	4	2	4	4	2	0	1	3	0	5	4	1	2	3	1	1	2	2
101	50	52	57	50	56.5	61.5	45	41	42	1	0	1	0	0	0	1	2	1	4	0	0	1	0	0	1	3	0	0	1	1
102	60	43	50	45	45.5	50.5	38	39	46	0	2	4	2	0	1	1	1	0	3	2	1	1	1	0	0	2	0	0	0	0
103	27	30	27	25	35.5	39.5	32	43	48	3	2	5	2	1	1	2	1	1	2	1	0	0	0	0	0	0	0	0	0	0
104	47	52	50	55	57.5	59.5	29	35	36	3	1	2	4	2	4	3	3	0	2	2	2	2	2	0	2	6	0	0	2	2
105	70	77	75	75	77.5	79.5	21	25	27	4	2	4	3	1	5	8	2	2	6	3	2	4	4	5	1	2	3	2	4	4
106	70	60	67	60	65.5	71.5	29	37	43	2	1	5	1	3	4	2	1	4	4	1	0	0	0	1	1	2	0	0	0	1
107	85	75	67	67	83.5	83.5	27	26	35	3	1	4	6	0	3	4	3	3	3	4	1	2	6	2	3	2	2	0	2	2
108	75	75	67	67	76.5	76.5	32	29	26	2	1	3	2	1	3	4	2	3	4	3	0	3	4	2	1	4	3	3	5	4
109	70	70	75	75	71.5	78.5	31	30	29	1	2	4	0	2	5	3	2	1	2	4	2	4	3	2	1	2	0	3	5	5
110	30	27	0	0	31.5	30.5	26	46	46	1	1	4	6	2	4	4	0	1	1	0	0	0	0	0	0	2	0	0	0	0
111	17	20	0	0	22.5	25.5	21	44	48	1	1	4	5	3	6	7	1	1	0	0	0	0	2	0	0	0	0	0	0	0
112	20	20	0	0	23.5	26.5	30	37	46	3	1	3	3	3	2	3	3	0	0	2	1	1	4	0	0	0	1	0	0	1

Table 21. Experimental test data and derived scores on 138 subjects; Part B. (cont.)

Subject	AC 2 Freq Rt	AC 2 Freq Lft	BC 2 Freq Rt	BC 2 Freq Lft	TIP A SRT	TIP B SRT	DIP Score SRT +5	DIP Score SRT +10	DIP Score SRT +25	V @ SRT +5	I @ SRT +5	P @ SRT +5	VI @ SRT +5	VP @ SRT +5	IP @ SRT +5	VIP @ SRT +5	V @ SRT +10	I @ SRT +10	P @ SRT +10	VI @ SRT +10	VP @ SRT +10	IP @ SRT +10	VIP @ SRT +10	V @ SRT +25	I @ SRT +25	P @ SRT +25	VI @ SRT +25	VP @ SRT +25	IP @ SRT +25	VIP @ SRT +25
113	27	30	0	0	31.5	29.5	37	45	48	2	3	0	1	2	1	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0
114	25	73	23	70	23.5	28.5	32	44	48	2	3	3	0	5	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
115	23	99	20	75	39.5	35.5	24	30	45	1	3	5	2	4	5	2	4	4	3	4	2	1	2	1	0	1	1	0	0	0
116	83	85	67	67	77.5	77.5	25	29	24	1	4	4	4	4	4	2	2	2	3	3	2	4	4	4	3	3	6	2	3	3
117	85	77	67	67	92.5	95.5	12	12	31	3	7	5	2	6	8	5	3	3	5	4	2	6	1	3	2	2	1	1	3	5
118	99	87	65	63	89.5	88.5	22	28	29	3	3	6	1	4	6	2	1	1	4	5	3	1	4	2	1	3	4	2	3	4
119	65	70	67	67	72.5	70.5	34	36	43	2	4	3	0	1	2	2	4	4	2	1	1	1	1	0	0	2	0	1	0	2
120	27	23	13	7	30.5	29.5	20	24	46	4	2	5	4	4	6	2	2	2	4	5	1	6	4	1	0	0	0	0	1	0
121	52	30	23	13	29.5	28.5	27	40	48	1	5	3	1	4	5	1	0	0	0	3	0	0	4	0	0	0	0	0	0	0
122	25	25	0	0	27.5	23.5	37	43	48	1	3	2	0	3	0	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0
123	35	33	0	0	39.5	39.5	36	38	47	2	1	3	1	2	1	0	1	1	4	2	1	1	1	1	0	0	0	0	0	0
124	40	52	7	7	44.5	44.5	30	41	44	2	4	2	3	2	6	1	2	2	1	0	1	2	0	1	0	3	0	0	0	0
125	30	50	15	27	31.5	38.5	21	36	44	3	6	4	2	7	4	1	1	1	4	3	0	1	2	0	2	0	0	1	0	0
126	33	53	30	45	42.5	36.5	37	46	48	2	3	0	0	3	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
127	90	90	75	75	96.5	85.5	24	32	37	1	4	4	1	6	5	2	2	2	2	2	1	3	4	2	1	3	2	0	1	2
128	57	43	45	40	52.5	56.5	34	35	37	3	3	1	0	1	6	3	1	1	2	2	1	2	2	0	0	2	0	0	0	0
129	70	77	75	75	72.5	70.5	35	37	32	1	1	3	1	4	2	2	2	2	2	2	0	1	2	1	1	4	2	0	5	3
130	77	87	67	75	79.5	79.5	34	36	38	1	3	1	0	1	5	2	2	2	2	1	0	3	2	1	2	1	2	1	3	0
131	35	45	35	43	45.5	39.5	37	39	48	1	1	0	0	2	7	0	1	1	4	1	1	2	0	0	0	0	0	0	0	0
132	61	61	75	75	66.5	66.5	20	24	35	2	6	3	1	5	8	4	2	2	6	5	1	2	4	1	1	3	1	1	1	5
133	70	60	61	61	74.5	74.5	40	35	35	2	4	2	0	0	0	2	1	1	2	1	2	3	2	2	2	2	1	1	2	3
134	27	32	30	30	26.5	31.5	16	24	39	3	3	5	3	7	9	4	2	2	4	2	3	6	3	2	1	1	3	1	1	0
135	55	97	62	75	72.5	72.5	16	22	25	4	4	4	2	7	7	3	3	3	5	5	1	4	5	2	1	4	4	1	3	3
136	47	40	37	35	51.5	55.5	39	43	48	2	1	2	1	1	1	0	1	1	2	0	0	2	0	0	0	0	0	0	0	0
137	77	75	73	60	79.5	77.5	26	25	33	2	3	4	2	3	4	2	3	3	3	3	2	3	7	2	2	1	2	1	3	4
138	40	70	33	33	44.5	43.5	37	40	44	1	4	0	0	1	1	0	2	2	3	1	0	1	1	0	1	2	0	0	0	1

APPENDIX B.

METHODS OF CLASSIFYING SUBJECTS INTO GROUPS

One of the tasks in this study was to find a way of forming diagnostic groups based upon the use of several variables. This is a task which has been attacked by biologists on a systematic basis over the past several years. Two terms must be defined; the first is classification. We will define classification as the ordering of organisms into groups or sets on the basis of their relationships, that is, of their associations by contiguity, similarity or both. The second term is taxonomy which is the theoretical study of classification including its bases, principles, procedures and rurals. Sokol and Sneath (1963) describe a procedure for numerical taxonomy which springs from their work in attempting to systematize taxometric procedures in the biological sciences. They define numerical taxonomy to mean "the numerical evaluation of the authenticity or similarity between taxonomic units and the ordering of these units into taxi on the basis of their authenticities. The approach which they used consists of a variety of multivariate techniques.

A set of four training programs was written by F. James Rohlf and John Kishpaugh at the University of Kansas utilizing the Sokal and Sneath procedures. These programs were adapted by Mrs. Eleanor Satir for use on the IBM system 360/67 at The Pennsylvania State Universtiy. We used those programs for this study.

In the system of classification used, the set of items to be classified, subjects tested in this case, are called operational taxonomic units or OTU's. Each OTU is evaluated for a set of characteristics; in our case there were 56 characteristics measured or 56 test scores for each OTU. Based on these values a similarity coefficient is computed between each pair of OTU. For our purposes, the raw data matrices consisted of the 56 scores on 138 individuals. Because of limitations of the system, it was necessary to use less than the total group tested and the 138 were chosen at random from the 174 tested. After the raw data matrices were entered into the computer, it was standardized. These new values were used to compute the resemblence matrices which consist of the coefficients of resemblence between all pairs of OTU's. It is possible to choose any of several different coefficients of resemblence. The two most commonly used are the product moment correlation coefficient and the taxonomic distance coefficient. We chose the product moment correlation coefficient. After computation of the matrices of coefficients the grouping of individuals into clusters is done by the pair group method. This requires that OTU's I and J, for example, form a group only if OTU I's highest correlation is with OTU J and OTU J's highest correlation is with OTU I. If, for example, J's highest correlation was with some other OTU, then it could not become part of the grouping at that point. The initial groupings, then, are according to pairs.

After all possible pairs are formed, a new matrix of coefficients is computed which reflects these new groupings. Following the recomputation of the matrix, new groupings are formed in the same way previously described; and the procedure is continued until all groups have coalesced into one group and the analysis is complete. At that point, a diagram of clusterings is printed and examined to determine the point at which it is possible to classify the operational taxonomic units into meaningful clusters.

Clustering was done under each of several conditions; that is, with several of the test variables individually removed.

OE 6000 (REV. 9-66)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

OFFICE OF EDUCATION

ERIC REPORT RESUME

ERIC ACCESSION NO.

CLEARINGHOUSE ACCESSION NUMBER

RESUME DATE 06-30-68 | P.A. | T.A.

IS DOCUMENT COPYRIGHTED? YES ☐ NO ☐

ERIC REPRODUCTION RELEASE? YES ☐ NO ☐

TITLE

Evaluation of Two Measures of Speech Hearing for Hearing Impaired Children

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SOURCE CODE

REPORT/SERIES NO.

OTHER SOURCE

SOURCE CODE

OTHER REPORT NO.

OTHER SOURCE

SOURCE CODE

OTHER REPORT NO.

PUB'L. DATE 6-30-68 | CONTRACT GRANT NUMBER USOE 32-48-0720-6012

PAGINATION, ETC

91 pages

RETRIEVAL TERMS

Exceptional Child Research
Hearing Impaired Children
Degrees, types and patterns of hearing loss
Speech reception testing

IDENTIFIERS

ABSTRACT Hard-of-hearing children were tested for speech hearing ability (threshold and discrimination) using the TIP and the DIP tests. Of the 202 subjects, a random selection of 138 were used for final data analysis. Subject age range was 5 to 13 years; subjects included a variety of degrees, types and patterns of hearing loss. The main analysis was related to TIP and DIP test reliability and validity. It is concluded that the TIP test is satisfactory as a measure of speech hearing threshold with hearing impaired children (thresholds correlated .88 to .98 with pure tone thresholds; test forms A and B correlated .89 to .97), and that the DIP test is satisfactory as a measure of speech hearing discrimination with hearing impaired children (test reliability .60 to .84).