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ABSTRACT

Tests were administered to 209 educable mentally handicapped children (mean age 10.8, mean IQ 77) to determine factors related to speech hearing. Results indicated that mental age, intelligence quotient, physiological age, institutionalization, and organic bases for retardation were not significantly related either to speech reception threshold or to speech discrimination test scores. However, chronological age was related to test performance. Also, the threshold and the discrimination by the Identification of Pictures tests were found both reliable and useful with the educable retarded subjects. (Author/JD)

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FINAL REPORT

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FACTORS RELATED TO THE SPEECH-HEARING OF CHILDREN OF BELOW NORMAL INTELLIGENCE

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Department of Health, Education, and Welfare

U.S. Office of Education
Bureau of Education for the Handicapped

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SUMMARY

This project was undertaken to investigate the relationships among mental age (MA), chronological age (CA), intelligence quotient (IQ), physiological age (PA), and speech hearing ability both for threshold and for discrimination among children with less than normal intellectual ability. In all, 209 children were included, of whom 39 had IQ scores between ninty and 114, and 170 had IQ scores of 89 or under. Range of chronological age was 6.3 to 15.2 years (mean age 10.8 years) and IQ ranged from 44 to 114 (mean 77 IQ). Included in the total sample was a group of eleven children with positive organic signs as the basis for retardation. Also in the total sample were 36 children from residential institutions for the retarded in Pennsylvania. All subjects were found to have pure tone air conduction acuity (two frequency average across 500, 1000, and 2000 Hz) no worse than 25 dB ISO 1964.

All of the subjects were drawn from either the public schools (special education classes or regular classes) or from the residential institutions for the retarded in Pennsylvania. All were classified as being in the educable mentally retarded range, in part judged from the child's adaptability to a formal classroom or teaching situation, but largely on the basis of intelligence testing.

Subjects were given the WISC test to abtain IQ and mental age scores (sub-categories of verbal and performance scores), and a series of performance, anthropomorphic and other measures to determine physiological age. In addition, subjects were given the Threshold by Identification of Pictures (TIP) test for speech reception threshold, and the Discrimination by Identification of Pictures (DIP) test for speech discrimination (or speech intelligibility) at the sensation level of SRT, SRT +5dB, and SRT +10dB.

Statistical analyses included product moment correlations and partial correlation, t test for differences between means, F tests for parallelism of regression, statistics for comparison of slopes of intelligibility curves, and evaluation of the distributions of the samples of data.

The major findings of the study were that within the age and intellectual ranges of the subjects studied, mental age, intelligence quotient, physiological age, institutionalization, and organic bases for retardation are not significantly

related either to speech reception threshold or to speech discrimination test scores. However, chronological age was supported as being a factor related to test performance.

Reliability of the TIP and DIP tests with these subjects compares favorably with reliability reported for non-retarded subjects. In addition, the usefulness of the TIP and of the DIP tests for educable mentally retarded children, especially those not demonstrating strong organic involvement, is supported.

CHAPTER 1

INTRODUCTION

The present study is the third in a series done at The Pennsylvania State University with the cooperation and the support of the U. S. Office of Education. The first study dealt with the development and standardization of two tests of speech hearing ability in children: Threshold by Identification of Pictures (TIP), and Discrimination by Identification of Pictures (DIP) tests.

The second study in this series applied these two tests to children with various types and degrees of peripheral hearing disorders. The major purpose of the second study was to evaluate the TIP and DIP tests for use with hypocusic children.

The results of these two studies were very promising in that the TIP and DIP tests appeared to be useful with children at least as young as mental age three years. They appeared to give reliable and valid measures of speech hearing ability in children who are normal and those with peripheral hearing losses. In the course of the researches it was possible to produce the test material in readily available forms.

As of this writing approximately four hundred sets of test materials with accompanying scoring sheets and research reports have been distributed throughout the United States and in some foreign countries. These materials were made available at a miniumal cost because of the support offered to the projects by the U. S. Office of Education.

At the present time these tests have been given a second printing and are being distributed to additional clinics and schools. Both of the tests appear to have a considerable value in the Audiology Clinic as judged by our experience at the Penn State Speech and Hearing Clinic. There have been at least two doctoral dissertations which have followed up the original research; these dissertations were especially concerned with the distinctive feature of influence or transitions between adjacent phonemes. It is too early yet for research results to be available, as these tests are used in other audiology and research programs. However, informal reports and anecdotal reports available indicate the tests are useful, and they are being subjected to rigorous independent research such as is needed whenever an evaluation or test procedure is developed.

It was the principle investigator's hope that the TIP and DIP test materials would be adequate to pursue further a number of aspects of auditory behavior, especially in children. Thus the present study was designed to investigate speech hearing abilities among mentally retarded children, giving special attention to mental age, chronological age, and physiological age. A number of hypotheses were developed relative to the interactions among these various ages and speech hearing ability.

However, as the following research report will show, in the main these hypotheses were not supported by the test results. On the other hand, the results produced what may be considered an even more gratifying result, namely evidence that the TIP and DIP hearing tests are satisfactory as measures of speech hearing ability among retarded children and that special considerations or compensations probably need not be made to any considerable extent as these test materials are applied to children with less than normal intelligence. Thus, it is hoped that a contribution has been made to the audiological literature and to the armamentarium of tests available to the audiologist dealing with children.

As with any sizable project, a large number of individuals make contributions which too often go unrecognized. In this project we are especially thankful and appreciative of the help given to us by various school administrators from Central Pennsylvania and even more so, the children and their parents who consented to participate in the study. It was necessary for the children to spend some time away from the regular classroom, and in most cases it was necessary to travel to State College, Pennsylvania for a portion of the experimental testing. While the test procedures were not noxious, nevertheless in some occasions they were demanding and required the attentive participation of the children. For all of this kind of help, including making available school records by the school administrators and in some cases assigning school personnel to participate in case selection as did many classroom teachers, the authors express their thanks.

We wish specifically to acknowledge the following school and clinic administrators for their cooperation which made this study possible:

In State College, Pa.:

Sister Jean Michael, Principal, Our Lady of Victory Catholic School

Mr. Gerald Robine, Principal, Penn State Demonstration School, University Park

Dr. Asa J. Berlin, Summer Clinic Coordinator, Penn State Speech and Hearing Clinic, University Park

In Bellefonte, Pa.:

Dr. Frederick Mauger, Superintendent of Schools, Bellefonte Area Schools

Mr. Arthur Kantner, Assistant Supervisor of Elementary Schools, Bellefonte Area Schools

Mr. John L. Roberts, Principal, Bellefonte Elementary School, East Allegheny Street

Mr. Robert Bryzanski, Guidance Counselor, Bellefonte Junior High School, East High Street

Mr. Michael J. Damon, Principal, Bellefonte Junior High School, East High Street

Mrs. Scull, School Nurse, Bellefonte Elementary School, East Allegheny Street,

Mrs. Witter, School Nurse, Bellefonte Junior High School, East High Street

Mrs. Diehl, Mrs. Shipe, Mrs. Shiffler, Special Education Teachers, Bellefonte Elementary Schools

Mrs. Gerald Robine, Special Education Teacher, Bellefonte Junior High School

In Clearfield, Pa.:

Mr. Elwood Rohrbaugh, Superintendent of Schools, Clearfield Area Schools, 108 East Cherry Street

Mr. Harold Blackwell, Supervisor of Special Education, Clearfield Area Schools

Mr. Frederick Herman, Superintendent Elementary Schools, Plymptonville Elementary School

Mr. James Stodart, Assistant Superintendent Elementary Schools, Plymptonville Elementary School

Mrs. Henchbarger, Chief Nurse, Clearfield Area Schools, Clearfield Senior High School

In Selinsgrove, Pa.:

Dr. John Zimmerman, Superintendent, Selinsgrove State School and Hospital

Miss Karen Demko, Head, Speech and Hearing Department, Selinsgrove State School and Hospital

In Cresson, Pa.:

Dr. Francis Taylor, Superintendent, Cresson State School and Hospital

Mr. William Benson, Principal, Demonstration School, Cresson State School and Hospital

Mr. Robert Kearn, Demonstration School, Cresson State School and Hospital

The several staff members from Penn State, graduate students and others who participated in the study at the data collection stage included Carol Hatch, Dennis Pirnot, Karena Gruen, Sally Weigle, Susan Murdza, Arlene Katz, and Barbara Leiber.

The principle investigator wishes especially to thank John Tardibuono and Jackie Sallade for their enthusiastic work throughout this project. For the first two-thirds of the project John Tardibuono was the project coordinator. John arranged for subjects, worked out the details of test procedures and their administration, he made numerous contacts with school people, and his convincing manner and knowledgeable approach to his task made possible the participation not only of schools but children and their parents. His devotion to the project far exceeded the commitment that would be expected.

Jackie Sallade acted as project coordinator during the last third of the project (having served as one of the research technicians earlier). Jackie carried on with John's fine work, when he had to withdraw from the project because of other demands. She continued his very high level of effort, completing the phase of data collecting and tabulation. She also was very effective in working with the project statistical consultant in carrying out the recommended statistical analyses and preparing the bulk of the review of literature and procedures resume.

This project depended heavily upon psychological test procedures, and the author wishes to acknowledge with thanks the important contributions of people from the School Psychology program at Penn State. Dr. Bartell Cardon assisted in planning the psychological procedures to be used and their place in the design of the research. Later, Dr. Joseph French provided psychometricans and other staff and he monitored their activities closely to assure that professional quality psychological testing was done. He materially assisted in locating subjects in the Pennsylvania schools and arranging entrance into the school records and access to children. He provided necessary over-all support to the project, especially in the psychological areas.

The physiological age testing, procedures which were a departure from usual speech and hearing clinic practices, were all done at or by personnel from the Laboratory for Human Performance Research on the campus, with Dr. Elsworth Buskirk as Director of the laboratory. Dr. Buskirk and his group designed and carried out the physiological age measurements, and from those measurements extracted data especially pertinent to the present project. The names of his several staff members who assisted appear as coauthors of chapter four of the body of this report.

Finally, we wish to acknowledge the astute advice offered by Dr. Paul Games, statistical consultant from the Department of Educational Psychology at Penn State. Not only

did Dr. Games and his graduate assistant do the mechanics of most of the statistical analyses, but more importantly, he helped clarify the experimental questions and translate them into forms which would lead to meaningful answers based upon the experimental data.

It is hoped that it will be possible to carry on other investigations of this sort using the TIP and DIP tests. Specifically, plans are being made to investigate hearing abilities using these test procedures with children having other types of diagnoses, namely, the brain injured child and the language-impaired child, who present disorders of special interest to the audiologist and to others dealing with children and communication disorders.

CHAPTER 2

BACKGROUND AND REVIEW OF THE LITERATURE

Hearing Loss in the Intellectually Subnormal

The clinical audiologist is called upon to measure the hearing function of children of school age. He has the responsibility for detecting educational placement and other problems posed by hearing disorders and of assisting in differential diagnosis among children suspected of hearing loss and/or reduced intelligence, for his area of professional interest is related to a wide range of communication, social and educational problems in children. In order to discharge his responsibility, the audiologist needs adequate clinical tools for the detection of hearing loss in children. Factors such as short attention span, shyness, lack of interest in the hearing test procedure and inability to comprehend or cooperate in the test make child-testing a problem, even with many normal children.

In the evaluation of mentally retarded (MR) and children with borderline intelligence, the same problems exist in an exaggerated form and are accompanied by other problems such as reduced vocabulary, lack of social, emotional, and physical development, unintelligible and/or retarded speech, and an orientation of failure toward test situations. All of these factors combine to make audiological testing of these children a difficult task and the interpretation of responses too often an art rather than a science. In addition, the audiology field lacks adequate baseline data for evaluating hearing test responses of the mentally retarded, whose performance may be influenced by factors other than status of the hearing end organ.

In many cases any difficulty that MR children have in school or in life adjustment is attributed to their reduced intellectual functioning. However, many of these children have other handicapping disorders, one of which is hearing loss. Birch and Matthews (1951) administered pure-tone tests to 247 institutionalized trainable MR children aged 10-19 years. They found that symptoms of hearing loss and symptoms of mental retardation often are similar. Over 44.5 per cent of their subjects passed the sweep check at 15 dB in both ears. Some explanations offered by Birch and Matthews for the poor pure tone test results by the mental retardates include past experience which impaired selective attention to sounds, rigidity of thinking, minimal cerebral dysfunction, poor frustration tolerance, anticipation of failure, special disabilities in different areas of auditory performance and specific memory defects. Foale (1954) reported better hearing than found by Birch and Matthews in her sample of one hundred mentally retarded boys age ten to nineteen years. However, her sample had a mean IQ of 66 in contrast to the previous study whose subjects had a median IQ of 49. Sixty-seven per cent of Foale's subjects had good hearing in both ears, good hearing being defined as hearing at least twenty dB on a pure tone test. Sheridan (1948) theorized that mental retardation involves functional unawareness of many of the finer speech sounds and that the child's auditory discrimination is primitive, as are his muscular control and intellectual processes.

Johnson and Farell (1954) reported on hearing testing of 270 educable retarded children. Their procedure involved pure tone testing over the range 250 to 6000 Hz. Criteria for hearing loss was a hearing level of 20 dB or more at two or more frequencies; of those tested 24 per cent had hearing losses. Kodman et al. (1958) obtained similar results testing 208 institutionalized mentally retarded adolescents and adults. The subjects were divided into two chronological age groups. The younger group (N = 84) had a mean age of 15.4. The older group (N = 105) had a mean age 38.70 years. Each subject was screened for hearing at 20 dB over the frequency range 250 to 8000 Hz. Hearing loss criteria were defined as thresholds of thirty decibels or greater at one or more frequencies in each ear. The incidence of hearing loss for the population tested was 21.43 per cent. Bradley et al. (1955) suggested that a battery of tests rather than pure tone testing along would demonstrate a smaller incidence of hearing loss. Rigrodski, Prunty, and Glovesky (1961) surveyed the incidence of hearing loss in 235 children and adults, of which only a minimal number where custodial cases, at the training school in Vineland, New Jersey. Frequencies tested were 250 to 8000 Hz. A hearing loss was defined as a hearing level of 20 dB or more for any two frequencies in any one ear. Twenty-five per cent of the subjects tested had impaired hearing.

Schlanger and Gottsleben (1956) reported on a similar population (498 subjects were included in their group). They found that 35 per cent of the testable subjects had demonstrable hearing losses which were significant and in need of conservation and remedial measures. They tested over 125 to 12,000 Hz.

Rittimanic (1959) tested 1220 patients ranging in IQ from 30 to 129 at the Dixon State School in Illinois. Subjects were selected on the basis of ability to respond reliably to a pure tone audiometric screening test. Untestable patients were severely retarded, emotionally disturbed, uncooperative or unwilling, or hospitalized. The criteria for hearing loss was a hearing level of 15 dB or greater for two or more frequencies tested at 250 to 8000 Hz in one or both ears. According to this criterion 40.5 per cent of the subjects had hearing losses which were thought to be significant. Eighty per cent of the hearing loss cases required only conservative medical treatment because their losses were not socially or educationally handicapping. Of the 25 subjects less than ten years of age who were tested, only four per cent showed hearing loss. Of the 297 subjects tested in the age range ten to nineteen years, however, 19.8 per cent were found to have hearing losses. The same investigator (1966) found 51 per cent of institutionalized mental retardates to have medically significant hearing losses. Siegenthaler and Krzywicki (1959) attempted hearing testing of 396 school and 242 non-school girls at an institution for potentially delinquent females of childbearing age in Laurelton, Pennsylvania. The school girls had a mean chronological age of 21.7 and a mean IQ of 52.4. The non-school girls had a mean chronological age of 35.0 and a mean IQ of 51.0. Incidence of hearing loss for the groups were seventeen per cent for the school girls and 32 per cent for the non-school girls when tested over the 250 to 4000 Hz range at 15 dB (ASA 1951). Most of the losses were less than thirty decibels.

Summarizing the literature in regard to hearing surveys of institutionalized retardates, hearing loss appears to be more frequent than in the normal population: consensus of surveys indicates about thirty per cent or greater incidence of hearing loss among retardates. This percentage varies with the decibel level set as a criterion for hearing loss. Approximately twenty per cent of the institutionalized MR group might be expected to have a hearing level for speech reception threshold of twenty decibels or more.

Speech Reception Threshold of Intellectually Subnormal Samples

Almost no mention has been made in the literature of the incidence of hearing loss in mental retardates when measured by speech hearing tests. Schlanger and Galanowsky (1966) reported on the results of tests of auditory discrimination with 86 normal and 85 retarded children. The retardates were eight to sixteen years old and had IQ's of fifty to seventy. The normals were in grades kindergarten through second, and were four to eight years old. All the subjects had normal hearing and intelligible speech. However, it was found that the normal children had significantly higher scores in all of the auditory discrimination tests.

A recent study by Clausen (1966) included three retarded groups: 68 eight to ten year olds, 105 twelve to fifteen year olds, and 103 twenty to twenty-four year olds. These groups were compared with 112 eight to ten year old normals. The retardates were selected to be in the fifty to seventy-five IQ range, but subjects who could not follow directions were excluded. A comparison was made according to pure tone audiometry and speech threshold. The criterion for pure tone hearing loss was threshold twenty decibels or greater for any two frequencies in the 500 to 8000 Hz range in one ear, and the criterion adopted for speech reception was twenty decibels or more hearing level. The retardates performed below the normals in terms of hearing acuity on both the pure tone test and the speech threshold test. The incidence of hearing loss in retardates proved to be higher according to the pure tone test than according to the speech reception test, which was not the case with the normals. On the speech reception threshold test the older retardates performed better as a group. The incidence of hearing loss according to these tests was 16.2 per cent for the eight to ten year old group and 7.6 per cent for the twelve to fifteen year old group, as compared to the following percentages of incidence of hearing loss according to pure tone test results: 23.5 per cent for the eight to ten year old group, 16.2 per cent for the twelve to fifteen year old group, and 20.4 per cent for the twenty-one year old group.

Testing the Hearing of Intellectually Subnormal Children

The incidence of hearing loss among retardates is, as previously mentioned, higher than that among normals. Fulton and Griffin (1967) suggest that this high incidence cannot be explained by audiometric test techniques or inability to respond in view of the high percentage of MR children requiring otological treatment, which in turn may be due to the inability of the mental retardates to obtain otological attention in early stages of ear disease. However, the findings of Clausen (1966) suggest that the conclusions about incidence rates of hearing loss in retardates on pure tone threshold alone may be misleading. That study showed a lower incidence of hearing loss for speech reception than for pure tone audiometry. How much of the variance of the apparent hearing loss in retardates can be attributed to primary sensory defects, arousal level, or methodology is still to be described. Perhaps both threshold for speech and pure tone should be used for diagnosing hearing loss in retardates. This notion was supported by the low correlation between pure tone and speech threshold, which showed the inability to predict accurately from one test to the other. The speech threshold test seemed to cause less test procedure difficulties than the pure tone test for the retardates and appeared to be a better indicator of the ability of an individual to interact with the environment. Speech hearing testing would therefore be the test of choice. The pure tone test may be given, in addition either to confirm the results of the speech reception test, and/or give additional information about the subjects arousal level or capacity for attention.

Other investigators have made similar observations. Myklebust (1954) and Wolfe and MacPherson (1959) reported that retarded subjects respond better to more meaningful test stimuli (e.g., speech signals) than they do to more abstract stimuli (e.g., pure tones). Schlanger (1961) used six different audiometric procedures to assess the hearing ability of retarded children before and after a period of listening training. A speech reception test showed the lowest threshold. Fulton and Graham (1964) reported that audiometric test-retest reliability in retardates is related to general functioning level. Thus, it seems well-documented that pure tone audiometry is not always the best indicator of auditory functioning in retardates. There seem to be valid arguments for a more extensive use of speech reception tests.

A further problem of validity in hearing testing procedure with retardates involves possible confounding of the results of the hearing testing with the symptoms of retardation itself (or one or more of the effects of retardation). Therefore, much attention has been devoted to developing testing techniques and evaluating the auditory capacity and auditory behavior of children (Barr 1955; Debyshire and McDermott 1958; Ewing and Ewing 1944; Hardy and Bordley 1951; and Lowell, Rushford, Hoversten and Stoner, 1956). Myklebust (1954) indicated that auditory testing of young children, especially those with hearing disorders, is a difficult task and it therefore must be approached with caution and skill in order to insure validity. Wood and Frisina (1962) also discussed types of audiological tests necessary for differential diagnosis, that are supplemental to tests of auditory sensitivity.

Mentally retarded children seem to respond better to test stimuli that are more meaningful and generally suitable to them than to the more abstract pure tones, as previously mentioned (Myklebust, 1954; Wolfe and MacPherson, 1959). Sortini (1960) reported that speech is also a more effective stimulus than are more abstract pure tones for many brain-injured children. Several special techniques and word lists (Keaster, 1947; Siegenthaler, Pearson, and Lezak, 1954) have been prepared for determining the speech reception thresholds of children. Dale (1962) and Solomon (1962) both used toy and game techniques to test speech hearing. However, some investigators warn that complex toys are often less effective than simple ones, both with young normally hearing children (Philips, 1961) and with the mentally retarded (Wolfe and MacPherson, 1959).

Besides arranging stimuli to improve the validity of hearing testing with young and/or retarded children, the responses required of the subject are often structured. For example, Myerson and Michael (1960) built an elaborate conditioning apparatus for testing the hearing of mentally retarded children which, according to them, works effectively. The Ewings (1944) and Lowell and his team (1956) developed some of the play conditioned response techniques employing simple toys and activities. McHugh and Hall (1954) discussed the use of music, loud speakers, noisemakers, rhythm band percussion instruments and the like. The peep show of Dix and Hallpike (1947) and the pediacoumeter (Gilford and Haug 1952) were among the first in a series of complex play conditioned response techniques involving hear-and-do combinations. Siegenthaler and Kaplan (1957) compared a modified peep show using pictures to the standard pure tone technique (hand raising) with 39 normal-hearing above average in intelligence, pre-school children. The former technique capitalized on the use of reinforcement. The peep show gave more acute thresholds by about 3 dB, was equally reliable to the standard method, required an easier and shorter orientation period, took slightly longer to obtain thresholds at three frequencies, was preferred by children, and was generally more successful.

There are several limitations to play audiometry (Dansinger and Madow, 1966) and to GSR conditioning (Thorne, 1962) when applied to the retarded (especially to the more severely retarded). The procedure and training involved in testing is often time consuming; the subject cannot maintain attention, cooperation and motivation; an experienced testing team is needed; the subject may fail to understand what is expected of him. Christiansen and Schlanger (1964) felt that special preparation is needed for the mentally retarded to make the test a more meaningful and accurate indicator of hearing ability. Iches (1963) found that when an accuracy indicator was used, subjects were more apt to report the presence of a weak stimulus, were less influenced by response bias, and had a mean threshold 6.5 dB lower than with ordinary pure tone audiometry.

In comparing standard audiometry, play audiometry, GSR audiometry, and a speech reception threshold test with mentally retarded children, Schlanger (1962) found that the SRT test produced the lowest threshold, was more reliable, did not depend on auditory training as much and enabled a greater proportion of the subjects to be tested. He used the Verbal Auditory Screen for Children (VASC). His criterion of hearing loss was fifteen decibles loss in either ear; 58.3 per cent were impaired. At thirty decibels, 12.6 per cent were impaired, and were believed to have sufficient hearing loss to interfere with communication.

According to Kodman et al. (1958), the purpose of hearing testing with the mentally retarded is not to obtain an absolute threshold but to rule out hearing loss as a factor in diagnosis. In agreement, Juers (1956) stressed the importance of knowing the speech hearing threshold as well as the pure tone threshold in order to compare the two to make a diagnosis. For example, greater loss for speech than for pure tone is common in most deafness, while greater loss for pure tones than for speech suggests psychogenic deafness. Lehrer (1964) studied ten children eleven to sixteen years old ranging in IQ from 69 to 116 (with a mean of 89). All were diagnosed to be psychogenically deaf and were treated by psychotherapy, which lasted from several weeks to three months per individual. Results were better school adjustment and no hearing loss. Thus, the speech reception threshold can be useful in diagnosis of normal and of retarded children and adults.

According to Myatt and Landis (1963), desired information includes not only the determination of speech reception threshold, but also a measure of how well speech is understood at above-threshold levels. Tests with this latter objective have been standardized (largely on adult populations) using the well known phonetically balanced lists of words. The proper administration of these tests requires the examiner to evaluate the subjects' response in terms of accuracy with respect to the presented stimuli. If the child is immature or has an articulation defect, it is difficult to evaluate an erroneous response to a stimulus word as to whether the child failed to discriminate the stimulus correctly or whether he is not repeating it correctly because of a speech problem. To avoid verbal response, some clinicians have used picture tests to obtain speech reception threshold. The value of this type of testing has been demonstrated by Streng and her associates (1955), among others.

In order for such a test to be useful for a wide range of children, several factors must be considered: words chosen to be illustrated must be within the vocabulary range of a wide variety of children, the pictures chosen must be adequate representations of the specific words in question, and intelligence of the child should not be a significant factor in his ability to recognize and designate the pictures. If the above factors are taken into account, the child's nonverbal performance on a picture discrimination test may be interpreted as an indication of the degree of discrimination ability.

Myatt and Landis (1963) studied four groups of twenty children each: a normal group, a speech defective group, an educable mentally retarded group (EMR), and a trainable mentally retarded (TMR) group. Children in all groups had normal hearing, as determined by audiometric testing consisting of pure tone sweep checks at fifteen decibles, and speech reception threshold testing. The picture test involved four pictures, of which the child chose the one mentioned. The words were assembled into twenty groups of four words each. The educable mentally retarded group had the smallest number of errors. In considering the reasons for this result, a study of the curriculum of the EMR group showed that these children were very much picture-oriented.

Therefore, the EMR child habitually responded to pictorial stimuli. The scores of the speech defective group and the normal group were highly similar. The scores of the trainable MR group were significantly lower than the score of the other three groups. The moderately high positive correlation of test scores with IQ for the TMR group and the absence of a significant correlation for the EMR group suggested that for children with above approximately fifty IQ, intelligence does not effect achievement on the picture test.

With regard to the reliability of hearing testing, it should be noted that approximately between 23.5 per cent and 29.0 per cent of those apparently of normal intelligence indicated errors greater than plus and minus five decibels between the initial test and re-test (Myatt and Landis, 1963). To investigate the question of threshold among the retarded, Fulton and Graham (1964) drew 51 subjects within the age range of ten to thirty years randomly from the population at the Fort Wayne State School. They ranged in IQ from borderline to severe. Auditory thresholds at 1000 Hz were obtained on four tests, with testing repeated at two week intervals for at least six presentations. Decibel differences were calculated between the base threshold (initial test) and all successive thresholds. A mean dB difference was computed for the first three thresholds and the last three thresholds for each subject and compared with the remaining individual test thresholds. Percentages of subjects within groups having test re-test reliability better than five decibels were determined. The results tended to indicate that plus or minus five decibels test re-test reliability is subject to the intellectual functioning level of the individual tested. However the only statistically significant difference between IQ groups was between the moderate and the severely retarded. The relative lack of reliability with the moderately retarded, and the frequent difficulty testing the severely retarded may have accounted for these results. There was good reliability, i.e. five decibels or less, for the borderline cases, but 35.7 per cent of the mildly and 53.3 per cent of the moderately retarded indicated test reliability values greater than five decibels.

Lloyd and Reid (1966) reported on the reliability of SRT's obtained from a random sample of institutionalized MR children covering the range of measured intelligence levels up to 75, and a wide range of auditory sensitivity. Subjects were tested with either the repeat-the-word or point-to-the picture speech methods using selected spondee words. Live voice procedures were employed. The right ear, left ear, and sound field SRT's were obtained. Better test re-test agreement was found for higher level retardates than lower level retardates. Clinically reliable SRT's generally can be obtained from the moderately retarded patients. It appeared that for most mentally retarded subjects who could be tested with conventional forms of both speech and pure tone audiometry, speech thresholds are slightly more reliable than pure tone thresholds.

Lloyd and Melrose (1966) investigated the agreement of pure tone and speech audiometry with mentally retarded children. They used forty subjects from eight to fifteen years old ranging in IQ from forty to sixty-nine. Thresholds for 500 Hz, 1000 Hz, and 2000 Hz, and pure tone averages were obtained by four methods: standard, slide picture show, ear choice and play. SRT's were obtained by standard and picture methods. All six audiometric methods yielded reliable results with mentally retarded children, reliable being defined as between .76 and .99 Pearson product-moment test and re-test correlations.

The previously reported adequate reliability for speech audiometry with mentally retarded children (Lloyd, 1965; Lloyd and Melrose, 1966) was supported by Lloyd, Reid, and McManis (1967) with twenty-four mentally retarded subjects ranging in age from eight to 21 years of age. They investigated the say-the-word and the point-to-the picture methods. They found good test and re-test reliability, i.e. .78, for one-day intervals with live voice for both methods and no significant difference between the mean SRT's. Lloyd and Melrose (1966b) obtained a .92 correlation for reliability; however, their between-test interval was only twenty minutes and they used a recorded voice.

Relationship between Speech Hearing and Some Organic Variables

A legitimate concern about mentally retarded children involves identifying variables related to their speech hearing performance. Subjects with a CA over twenty years more often showed hearing impairment, particularly in the high frequency area, than those under twenty in a study by Schlanger and Gottsleben (1956). Seventeen per cent of the population, however, were non-testable. These subjects usually fell below an MA of five years, had personality disturbances to varying degrees, and achieved social quotients below forty. Watkins and Ryan (1966), in attempting to standardize hearing tests on a group of 26 subjects, aged 5-11 to 11-4 and of IQ twenty-nine to fifty, found that MA did not correlate significantly with pure tone hearing. Correlation coefficients between hearing test scores and pure tone three-frequency averages, and between SRT and hearing test scores were significant at the .05 level. No significant correlations were found between CA and any of the test methods.

On a population of 638 girls from Laurelton State Hospital, Siegenthaler and Krzywicki (1959), using the better ear average threshold for each girl as a level of hearing acuity according to pure tone testing from 500 through 2000 Hz, found no significant correlations between age, IQ, and hearing loss. Johnston and Farrell (1954), investigating the hearing of 270 subjects, found no significant differences between the normal hearing group and the hearing loss group in mean CA, IQ and length of institutionalization.

However, Zaner et al. (1968), using fifty normal subjects four to eight years old, found that auditory perception (using pure tones with differing frequencies, intensity, and varying duration patterns) followed a developmental pattern. Unlike other studies of sensory perception, this one reported the greatest increase in perceptibility between four and five and six and seven year olds. Moreover, Siegenthaler and Haspiel (1966) reported an age effect with respect of hearing ability for both males and females.

Kennedy (1957) hypothesized that hearing was a maturational phenomenon. Her sample consisted of 433 males and females aged six to twenty-three who ranged in IQ from 97 to 149. She found significant pure tone hearing differences between six and fifteen year boy and girl groups; the same findings occurred between six and eight year olds and between girls of eight and fifteen. She concluded that hearing is a maturational process without significant sex differences, and that this process has spurts and plateaus rather than showing a straight line function.

Relating to speech discrimination, Hutton and Weaver (1959) investigated 53 public school students receiving speech therapy and who had normal pure tone hearing, were in grades kindergarten to twelfth grade and were of normal intelligence. Word familiarity was varied as measured by the frequency of occurrence. The fifteen least familiar words were less intelligible than the fifteen most familiar words. Intelligibility increased with age, especially for the least familiar words at lower age levels. Cohen and Diehl (1963) found speech sound discrimination ability to be related to grade level in children with severe articulation problems from grades one to three. Speech sound discrimination ability, according to the data, tends to improve with grade level; however, the speech defective group performed inferiorly to normal-speaking children.

If the high incidence of hearing loss identified in the mentally retarded population is, at least partially, the result of retardation or of a word familarity factor, the incidence of loss should be correlated with intelligence in this group. However, Siegenthaler and Krzywicki (1959) did not find the presence of hearing loss to be significantly related to IQ. Product-moment and partial correlations between hearing loss, IQ, and chronological age yielded no significant relationships. (The restricted IQ range of their group may also explain the lack of correlation in part). Schlanger and Gottsleben (1954) also presented data with similar implications. The incidence of hearing loss was found to be 31 per cent in the mildly retarded group; 20 per cent for the moderately retarded; 16 per cent for the severely retarded; and 21 per cent for the profoundly retarded.

Hence, a clear pattern of increasing incidence of hearing loss from mildly retarded to severely retarded has not been found. The pre-selection of cases for testing as found in most studies may explain why the level of retardation and the incidence of hearing loss have not appeared to be related. Even though more subjects in the lower IQ range might have been classified as having hearing loss if tested, only the ones who were less apt to exhibit hearing loss (because of adequate responses) may have been tested, thereby avoiding an apparent high incidence of loss (Webb, Kinde, Weber and Beedle, 1966). An appropriate conclusion might be that hearing loss is high in retardates, but not because of the retardation since hearing loss does not increase as retardation increases. Perhaps the high incidence usually found occurs as a result of the preselection of patients for institutional placement. Another possible explanation is that the effects of institutional placement, in itself, may result in hearing loss or lack of responses to sound. However, this second possible explanation has not been substantiated by the results of Webb, Cowie, and Beedle (1963), who found a correlation of .37 between per cent of chronological age spent in an institution and number of observed responses to free field live voice sound. The higher the per cent of his life a patient had been in the institution, the more responsive to sound he was. Their interpretation of this finding was that auditory stimulation may become more meaningful with institutionalization, thereby arousing the subject's attention more.

From the above studies it can be seen that the significant variables possibly accounting for obtained differences in hearing test survey results are chronological age, mental age, and criteria for hearing loss (including the frequencies, intensities and number of failures to respond). Other intervening variables are the type of patients excluded from testing and the procedure for determining which patients would be considered testable subjects.

While examiners who have used normal subjects have frequently found lower IQ for those with poor hearing (McKane, 1933; Oeron, 1950; Pinter and Reamer, 1920; and Kishey, 1956), Luszki (1965) found that 117 mentally retarded instiutionalized subjects, aged ten to forty, who differed in degree of hearing impairment according to pure tone tests, SRT, and speech discrimination did not differ in the following: total WISC test score, total full scale IQ, performance subtest scale scores, total performance scale scores, total verbal scale scores, and verbal subtest scale scores.

Relationship between Intelligence and Physiological Factors

It is generally believed that intelligence is the result of many factors which interact differently for any one individual (Guilford, 1967; Tizard, 1965; Thorne, 1965; Jordan, 1966). Many of these factors, whether they are genetic, environmental, and/or psychological, are also responsible for determining the pattern of physical growth and development for the individual (Tanner, 1962; Watson and Lowrey, 1962). That intellectual and physical factors have not been considered jointly is attested to by the relative absence of physical growth data related to the mental development of children and adults. Most studies dealing specifically with the relationship between mental and physical development are over thirty years old or are very limited in their coverage of either of the two parameters (Haas, 1969). Flory (1936) and Abernathy (1936) studied the physical growth and development of mentally retarded children. The latter study showed that the early adolescence or puberty stage of development occurs later and lasts longer for a mentally retarded group than for the normal population. Flory's study was concerned with the skeletal, dental and morphological development of mentally retarded males. He found that the average physical growth rate is slower and the growth period is longer for a mentally retarded group as compared to the normal group. This decreased rate of growth was noted over the entire age range from five to twenty-five years, and the degree of mental development varied directly with the degree of physical development.

Henderson (1970), in a review of studies of the relationship between physical defects and mental age or intelligence quotient, concluded that mental retardates as a group have a high incidence of physical defects of all kinds. Therefore, he felt that for differential diagnosis of multiply handicapped mentally retarded children (such as mentally retarded children with hearing loss) more extensive and sensitive test procedures are needed.

Kugel and Mohr (1963) reported that mentally retarded subjects are not different from normals in height and weight, or show only slightly retarded height and weight development when the subject groups consist of large numbers of children covering a wide age range and when mental retardation is defined as from just below normal IQ to severely retarded. This type of sample, consisting of 550 girls and 522 boys covering the age range from birth through late adolescence and including children with IQ's from severely retarded through well above average, was investigated by Dearborn and Rothney (1941). Partial correlations, with CA held constant, between anatomical measures and average IQ scores yielded correlations no higher than .234 for a sample of 533 boys. Correlations were calculated between several variables. Between height and weight the correlation was .676; the correlation between intelligence and height was .224; and the correlation between intelligence and weight was .137. A multiple correlation between intelligence and height, weight, iliac size, chest depth, and chest width was only .247.

Mental and physical relationships have generally correlated more highly among the feeble minded, and the correlation is progressively greater for lower IQ groups. The correlation between weight and height is greater for those who have lower IQ (below one hundred) than higher IQ (above one hundred). Correlations between height and weight and for groups consisting of subjects who are mentally retarded, normal or above average in IQ have been around .15. For above average IQ groups the correlation are .04 to .06; and for below average IQ groups the correlations are .13 to .14 (Mudock and Sullivan, 1923). Doll (1916) found correlations among height, weight and IQ from .31 to .47 for sub-normal and feeble minded boys and girls.

Woodrow and Lowell (1921) and also Prescott (1923) found low positive correlations between mental development and stage of ossification of the wrist bone. Prescott (1923) studied 3,050 six to eighteen year old mental retardates, and Woodrow and Lowell (1921) five-and-a-half year old mental retardates and normals with similar results. Even lower, but still positive, relationships were found between dentition and intelligence (Woodrow and Lowell, 1927) and mental development and pubescence (Leal, 1929).

Howe (1959) compared mentally retarded and normal public school children, matched for CA, with respect to performance on a variety of motor skill tasks. The purpose was to relate intellectual test results and motor performance. Forty-three retarded and forty-three normal children, aged six to eleven, were included in this study. The retarded children had a mean IQ of 67.5 for boys and 64.5 for girls. The normal children had a mean IQ of 99.9 for boys and 97.5 for girls. Normal children were consistently superior to the mentally retarded on motor skill tasks. For boys, the normal group was significantly superior to the retarded group on all tasks. For girls, differences favored the normal group for all tasks except grip strength and accuracy in throwing a ball at a target.

Auxter (1966) compared an intellectually typical population composed of 35 boys aged nine to eleven, with a mentally retarded population of 91 educable boys aged nine to eleven. The mentally retarded group was divided into 33 non-brain-damaged, 31 brain-damaged and 27 undifferentiated boys. The ability to withstand the onset of muscular fatigue was examined (i.e., the ability of a group of muscles to maintain maximal functioning over a period of time). The normally intelligent group performed significantly better than any of the MR groups, and the non-brain-damaged group performed significantly better than the brain-damaged or undifferentiated groups.

Klausmeir and Check (1959) investigated the relationship among physical, mental and personality measures in children of low, average, and high intelligence of about 9-4 years old. Their sample of sixty consisted of twenty subjects of each sex of low IQ (55-80 full scale score on WISC), of average IQ (90-110) and of high IQ (120 and above). Measures of grip strength, height, weight, bone development of the hand and wrist, IQ on the WISC, and number of permanent teeth were obtained. Four physical measures (height, weight, strength and carpal age) were significantly related, although the correlations were low. Number of permanent teeth did not correlate significantly or consistently with the other physical measures. Grip strength was the only physical measure showing positive and significant correlations (e.g., .39 to .54) with IQ (for both sexes). The low IQ group was lower than the average and high IQ groups in grip strength. The children of low IQ did not differ significantly from those of average or high IQ in the following measures: weight, number of permanent teeth, and carpal age.

Sex differences in dental maturation are slight, so that for equivalent stages of development of permanent teeth the average age of a girl is 95 per cent that of a boy. For the maturation of the bones of the hand at a given stage, a girl is 80 per cent as old as a boy. Estimation of age by teeth is better than using hand x-rays (Hunt and Gleiser, 1955).

Douglas, Ross and Simpson (1965) studied the relationship between measured school ability, stature and sexual development. Mosier et al. (1962) studied the development of secondary sexual characteristics of mentally deficient children. These two studies arrived at conclusions similar to that of Flory (1936), and Abernathy (1936), both of whom, as previously mentioned, had found that the average growth rate is slower and the growth period is longer in the MR than in normals.

Most of the previously mentioned studies have only dealt with lower level MR children (i.e., less than one per cent of the child population). Their retarded mental and physical development may be due to a combination of hereditory and environmental pressures. On the contrary, the process of growth and development of the child who falls into the 75 to 95 IQ range has been neglected in the literature. These dull-normal or borderline children, although reared in an environment basically similar to the normal child, may be influenced by some of the factors that account for the low mental and physical development of the lower IQ groups.

Brain injured children have been mentioned in one study previously, that of Auxter (1966). Grey, D'Asaro, and Sklar (1965) investigated auditory perceptual thresholds in 48 brain-injured children, aged five to eight years old, with IQ' ranging from 71 to 130. This study was designed to determine how congential brain injury, alone or in combination with sensory-neural hearing impairment, affects figure-ground thresholds for speech in young children. When brain injured and non-brain injured children with equivalent hearing sensitivity are compared, no significant differences occur in their responses to speech stimuli under optimal or difficult conditions. The same is true of hard-of-hearing and of non hard-of-hearing brain injured children. Pure tone thresholds for 500, 1000 and 2000 Hz were used as a measure of hearing acuity. Also, speech frequency averages and speech perception thresholds in quiet were obtained. The latter was obtained by having the subject point to pictures. At least one aspect of auditory perception in young children, word identification at threshold levels, was unimpaired both for subjects with congential brain injury and for subjects having brain injury and hearing loss, even under different listening conditions.

Sievens and Rosenberg (1960) found differences between brain injured and non-brain injured mentally retarded children in language facility tests. The brain-injured children had more difficulty hearing fragmentary parts of speech and integrating them into wholes, reproducing a series of meaningless sounds, perceiving grammatical incongruencies, and hearing a fragment of any sentence and supplying the necessary verbal symbols to make a whole.

Summary of Literature Findings

The audiologist needs adequate clinical tools for the detection of hearing loss in children and adequate baseline data for evaluating hearing test responses of the mentally retarded. Incidence studies generally report a much higher incidence of hearing loss among retardates than among normal children. The incidence varies, however, with criterion of hearing loss, sample selection procedure, intelligence range, age, and type of testing procedure. The retardates' performance is not inferior to normals on speech hearing tests for threshold. Such tests appear to be a better indicator of the ability to hear and interact with the environment. Because it often is hard to separate symptoms of hearing loss and of mental retardation, different stimuli have been used to test hearing, aimed at making test procedures meaningful and valid. Also, responses required of the subject have been varied for the same purpose. Speech hearing testing seems to be a valid technique to use with the intellectually subnormal, not only to test hearing acuity but as an aid in differential diagnosis. Clinically reliable SRT's can be obtained from moderately retarded persons.

Several studies have reported non-significant relationships between hearing acuity and age, IQ, and MA in mentally retarded groups, but more heterogeneous or normally intelligent groups have shown maturational factors operating in hearing acuity. An age effect seems to occur in speech hearing, also. Sex differences, however, are rare. Although hearing loss is frequent in retardates, it does not appear to vary directly with intelligence level.

Lower intelligence groups are found, however, to be slower in physical growth and development, motor skill, and strength development, and to have a higher incidence of physical defects. With a heterogeneous sample in terms of CA and IQ low positive correlations have been reported between intelligence and height, weight, other anatomical features, bone age, dentition and pubescence. All of these correlations are somewhat higher for retardates than for normal samples. Intra-physiological correlations are much greater than correlations between intelligence and physiological indices. A question still remains as to the relationship between physical factors, hearing acuity, and intelligence in intellectually dull-normal children.

Context of the Present Study

The important place of speech reception threshold testing and discrimination testing in audiological practice is indicated by several authorities (Hirsh, 1952; Davis, 1947, and Newby, 1964). Audiological tests of speech discrimination have been developed for use with children (PBK and PBF word list) and have been demonstrated to be applicable with children as young as eight years of age (Siegenthaler and Hardick, 1959). However, a number of studies have demonstrated that factors other than phonetic balancing, such as word length, distinctive features of phonemes, context, and word familiarity make major contributions to intelligibility. For example, a study by Owens (1961) which is representative of research involving word familiarity, showed that the relative intelligibility of a word is related to the frequency of occurrence of that word in general usage.

A current need for mentally retarded children is indicated by the following statement taken from what is probably, to date, the most comprehensive study of hearing testing among mentally retarded children.

> Perhaps the most important aspect of this study is to bring into serious question hearing test procedures, as modified and intended to be similar to those previously defined by other investigators, when applied to retarded patients. Multiple test administration does not appear to be advisable unless the tests are adequately evaluated on the population to be tested in terms of test-re-test interjudge reliability and the ability to discriminate hard-of-hearing subjects from behavioral categories with similar observed characteristics. The major point is that many of the test procedures, as evaluated in this project, did not appear to result in valid estimates of hearing ability when applied to this population (Webb et al., 1964).

The Pennsylvania State University Speech and Hearing Clinic has completed investigations into two measures of speech hearing in children: The Threshold of Identification of Pictures test (TIP) which is used for measuring speech reception threshold, and the Discrimination by Identification of Pictures test (DIP) which is used for describing speech intelligibility. Both of these tests are intended to accommodate to the special problems found in the testing of children with various kinds of hearing dysfunctions. The TIP and DIP tests were developed under a two-year project sponsored by the U. S. Office of Education (Siegenthaler and Haspiel, 1966).

Haspiel and Siegenthaler (1968) engaged in another USOE sponsored project for the evaluation of the TIP and DIP tests with hearing-impaired children. Data from this latter p. ject indicated the usefulness of the TIP and DIP test as measures of speech hearing functions among hypacusic children a l sensitivity of both tests for detecting hearing problems. Because of the underlying rationale, the construction of the TIP and DIP tests, and their demonstrated reliability and validity, they are believed to be significant improvements over other threshold and discrimination tests that are currently available for children. Past experience with these tests has shown them to be helpful in overcoming many of the difficulties in testing young children, and these tests have been observed to be clinically useful for testing the hearing functions of mentally retarded children.

The problem is not one of simply developing techniques for obtaining responses from mentally retarded children. The TIP and DIP tests for speech hearing are useable with children having mental ages at least as low as three years, and the state of the audiological art permits pure tone testing with children this young in mental age. There is a more important aspect, that of age base line against which a given mentally retarded child's responses are to be evaluated. Previous research indicates that hearing for speech improves with maturation in normal children, and the correct age base line should be used when evaluating hearing test scores (Siegenthaler and Haspiel, 1966). Also, it is often believed that among the mentally retarded, problem-solving behavior tends to be characteristic of mental age (Dunn, 1964). These two pieces of information suggest that the speech hearing test scores for the mentally retarded subject should be evaluated against his maturation level.

Recently, however, some question has been raised regarding the assumption that mental age is the determining factor in the behavior of the mentally retarded. Involved are such issues as the differential between MA and CA, perceptual deficits which lower IQ scores but which are accompanied by what may be essentially normal intelligence in other areas, and physical maturation status, and it may be expected that life experiences will influence test behavior. Furthermore, speech hearing tests are designed to be relatively free from sensitivity to intelligence and such tests may not be typical problem-solving tasks. The hearing process involves both a cortical level of understanding and interpretation, as well as a sensory process level dependent upon physical status which, especially among the mentally retarded, may or may not be consistent with chronological age. Thus, the possibility exists that among mentally retarded children there is a more complex factor than only mental age (assuming normal hearing acuity) which influences test score. It is reasonable to suggest that there may be interaction between MA, CA and IQ as well as physiological maturation status, and if present that this interaction should be taken into account when interpreting the auditory behavior of the mentally retarded.

The present project considered certain maturational and intellectual factors, and the possible interplay among them as they are related to speech hearing ability (speech reception threshold and speech discrimination) among educable mentally retarded and borderline intelligence children without hearing loss. This aspect of the mental retardation problem, especially as related to hearing (with absence of frank ear pathology in the usual audiological or otological sense) has heretofore been unexplored.

Statement of Problem

The general purpose of this study was to investigate the relationships among mental age (MA), chronological age (CA), intelligence quotient (IQ), physiological age (PA), and speech hearing ability (threshold, and discrimination) among children with less than normal intellectual ability in the borderline and educable range.

CHAPTER 3

METHODS

Test Descriptions

The Wechsler Intelligence Scale (WISC) for children (Weschsler, 1949) consists of twelve tests which are divided into two subgroups identified as Verbal and Performance. Most of the verbal tests correlate better with each other than with tests of the performance group. The tests of the scale are grouped as follows: information, comprehension, arithmetic, similarities, vocabulary, digit span; performance: picture completion, picture arrangement, block design, object assembly, coding, and mazes. In standardization of the WISC, all twelve tests were given to every subject, but in the interest of shortening the time required for examination, the scale is reduced to ten tests. Ordinarily, five verbal and five performance tests are administered to the subject and IQ values are calculated on this basis. This procedure was followed in the present study. (The two tests omitted in establishing the IQ tables are digit span in the verbal part and mazes in the performance part of the examination.)

Reliability coefficients of the individual tests and of the verbal, performance, and full scale scores have been presented by Wechsler (1949) for ages 7 1/2, 10 1/2, and 13 1/2 years. Individual test reliability coefficients ranged from the .60 to .90, while full scale verbal and performance reliability coefficients are quite high, ranging from .88 to .96. The standard error of measurement for the verbal IQ of the seven and a half year old is 5.19, which indicates that the true IQ is probably within five points of IQ of the obtained score.

The Threshold by Identification of Picture Test (TIP) is for measuring speech reception threshold (SRT). Form A of this test is composed of a set of six cards, approximately twelve by fifteen inches, carrying five pictures in color per card (e.g., fish, house, shoe, doll, comb). The specific test items have been 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 five hundred words of Basic Vocabulary for Elementary School Children by H. A. Rinsland, New York: Macmillan, 1945. The first card is for practice and the remaining are test cards. Words (pictures) on a card are called to the subject at decreasing sound levels. Responses over the five test cards are used to obtain speech reception thresholds. The research data and the test materials were developed under U. S. Office of Education contract No. OE5-1-003 completed June 1966 (Siegenthaler and Haspiel, 1966). The standard error of estimated for TIP thresholds is 3 dB; i.e., two-thirds of the retest thresholds will be expected to fall within 3 dB of initial test thresholds. The TIP test protocol appears as Appendix B.

The Discrimination by Identification of Pictures (DIP) test is for measuring speech discrimination (also called speech intelligibility in this report). The DIP test is composed of 52 cards (four practice and 48 test items), twelve by fifteen inches in size, with two pictures per card. The subject is told to indicate one of the items on each card by "Point to the ______", according to the prepared test protocol. After each item, the card is turned, exposing the next pair of pictures. Sound level for test words is at sensation level of choice, in the usual manner for intelligibility tests of hearing. The pictures are things familiar to children, unambiguous in name, and arranged in pairs to be different in the phonetic factors of consonant voicing (e.g., pear, bear), of transition (e.g., peas, keys), of pressure pattern of consonant (e.g., hat, cat), or a combination of these phonetic factors. All words appear in the Teachers Workbook of Thirty Thousand Words (E. Thorndike and I. Lords, Teachers College, Columbia University, New York, 1944) among the "most familiar" category. Scoring is according to correct or incorrect selection of the item called in each pair, and provides an overall per cent correct. The test materials were developed at Penn State under U. S. Office of Education contract #OE5-10-003, completed June 1966 (Siegenthaler and Haspiel, 1966). Three forms (sets of call words) are available. The DIP test protocol appears in the Appendix C.

ADMINISTRATION OF TESTS

All intellectual evaluations were administered individually by a qualified school psychologist in a quiet, distraction-free room at the school which the child attended. The hearing testing also was done at the school which the child attended for most of the subjects. An effort was made to find the quietest room within the building; in most cases this room consisted of an empty classroom or a large supply closet. Some of the children were given the hearing tests at the Penn State campus using the Speech and Hearing Clinic audiology rooms.

Most of the physiological age testing was done at the Laboratory for Human Performance Research at Penn State University. However, the physiological test for fifty per cent of the institutionalized populations was at the institutions, with the necessary equipment transported to each site.

For SRT and speech discrimination testing the child was seated comfortly before a small table, the test materials were placed before him, and the examiner sat beside him with the scoring sheet, monitoring earphone, and tape-transport switch in his hand. In all cases, the examiner allowed the child to see all of the TIP and DIP pictures to make certain that they were known to the child. For any child who could not identify a particular picture, the examiner told him what the picture was and his understanding was verified before testing began. 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.

For the TIP test the child was presented one card at a time and told "Point to the _____" according to the prepared test protocol using the speech audiometer tape playback. Five responses are obtained using the pictures on a card. After each item, the examiner's voice level (tape-recorded) was reduced five decibels. The first item on each card was at the original beginning level. The test obtains twenty-five responses from the five cards and permits obtaining of the decibel level for fifty per cent threshold using either a graphic or a tabular method. Form B protocol is administered in the same way as Form A, but different picture items are used.

In DIP test administration, the examiner begins by monitoring the voice signal at VU 0 dB and continues administering the test items without changing presentation level to complete all four practice items and the forty-eight items on the form. Each item is called only once. The DIP test was administered at 0, 5 and 10 decibels relative to each subject's individual SRT level. The standard error of measurement is 4.8 items (ten per cent) for the DIP test.

Hearing Test Equipment and Recordings

For the present purpose, tape-recorded versions of the TIP and DIP tests were used. Copies of master tapes were made and used for experimental testing.

The apparatus consisted of an Ampex 620 series tape transport and amplifier (only one channel used). The output signal was monitored by a Ballentine VTVM and fed to a Deven decade attenuator box (X10, X1, and X.1 dB steps) and a pair of binaural matched Telephonic earphones (Model TD39) in MX41/AR cushion with headband. The system was calibrated for sound pressure level re .0002 dy/cm^2. This equipment was used for testing in the field. Testing in the Clinic was done by feeding the signal through a Grason Stadler speech audiometer to earphones, also calibrated in SPL re .0002 dy/cm^2.

The recording of each TIP and DIP test word, preceded by the carry phrase "Point to the ______" was done in a quiet sound-treated room with all words monitored at VU 0. The tape recorder was an Ampex 620 series with amplifier and Electrovoice Model 633 dynamic microphone. By re-recording, each word was brough within one decibel of the monitoring level. The final equalized tape was copied back onto the Ampex 620 tape recorder to produce a master tape, with 1000 Hz tone at the same VU meter level as the test words. TIP tests were made with progressive 5 dB attenuation after each of the five items for a test card. Each test card series began with the standard beginning level of 0 attenuation.

DIP items were all recorded without attenuation because the DIP tests were to be given at intensities that were relative to the SRT values determined by the TIP test. Either TIP Form A or Form B was recorded at the beginning of the test tape, and followed by three DIP test forms. The last DIP form was followed by the TIP test form which did not appear at the beginning of the tape. The order of the TIP Forms A and B and DIP Forms 1, 2, and 3 were rotated among several tape recordings but DIP Forms 1 and 2 were never adjacent to each other. Four test sequences were generated. The sequences of the tests on the final tape recordings were: Sequence 1 (TIP A, DIP 1, DIP 3, DIP 2, TIP B); Sequence 2 (TIP B, DIP 1, DIP 3, DIP 2, TIP A); Sequence 3 (TIP A, DIP 2, DIP 3, DIP 1, TIP 3); Sequence 4 (TIP B, DIP 2, DIP 3, DIP 1, TIP A). The various TIP and DIP sequences, as prepared on tape recordings, were rotated as subjects were tested to minimize order effects, even though previously this was shown to be minimal previously. The DIP test forms were administered at three dB levels relative to the subjects' initial speech reception threshold with the

TIP test: SRT, SRT +5 dB, and SRT +10 dB. The three DIP test decibel levels were rotated among subjects to minimize further order effects.

At the beginning of each TIP-DIP testing the 1000 Hz tone was adjusted to a voltage setting determined by previous calibration to give a known sound pressure level of test word. Attenuation was done from that reference point and was accomplished by the 10 dB and 1 dB step intenuators. Each succeeding test list was checked for 1000 cycle tone calibration at the reference voltage.

The equipment and test recordings were calibrated reference .0002 dy/cm^2 because of the ease with which such calbration could be done. The experimental design did not intend to be concerned with hearing acuity or discrimination score among the retarded as a primary consideration. Rather the interest was in how hearing abilities related to other measures, so that for the present purposes actual hearing levels or discrimination scores as compared to normal in of little interest.

Subjects

School districts in Centre and Clearfield Counties agreeint to participate in the projects were the primary source of subjects. These districts were especially accessable because of proximity to Penn State and personal relationships with the school staffs. The two state residential insititutions enrolling mentally retarded boys and girls closest to Penn State were at Cresson and Selingsgrove, Pa., and the staffs there agreed to allow their children to participate. Appropriate administrative personnel were contacted for each school district or institution included in the study first by mail or telephone and then by personal interview. The following steps were taken after a school agreed to participate:

1. Children for the present study were from the following locations: the elementary and junior high schools in Bellefonte, Pa. and from the elementary and secondary special education classes within the Bellefonte district, five elementary schools within the city of Clearfield and two special elementary classes which service all of Clearfield County; Our Lady of Victory Catholic Elementary School in State College, Pa. and

educational programs within the state institutions at Cresson and Selingsgrove and Penn State University.

2. Records of children on file within the cooperating schools and institutions were screened to find subjects who satisfied the following preliminary criteria for inclusion:

   a. appropriate age: 6 years 0 months to 16 years 11 months (age taken to nearest birthday)

   b. no peripheral hearing level greater than 25 dB (ISO 1964) at any frequency 500, 1000, 2000, and 4,000 Hz in either ear.

   c. School-administered intelligence tests indicating an IQ of less than 95, but more than 44, and confirmation from teachers, in most cases, that the child was doing below grade level work in comparison to normal children of the same CA. (Because various types of tests were used in the different schools, the IQ of 95 was used as an upper limit to increase the probability for inclusion of potential subjects of probable below normal intelligence.)

   d. No significant visual, neurological, motor, physical, or emotional problems as indicated by teachers or by school records.

3. Permission was obtained from parents to allow their children to participate in the study. This was accomplished by a home visit in which the entire project was explained and during which a signed release form was obtained. Attached to the release form was a sheet asking for additional information dealing with the child's general activity level and health. Questions such as, "Is he ever short of breath other than after hard exercise?" Where answered by "Yes" explain. (See Appendix A for the release form)

4. The Wechsler Intelligence Scale for Children (WISC) was administered to each child by the project staff. A full scale IQ of less than 90 was used as an upper limit for inclusion into the study as part of the intellectually subnormal sample. Thirty-nine children who achieved IQ of 90-114 were included in the normal IQ subsample.

5. Estimates of visual defects were obtained from either

recent school records or from an on-site check using a Snellen eye chart. Children having 20/20 vision only were included in the study. An audiometric sweep check administered by project staff was passed by each subject at 20 dB (ISO 1964) across at least two of the frequencies 500, 1000, 2000 Hz both ears.

6. Each child was given a follow-up pure tone threshold test in each ear by air conduction for the audiometric octave frequencies of 125 through 8000 Hz. All tests were done using a descending-ascending-descending series of tone levels at 5 dB intervals, with threshold as the lowest level at which at least two of three tones were heard. A Maico MA-2 or Beltone Model 15 audiometer was used for all testing. Bi-weekly calibration checks were made, using a Bruel and Kjaar audiometer calibration system Model 158.

7. The Threshold by Identification of Pictures (TIP), and the Discrimination by Identification of Pictures (DIP) tests at SRT, SRT +5 dB, and SRT +10 dB were administered to each child binaurally under earphones using tape recorded materials.

8. For every child accepted as a subject, a physical examination report was obtained from a medical doctor - e.g., family physician, school physician, or a project medical consultant. Only one child was found to have physical or health difficulties which would prohibit strenuous exercise, and he was excluded.

9. Children were brought to the Laboratory for Human Performances Research at Penn State Universiry for a series of physiological age tests. These included anthropometric measures, x-rays of the wrist (to determine bone age), strength age, and other measures taken during strenuous walking on the progressive treadmill. Another physical examination by a physician on the Laboratory staff was done before permitting physiological age testing.

Although the intent was for the tests to be administered in the order listed above, scheduling difficulties made a precise sequencing impossible. For example, in some cases, audiometric testing was done prior to intelligence testing, or physiological testing was done earlier than planned.

Originally 419 potential subjects were identified (251 males, 168 females) according to school or institution records as having IQ less than 95 and more than 44, as well as having the criteria for inclusion. Table 1 shows the disposition of these potential subjects.

The completed experimental sample consisted of 209 subjects, those on whom at least two of the three test procedures could be obtained (intelligence, TIP-DIP, physiological age). Of these, 122 were male and 87 were females. A comparison of test results on at least two of the different test areas could be made even for the subject who has missed one test procedure.

Table 2 shows the distribution of experimental subjects by age and sex.

Table 3 indicates the ranges and means for CA, MA, and IQ of the sample. In the original design of this study subjects with IQ over 90 were not to be admitted. As the field testing for intelligence was begun such children appeared and were rejected even though the school records indicated otherwise. Approximately midway in the project, as the data began to be available in all of the experimental testing areas, this type of child was reconsidered, and there appeared to be scientific merit in including a group of them: (a) they were considered to be lower in intelligence by school personnel and they tended to function at this level of expectation, (b) in audiological practice such children would be seen for hearing testing and experimental data involving them would be of interest, and (c) including them would provide a wider range of IQ and other test scores, increasing the likelyhood of the data to produce information of interest to the purpose of the project. Therefore, some subjects were admitted on the basis of school records showing IQ levels below 90, but IQ level as measured by the project staff to be over 90. These subjects, also given either physiological age or hearing tests, are included in Table 3.

Table 4 shows the same data for the eleven subjects with confirmed organic signs for MR, and also for the 36 subjects drawn from residential institutions (including the eleven organic subjects).

Table 1. Disposition of subjects considered for experimental testing.

	M	F	Total
Eligible S's, based on school or institution records	251	168	419
Parents contacted	214	142	356
Parents refused	29	16	45
Intelligence tests administered	166	131	297
Failed physical examination by physician or had physical defect (previous record)	9	6	15
Hearing screening test at 20 dB			
(a) Not Tested	91	65	156
(b) Passed	139	85	224
(c) Failed	24	15	39
TIP-DIP tests administered	98	73	160
Physiological age tests			
(a) Tested	98	76	174
(b) Not-tested because of absence, parental refusal at Laboratory, ran out of time, etc.	94	60	154
(c) Eliminated by previous procedures (e.g., high IQ, failed hearing test, etc.)	56	35	91
Accepted for this study, and completed at least two of three tests (intelligence, hearing, physical age)	122	37	209

Table 2. Distribution of 209 experimental subjects by age and sex.

	Age in Years (to nearest birthday)										
	6	7	8	9	10	11	12	13	14	15	Total
Male	6	7	16	13	15	11	21	15	12	2	118
Female	12	10	10	12	6	11	8	13	9	0	91
Total	18	17	26	25	21	22	29	28	21	2	209

Table 3. Number of subjects, mean, standard deviation, and range for CA, MA, and IQ of subject sample.

	Total Group N 209			IQ 90 or over N 39			IQ 89 or under N 170		
	CA	MA	IQ	CA	MA	IQ	CA	MA	IQ
Mean	10.8	8.1	77	8.2	7.8	96.7	11.4	8.2	72.6
Std. Dev.	2.5	1.8	13.7	1.4	1.2	5.2	2.3	1.9	10.6
Range	6.3-15.2	4.4-12.2	44-114	6.3-12.7	5.8-11.5	90-114	6.5-15.2	4.4-12.2	44-89

Table 4. Means and ranges of CA, MA, and IQ for the organic type and the institutionalized subjects.

	Organic (N 11)		Institutionalized (N 36)	
	Range	Mean	Range	Mean
CA	8.0-15.2	12.2	6.6-15.2	12.4
MA	5.9-11.8	8.1	4.4-11.7	7.7
IQ	45-93	67.4	44-87	61.7

Data Tabulation

The following information was obtained for each child and was entered on a set of two IBM cards for each subject, verified and, together with appropriate computer program cards, entered into the Penn State's IBM Computer System 360.

Identification number of the subject.

Sex.

Chronological age determined by the time of the physiological testing or, in cases where no physiological examination was administered, determined at the time of intelligence testing.

An indication of whether the child was organically impaired or not, and institutionalized or not.

IQ scores: Verbal, Performance, and Full-Scale.

Mental ages: Verbal, Performance, and Full-Scale.

Pure tone threshold. (Two-frequency average for 500, 1000, and 2000 Hz.)

TIP A (i.e., threshold value in dB re .0002 dy/cm^2).

TIP B (i.e., threshold value in dB re .0002 dy/cm^2).

TIP Mean (average of the threshold on TIP A and TIP B).

TIP testing sequences.

TIP slope (slope expressed as change in number of items correct per dB change in signal level over middle of the TIP test intelligibility curve drawn graphically for each subject).

DIP 0 score (number of items correct at SRT level).

DIP 5 score (number of items correct at SRT plus five dB).

DIP 10 score (number of items correct at SRT +10 dB)

DIP testing sequence.

DIP lo slope (obtained by subtracting the number correct at SRT from the number correct at threshold plus five dB).

DIP hi slope (obtained by substracting the number correct at threshold plus five dB from the number correct at threshold plus ten dB).

Secondary sex characteristic score (obtained by multiplying the stage of breast/genital development by the stage of pubic hair development; these stages were represented by numbers from one through five, one being the least advanced development, and then adding one or zero for boys for larynx or absence of larynx development and adding one or zero for boys and girls for absence or presence of auxiliary hair; for females, instead of the larynx score, there was a menarche score from zero through five: zero representing the absence of menarche and one through five indicating the age of appearance of menarche; the secondary sex score obtained through this formula could range from zero through thirty).

Strength age (obtained through norms published in 1935 by Meredith for boys and Metheny for girls. These norms converted strength in kilograms to age norms; the table showed an average grip strength at various ages from three through eighteen; the norm of the table was obtained on 4999 boys and 4787 girls at a private school in Iowa City.)

Relative weight (obtained by dividing the actual weight of the child in kilograms by the table weight; the table weight was the weight obtained from the Stewart-Marith Tables (1946); the table presents age norms for height in centimeters and weight in kilograms for ages 5 through 18 years; the data were collected between 1930 and 1945 and were based on 3771 measurements of several hundred Iowa City boys and girls of Northwest European ancestory, who attended the University of Iowa Experimental Schools).

Ideal weight (used as the basis of weight age; the ideal weight was obtained by taking the weight of the child times the per cent of fat, yielding the kilograms of fat; this was subtracted from the child's weight, yielding fat-free weight; the ideal weight is fat-free weight plus fourteen per cent of the fat-free weight (for both girls and boys); this weight was used in referring to the 50th percentile age norms of the Stewart-Meredith Tables to obtain a weight age).

The same procedure was used to obtain a height age, except that the child's actual height was used when referring to the tables to obtain the fiftieth percentile age norms for that height.

Bone age (obtained from age norms for hand x-rays).

Dental age (obtained by counting number of permanent teeth errupted).

Thus twenty-five variables were included on the IBM cards (plus a number indicating the card identification, i.e., whether the first or the second card for a subject was represented).

CHAPTER 4

MEASURES OF PERFORMANCE AND RELATED PHYSIOLOGICAL CHARACTERISTICS

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Methodology

General Procedure. When the children arrived at the Laboratory for Human Performance Research they were introduced to the staff were given a tour of each of the rooms they would visit, and an explanation was given as to what would happen (type of measurements, kind of exercise, etc.) during that day. After the brief introduction, each child was given the following: physical examination, body measurements, x-rays, strength tests, and an exercise test. Each child learned how to walk on the treadmill before the exercise was given.

Physical Examination. All children included in this study had had a preliminary medical examination by their school physician, family physician or a project consulting physician. The physician's permission was obtained before they participated in the study. Before being allowed to exercise on the treadmill they were again examined by the Human Performance Laboratory staff physician to exclude any with a medical or orthopedic condition not previously detected which would modify their response to the exercise or which might affect their health if they exercised. Any child with an infectious disease, acute or chronic respiratory infection, congenital heart defect (which limited his physical activity or was accompanied by cyanosis), or history of rheumatic fever complicated by heart involvement was excluded from exercising on the treadmill. Orthopedic problems which reduced coordination enough so that the child could not walk freely on the treadmill or could not obey simple instructions while exercising were also reasons for exclusions from this part of the study. Examples included: spasticity, leg paralysis, markedly dystrophied leg muscles, or marked distortions of the rib cage or spine. A history of convulsions which required medical treatment also excluded the child from the exercise portion of the study. Any child who refused to participate in the exercise was not required to do so.

Dentition. The teeth of all children were examined by the staff physician using a dental mirror. The deciduous and permanent teeth were classified according to their size, shape, number of cusps, and color of the enamel. The number of deciduous and permanent teeth was noted and the dental age was evaluated from the number of permanent teeth according to Tanner (1962), separately for boys and girls. Just erupted teeth, carious teeth, and extracted permanent teeth (if the extraction was affirmed by the child) were included in the evaluation.

Secondary Sex Characteristics. In boys, larnyx enlargement was judged according to the prominence of the thyroidal cartilage, presence or absence of axillary hair was noted and the genital development and pubic hair were judged according to the five stages listed by Tanner (1962):

Genital Development

Stage 1. Pre-adolescent. Testes, scrotum and penis are about the same size and proportion as in early childhood.

Stage 2. Enlargement of scrotum and testes. The skin of the scrotum reddens and changes in texture. Little or no enlargement of penis.

Stage 3. Enlargement of penis, which occurs at first mainly in length. Further growth of testes and scrotum.

Stage 4. Increased size of penis with growth in breadth and development of glands. Further enlargement of testes and scrotum; increased darkening of scrotal skin.

Stage 5. Genitalia adult in size and shape.

Pubic Hair

Stage 1. Pre-adolescent. The vellus over the pubes is not further developed than that over the abdominal wall, i.e., no pubic hair

Stage 2. Sparse growth of long, slightly pigmented downy hair, straight or only slightly curled, appearing chiefly at the base of the penis or along the labia.

Stage 3. Considerably darker, coarser and more curled. The hair spreads sparsely over the junction of the pubes.

Stage 4. Hair now resembles adult in type, but the area covered by it is still considerably smaller than in the adult. No spread to the medial surface of the thighs.

Stage 5. Adult in quantity and type.

For the girls, presence or absence of axillary hair was noted and pubic hair was evaluated in the same five stages as for the boys. Beginning at the age of 9 years, each girl was questioned as to whether she had experienced menarche and the age of its occurrence. In addition, the breast development was evaluated in five stages according to Tanner (1962):

Breast Development

Stage 1. Pre-adolescent: elevation of papilla only.

Stage 2. Breast bud stage: elevation of breast and papilla as small mound. Enlargement of areolar diameter.

Stage 3. Further enlargement and elevation of breast and areola, with no separation of their contours.

Stage 4. Projection of areola and papilla to form a secondary mount above the level of the breast.

Stage 5. Mature stage: projection of papilla only, due to recession of the areola to the general contour of the breast.

Skeletal Age. Skeletal age was assessed by the Tanner-Whitehouse Method (see Tanner, Whitehouse and Healy, 1961; and Tanner and Whitehouse 1959). Posterior-anterior radiographs of the left hand and wrist were made with the use of a portable, 15ma x-ray machine at a focal distance of 40 inches and 55 Kv. These radiographs were inspected and scored in terms of the degree of osseous development of seven round bones of the wrist and the epiphyses of the ulna, radius and eleven selected metacarpals and phalanges. The scoring system was based on the degree of development of these twenty osseous centers as they passed through eight distinct stages of growth and differentiation. The highest attainable score for the entire hand-wrist complex was 1000 points which represents the adult stage of development. This score of 1000 can be interpreted as a maturity index which represents 100 percent skeletal maturity. The carpal (round) bone score represents one-half of the total maturity score and the long bone score represents the other half. The more reliable maturity indicators are weighted more heavily in the scoring. The total maturity score is then converted to skeletal age with separate conversion tables for boys and girls to account for the different rates of growth that exist between the sexes.

Physiological Development Index. As a means of estimating the physiological development of each child the following formula was constructed:

> (0.6 Skeletal Age) + (0.1 Dental Age) + (0.1 Strength Age) + (0.1 Height Age) + (0.1 Weight Age) + Secondary Sex Characteristics Correction Factor

Skeletal age was determined by the Tanner-Whitehouse method and dental age was determined by the Tanner method. The other ages were determined by locating the age at which the median value for strength, height, or weight was the same as the actual value obtained on each subject. The norms used for grip strength were those of Meredith (1935) for boys and of Metheny (1941) for girls. Height and weight norms used were those of Stuart and Meredith (1946).

The correction factor was based on the number of points given for secondary sex characteristics of the subjects. For boys, these points were obtained by multiplying the stage of genital development (1-5) by the stage of pubic hair growth (1-5) and by adding one point if axillary hair was present and one point if larynx enlargement had occurred. The possible range was from 1-27. With girls, the points were obtained by multiplying the stage of breast development (1-5) by the stage of pubic hair growth (1-5) and by adding one point for presence of axillary hair and adding 0-5 points for age at menarche (5 at age 9, 4 at age 10, 3 at age 11, 2 at age 12, 1 at age 13, and 0 at age 14+). The range possible for girls was from 1-31. The correction factor was then based on the total number of points obtained: For 1-5 points, 0.5 years was subtracted from the composite age derived by the above formula; for 6-10 points, no correction was made; for 11-15 points, 0.5 year was added; and for more than 15 points, 1.0 year was added.

Anthropometry. During all body measurements the boys wore only underpants and the girls wore underpants and shirts. In addition to height and weight, various measurements were taken and recorded.

1. Anthropometer: arm span, sitting height, upper arm length, lower arm length, hip breadth, shoulder breadth, transverse chest diameter, chest depth,

and head height.

2. Tape: circumferences of the head, chest, upper arm, and wrist.

3. Skinfold calipers: chin, right upper arm, right forearm, left wrist, right subscapular, and right calf.

Roentgenogrammetric Method for Brachial Tissue Analysis. For determination of the inner upper arm composition from differential density of the tissues, standardized lateromedial radiographs were made of the brachium. The radiographic method included a focal distance of 36 inches and used a portable x-ray machine of 15ma. The general procedure followed that established by Baker, Hunt and Sen (1958). Transverse diameters of the radiographic shadows of its chief tissues. perpendicular to the shadow of the humerus, and at a point halfway from the olecranon to the acromion were recorded to the nearest millimeter with a dial Helios caliper.

These measures included the total diameter of the brachium, muscle-humerus diameter, humerus diameter, and marrow. The fat diameter was obtained by subtracting the muscle-humerus diameter from that of the total brachium, while the muscle diameter was obtained by excluding the humerus diameter from that of the muscle-humerus. By excluding the marrow diameter from that of the humerus, the cortical bone was determined. Assuming that the tissue masses were concentric cylinders (Baker, Hunt and Sen, 1958), these diameters were then converted into areas of cross-section, utilizing the formula:

$$A = \frac{\pi}{4} d^2$$

where A represents the area of cross-section, π equals 3.1416 and d is any of the brachial diameters listed above.

Strength Testing. Every child participating in the experiment was given two strength tests. They were instructed in advance to try to pull or squeeze as hard as possible in all tests.

(1) Grip Strength - The grip strength of both hands was measured on a grip dynamometer which was adjusted to the size of each child's hand. Two trials were given with each hand and the higher value was recorded.

(2) Elbow Flexion - With the subject in a sitting position, the elbow flexion strength of the right arm was measured four times using an isometric gauge dynamometer. The upper arm rested parallel to the floor on an adjustable platform and

the forearm was strapped to the lever arm of the strain gauge at an angle of 90 degrees to the upper arm. On command, each child flexed his forearm against the bar of the strain gauge. The highest isometric force was measured and converted into kilograms.

Exercise Testing. The boys and girls were divided into four groups according to their age (Group I included children 6.0-7.9 years; Group II, 8.0-9.9; Group III, 10.0-11.9; and Group IV, 12.0-15.5 years.) Each child then underwent one test among three different types to determine his maximal oxygen consumption. The assignment of children to a particular test procedure was randomized as follows: the first child in each age group underwent test type A; the second child, test type B; the third child, test type C; and the fourth child, test type A to begin the assignment cycle again.

Prior to the beginning of the work tests, each child was given instructions and a few minutes of practice to get accustomed to walking on the treadmill and wearing the apparatus to collect expired air. After it was determined that each child was able to walk on the treadmill comfortably, he was asked to rest for several minutes, during which time the test procedure was explained. After the explanation, each child was given a warm-up period of three minutes (3.5 mph, 7.5% grade). Heart rate was monitored near the end of each minute. This warm-up period was followed by a four-minute rest period, after which each child underwent one of the three tests to determine maximal oxygen consumption.

In test type A, the first work load was 3.5 mph, 10% grade; this was increased by 2.5% at the end of each two-minute period until the subject reached a self-imposed maximum. Heart rate was recorded near the end of each minute and a sample of expired air was taken during the second minute of each work load.

Test type B used the same procedures as those in A, except that the grade was increased at the end of each three-minute period. Heart rate was recorded near the end of each minute and samples of expired air were taken during the second and third minute of each work load.

In test type C, the subject walked for four minutes at 3.5 mph, 15% grade after the initial warm-up. If the subject completed the four minutes he rested for ten minutes, after which he walked for four minutes at 17.5% grade. Thus, the grade was increased by 2.5% after each four-minute period (with ten minutes of rest between each work load) until the subject reached a self-imposed maximum. Heart rate was recorded near the end of each minute of exercise and samples of expired air were taken during the second, third and fourth minutes.

All subjects were verbally encouraged to continue as long as possible when they were approaching their maximum so that valid criteria for reaching a maximal oxygen intake could be reached in as many subjects as possible.

Results

Physical and Mental Characteristics. Chronological age, dental age, and skeletal age were similar for boys and girls at all ages (see Table 5). On the other hand, there were significant differences between chronological age and the estimate of physiological development. On a group basis, this index was significantly lower for all subjects and all boys. When values were compared at the different age groups the index was lower in boys 6 to 11.9 years old and in girls 8 to 9.9 years old; little difference was found in either sex at ages 12 to 15.5 years. Since there were no differences between chronological age and the more commonly employed indices of physiological age (i.e., dental and skeletal age), chronological age was used to classify the children in most of the subsequent analyses.

In Table 6 the height, weight, percent body fat, and IQ of the subjects are listed. When values for height and weight were compared with those obtained on other retarded children and on a sample of normal children (see Figures 1 and 2), there were insignificant differences among the three groups. The average IQs of the children in this investigation were around 90 in boys and girls aged 6 to 7.9 years; these decreased significantly to approximately 72 in the children who were 10 to 15.5 years old (see Figure 3). The frequency distribution of IQ in the different age groups can be seen in Figure 4. In the two younger age groups there were a number of children who would be classified as having "normal" intelligence (IQ = 90 or more) but the numbers decreased with increasing age.

TABLE 5: Comparison of various indices of age among children administered various physiological characteristic measures.

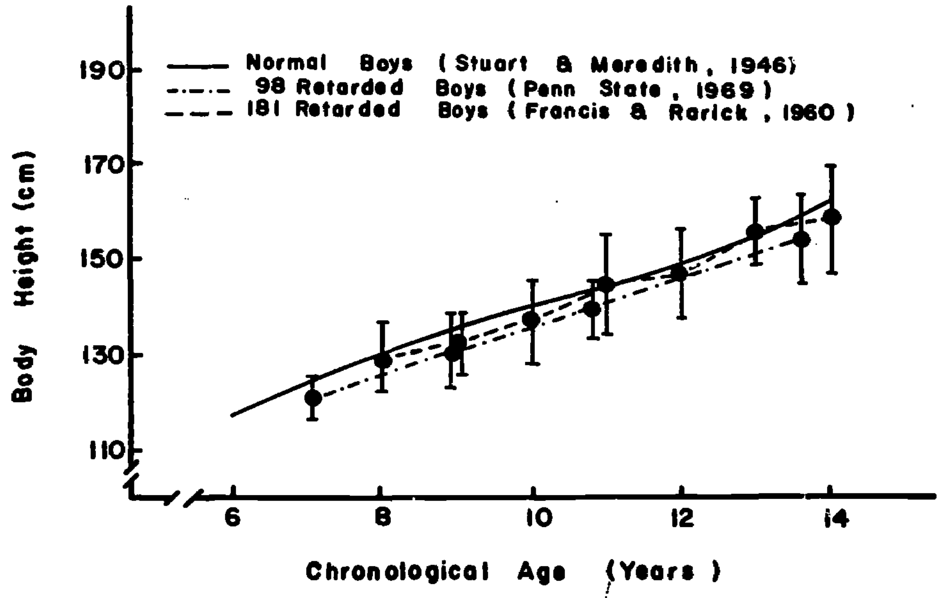
	Chronological Age (years)			Dental Age (years)			Skeletal Age (years)			Physiological Development Index (years)		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
All	167	10.5	2.6	174	10.6	2.7	167	10.4	2.8	159	9.8*	3.0
Boys	98	10.6	2.5	98	10.9	2.7	98	10.3	2.9	92	9.8*	3.1
Girls	69	10.4	2.7	76	10.2	2.6	69	10.5	2.6	67	9.8	2.9
Boys												
6.0–7.9	15	7.2	0.5	15	7.8	1.2	15	6.9	1.3	13	6.2*	1.0
8.0–9.9	32	9.0	0.6	32	9.0	1.1	32	8.6	1.6	30	7.6*	1.2
10.0–11.9	18	10.8	0.6	18	10.9	1.5	18	10.4	1.8	17	9.7*	1.2
12.0–15.5	33	13.6	1.0	33	14.0	1.3	33	13.4	1.4	31	13.1	1.9
Girls												
6.0–7.9	18	7.1	0.5	19	7.3	0.8	18	7.4	1.3	16	6.7	1.0
8.0–9.9	16	9.0	0.6	17	8.7	0.7	16	9.3	1.1	15	8.3*	1.0
10.0–11.9	12	11.1	0.6	16	10.8	1.0	12	11.2	1.3	14	10.6	1.8
12.0–15.5	23	13.6	0.9	24	13.2	1.6	23	13.2	1.2	22	13.1	1.6

* Chronological Age vs. Physiological Development Index ($p < 0.05$).

TABLE 6: Selected physical characteristics and I.Q. among children administered various physiological characteristic measures.

	Height (cm.)			Weight (kg.)			Body Fat (%)			I.Q.		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
All	174	138.4	14.6	173	34.0	13.3	174	20.4	6.5	171	78.7	12.9
Boys	98	139.1	14.7	98	34.3	13.3	98	16.6	4.1	96	78.1	12.7
Girls	76	137.5	14.5	75	33.5	13.3	76	25.4	5.6	75	79.6	13.2
Boys												
6.0–7.9	16	121.1	4.7	16	23.9	7.1	16	16.0	2.7	15	89.9	13.7
8.0–9.9	30	131.0	6.0	30	28.2	10.6	30	16.1	2.9	30	81.7	13.4
10.0–11.9	19	139.8	6.4	19	32.4	4.3	19	17.0	3.7	18	72.1	10.7
12.0–15.5	33	154.8	9.2	34	45.8	12.9	34	17.0	5.6	33	72.8	11.1
Girls												
6.0–7.9	20	122.6	5.9	20	23.3	3.1	20	25.7	3.1	19	91.1	9.1
8.0–9.9	17	130.4	8.2	17	28.7	9.7	17	27.9	5.3	17	81.1	13.2
10.0–11.9	17	143.4	10.1	17	35.5	8.7	17	28.1	2.8	16	72.9	11.6
12.0–15.5	22	152.3	8.7	20	45.9	15.3	22	21.3	6.7	23	73.7	10.9

Figure 1. Relationship of body height and weight to chronological age in boys. Comparison with results in the literature. Brackets indicate standard deviation.



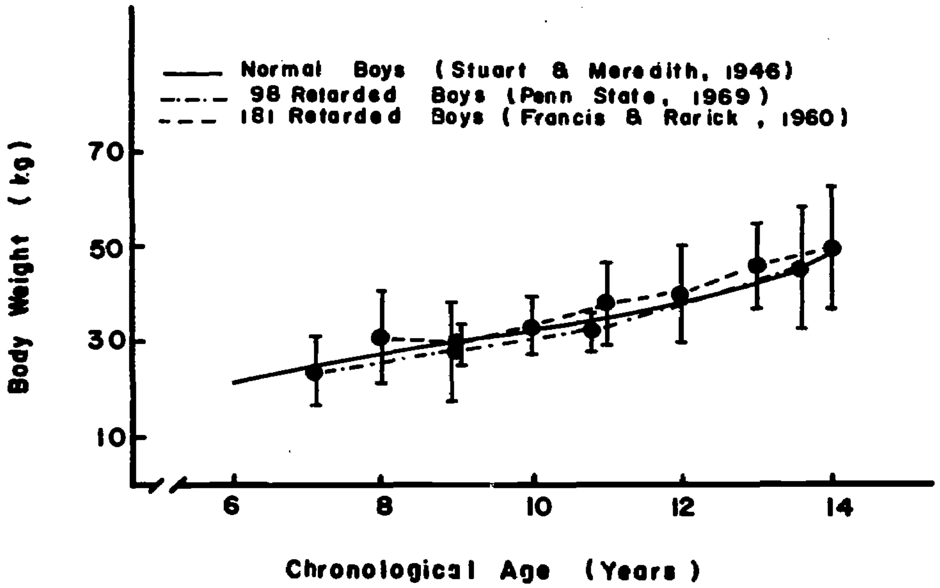


Figure 2. Relationship of body height and weight to chronological age in girls. Comparison with results in the literature. Brackets indicate standard deviation

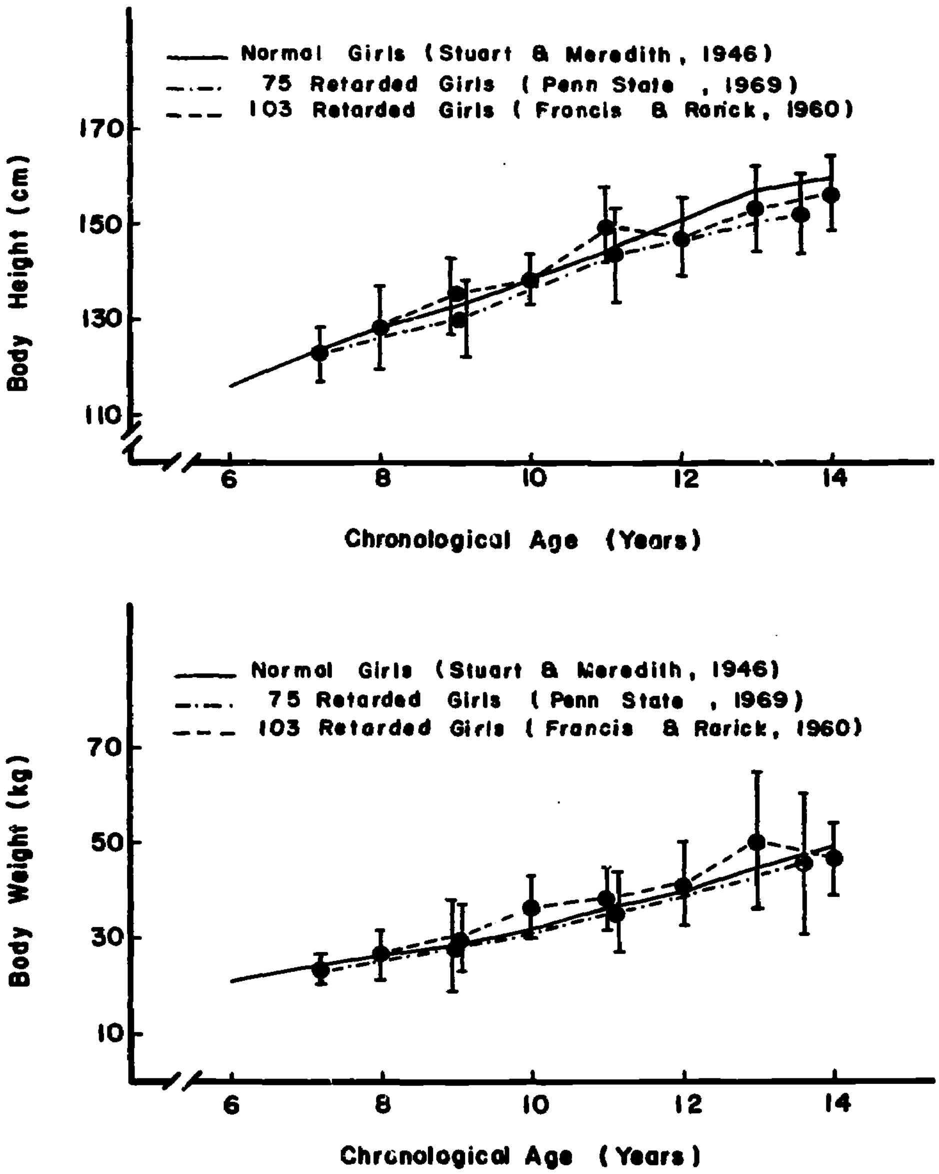
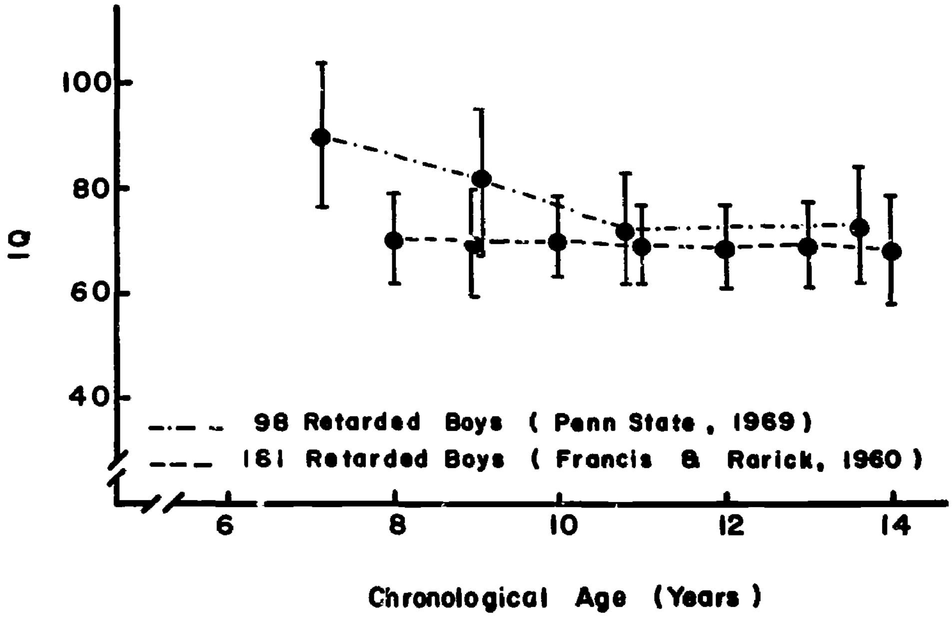


Figure 3. Relationship of I.Q. to chronological age in boys and girls. Comparison with data of Francis and Rarick, 1960.



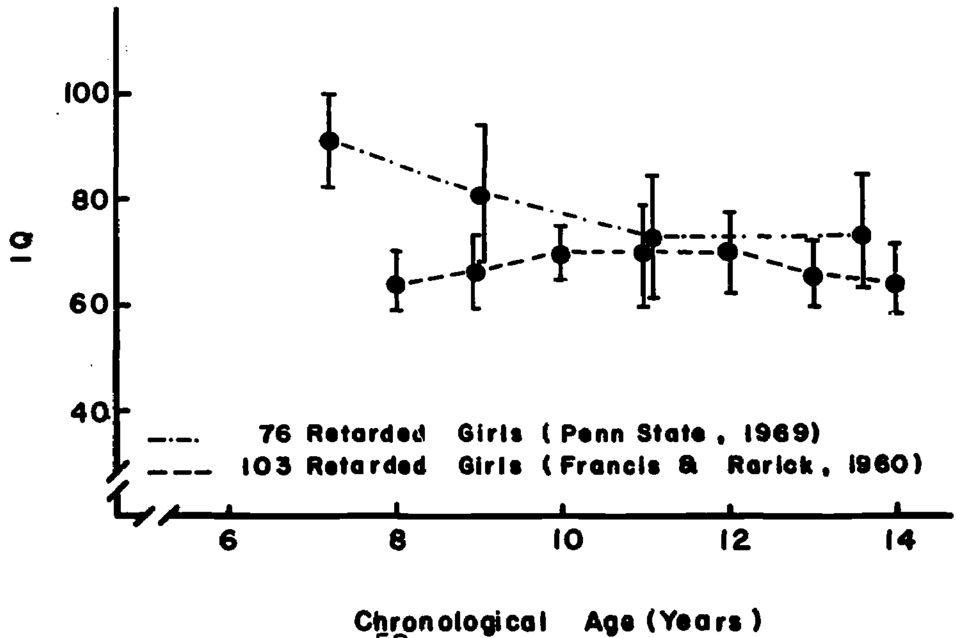
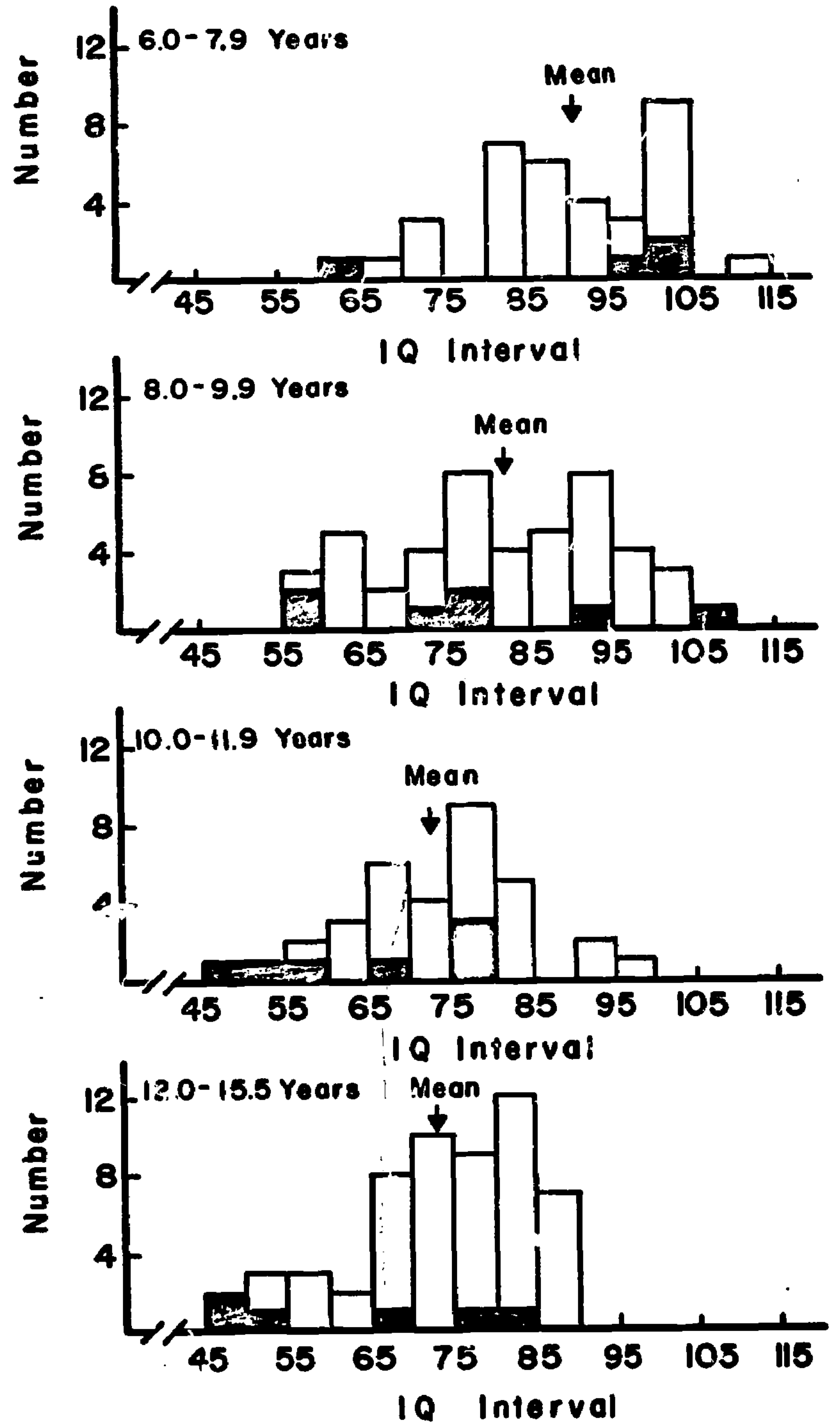


Figure 4. Number of children by I.Q. and C.A. who served as subjects. Darkened portions indicate number who did not participate in exercise tests.



Strength. The grip strength of the children in this investigation tended to be slightly lower than a group of normal children and slightly higher than that of a group of retarded children of the same age (see Figure 5). The slope of the strength curves, however, are similar for the normal and mentally retarded children.

Exercise Testing. Not all of the children who came to the laboratory were exercised on the treadmill. Five children were excluded for medical reasons and 24 children refused or were unable to walk on the treadmill (5 refused to walk at all, 12 refused to complete the testing, 3 refused the mouthpiece required to collect expired air samples, and 4 lacked the coordination to walk on the treadmill). The distribution of the IQs among those who refused or were unable to exercise can be seen in Figure 4, (the black portion of the bars represents the number of these children). From Figure 4, it would appear that the majority of children not exercised were on the lower end of the IQ continuum. If the subjects are grouped according to IQ, (e.g., those with 90 or more who would considered "normal" vs. those with 89 or less) there is no difference in the ratio of those exercising or not exercising (see Table 7a). However, if the subjects are grouped by those with an IQ of 79 or less (if 50 to 79 is considered "educable mentally retarded") vs. those with 80 or more, then a significant difference in participation is present (Table 7b), i.e., a greater percentage of children with IQs less than 80 refused or were unable to do an exercise test. When participation in the exercise tests was compared on the basis of place of residence (Table 7c), it was found that more institutionalized children did not complete the treadmill test. There was no difference, however, between the participation of boys and girls (Table 7d).

As mentioned earlier, three different types of exercise tests were given. No significant differences were found among the three tests in the values obtained for maximal oxygen intake (liters/min and cc/kg min) or maximal heart rate at any age (Figure 6). Similarly, at each submaximal work load there were no significant differences in oxygen intake (cc/kg min) or heart rate obtained from boys and girls on the three types of tests (see Figures 7 and 8). Since the three tests yielded essentially the same results, the data were combined for all subsequent analyses.

When the exercise data on boys and girls were compared (Figure 9), it was found that the boys had a significantly higher maximal oxygen intake (cc/kg min) than the girls at all ages except 10 to 11.9 years. Girls had a significantly higher maximal heart rate as a group: there were no differences, however, at each age level except 10 to 11.9 years.

Figure 5. Relationship of grip strength to chronological age in boys and girls. Comparison with results in the literature.

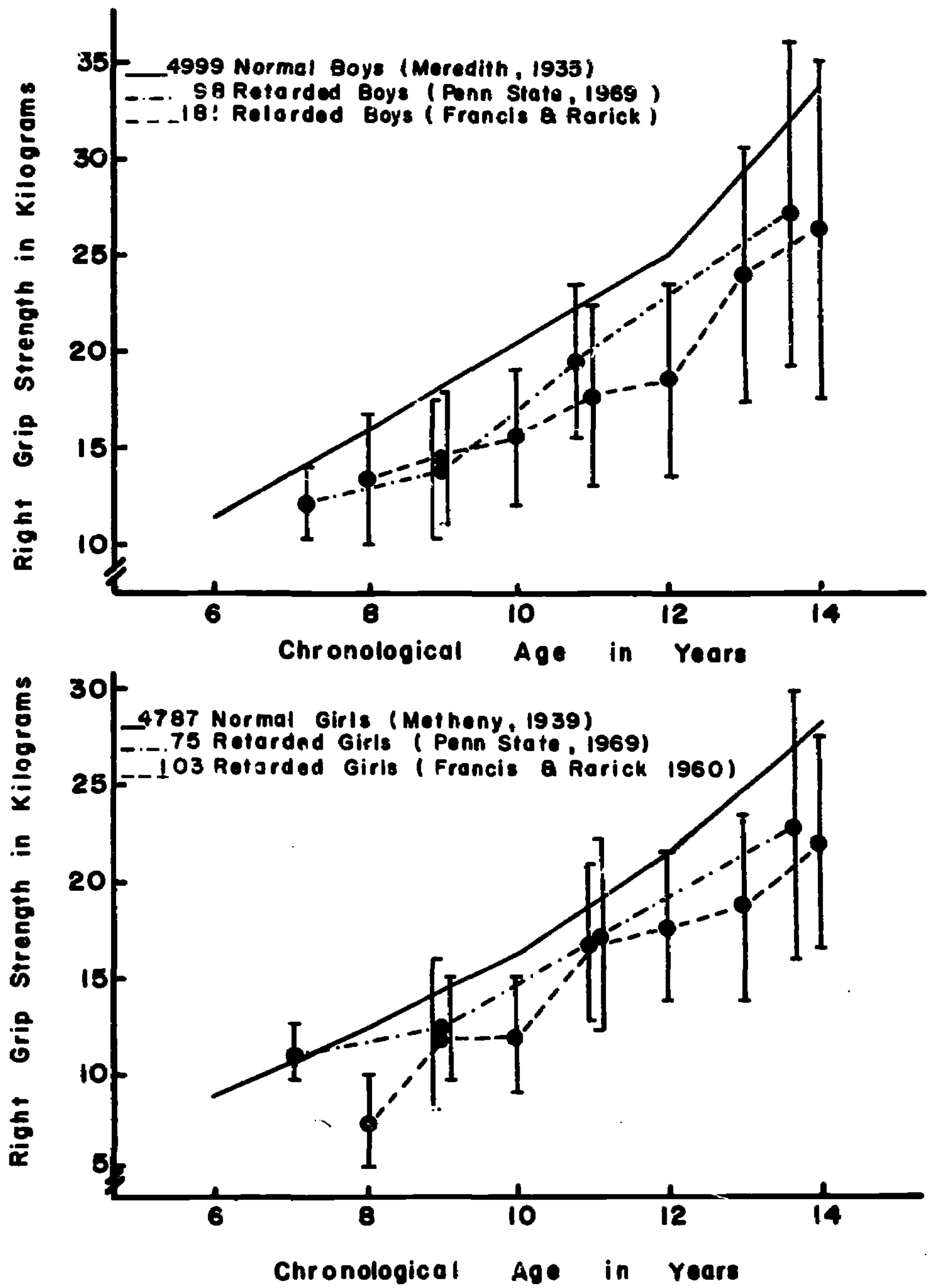


TABLE 7. Percent participation in exercise in relation to I.Q., place of residence and sex.

a. I.Q.

	≤89	≥90	Total
Refused or Unable to Exercise	19 (79%)	5 (21%)	24* (15%)
Exercised	105 (77%)	31 (23%)	136 (85%)
Total	124 (77%)	36 (23%)	160* (100%)

b. I.Q.

	≤79	≥80	Total
Refused or Unable to Exercise	18 (75%)	6 (25%)	24* (15%)
Exercised	63 (46%)	73 (54%)	136 (85%)
Total	81 (51%)	79 (49%)	160* (100%)

c. Residence

	Institution	Home	Total
Refused or Unable to Exercise	9 (37%)	15 (63%)	24* (15%)
Exercised	6 (4%)	130 (96%)	136 (85%)
Total	15 (10%)	145 (90%)	160* (100%)

d. Sex

	Boys	Girls	Total
Refused or Unable to Exercise	12 (50%)	12 (50%)	24* (15%)
Exercised	79 (59%)	57 (41%)	136 (85%)
Total	91 (57%)	69 (43%)	160* (100%)

* Does not include 5 subjects who were not exercised for medical reasons.

Figure 6. Oxygen consumption ($\dot{V}_{O_2}$) and heart rate in relation to chronological age. Data for three work tests are given. (See text for explanation of work tests.)

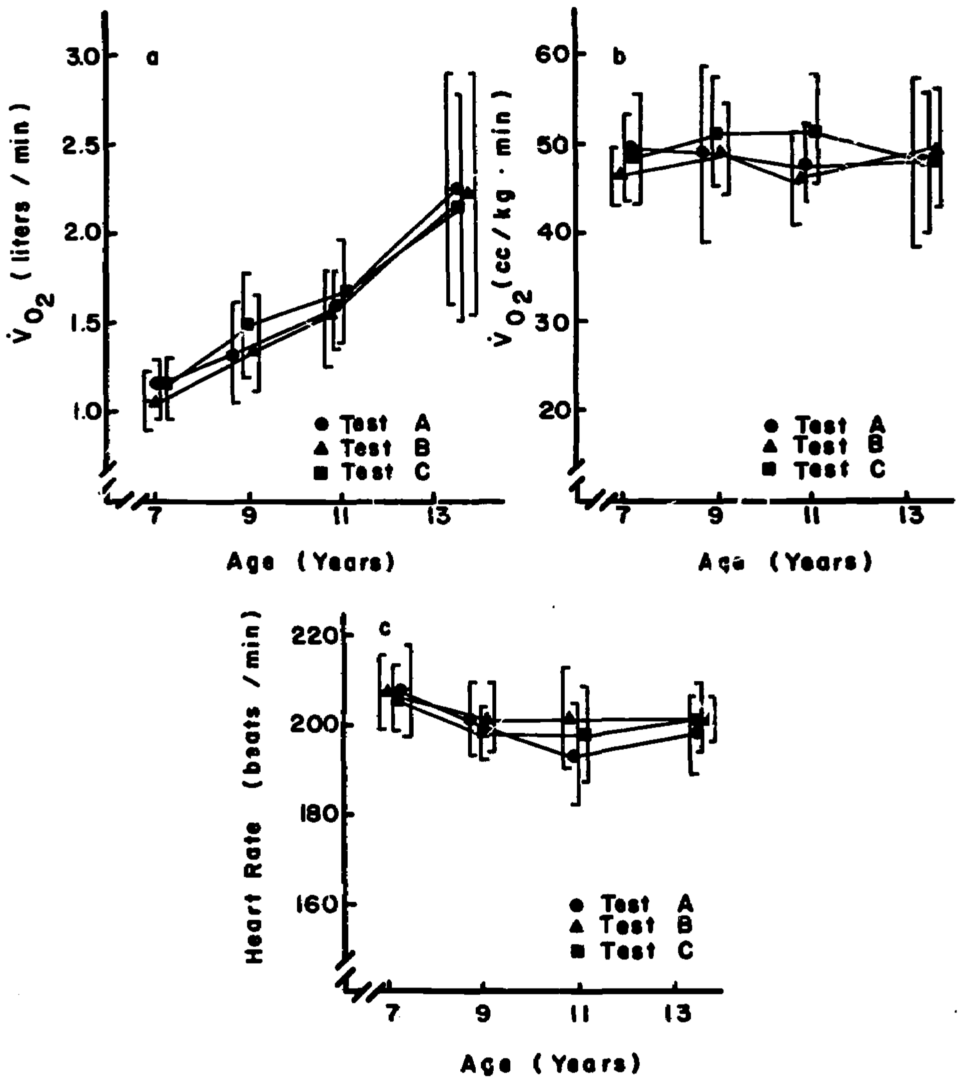
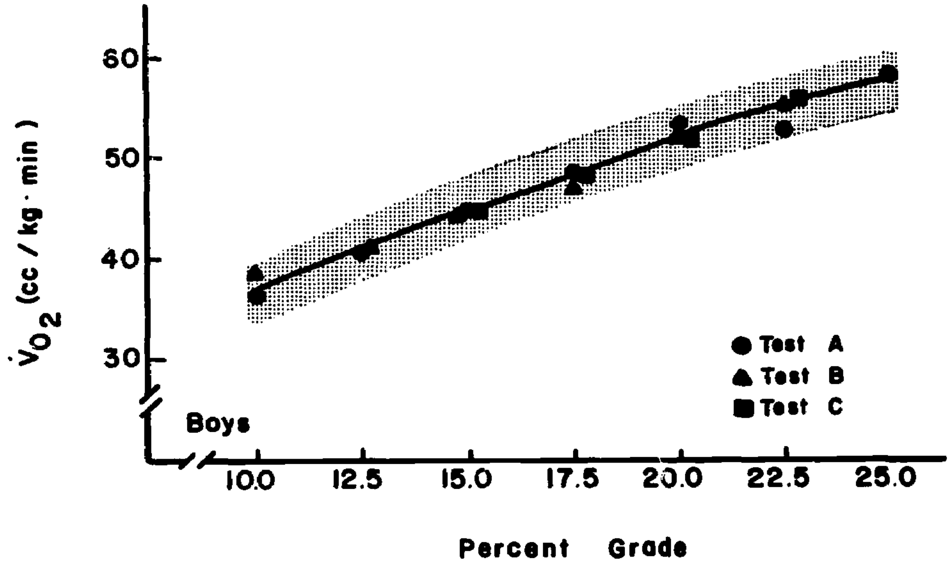


Figure 7. Oxygen consumption ($\dot{V}_{O_2}$) for boys and girls in relation to work load on the treadmill as represented by percent grade. Speed was constant at 3.5 miles per hour.



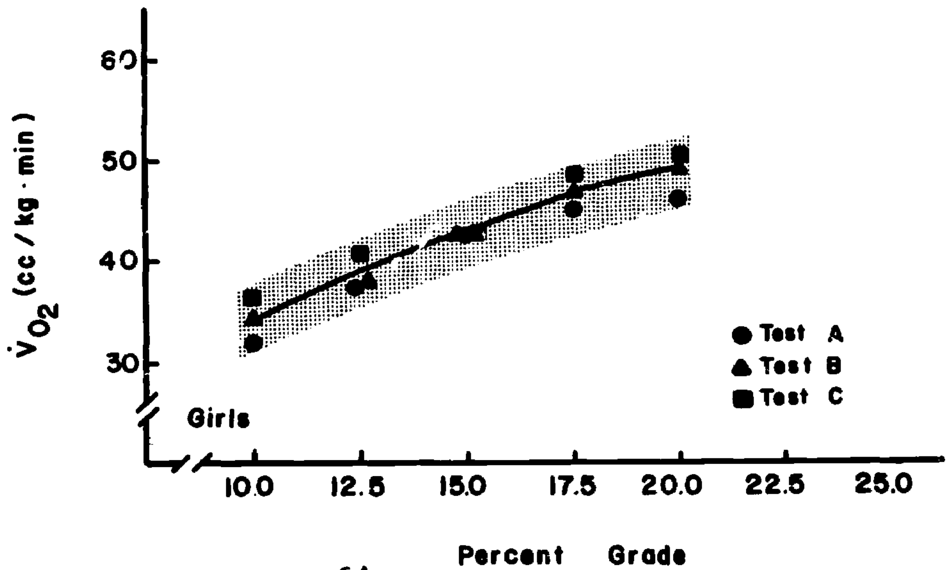


Figure 8. Heart rate for boys and girls in relation to work load on the treadmill as represented by percent grade.

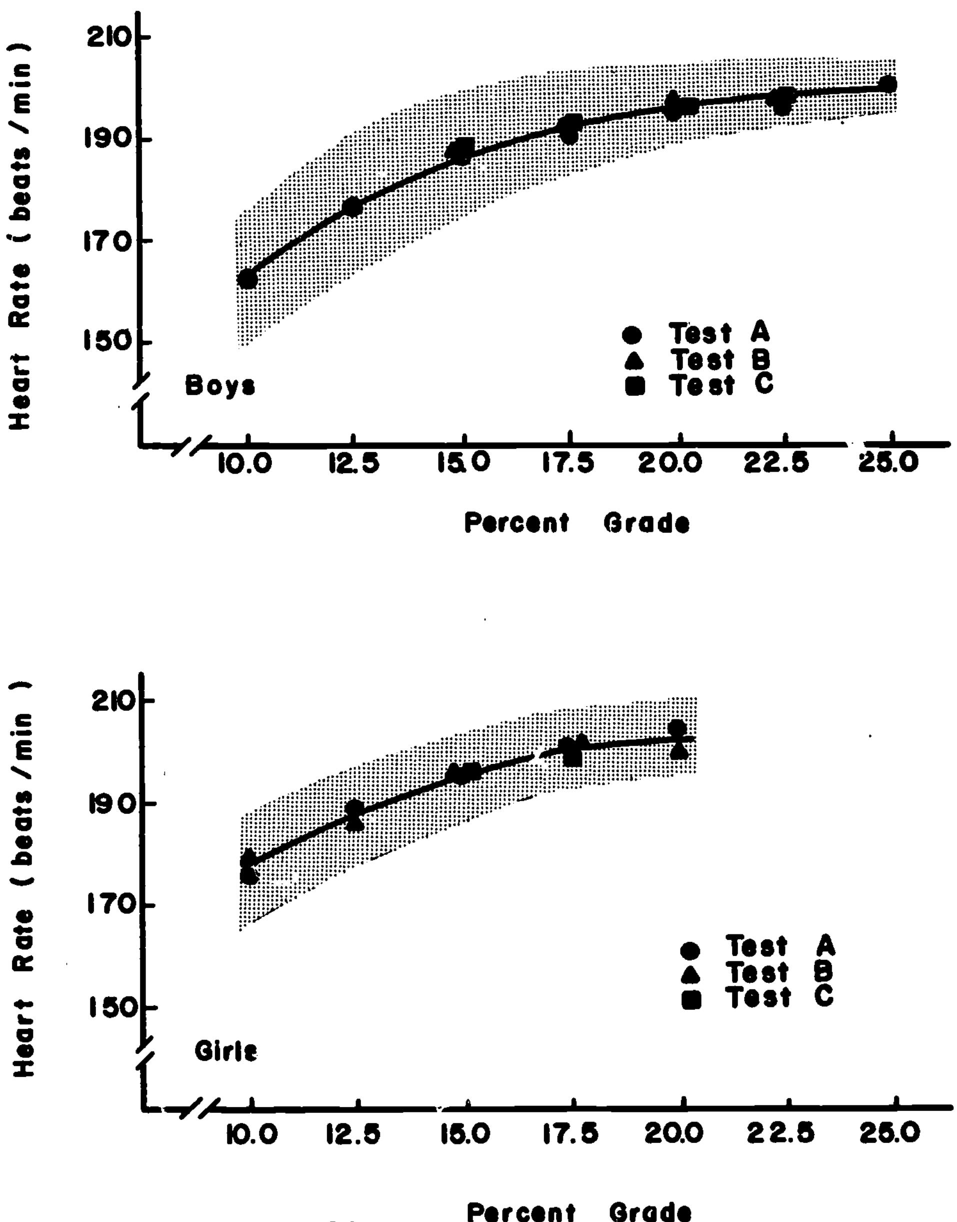
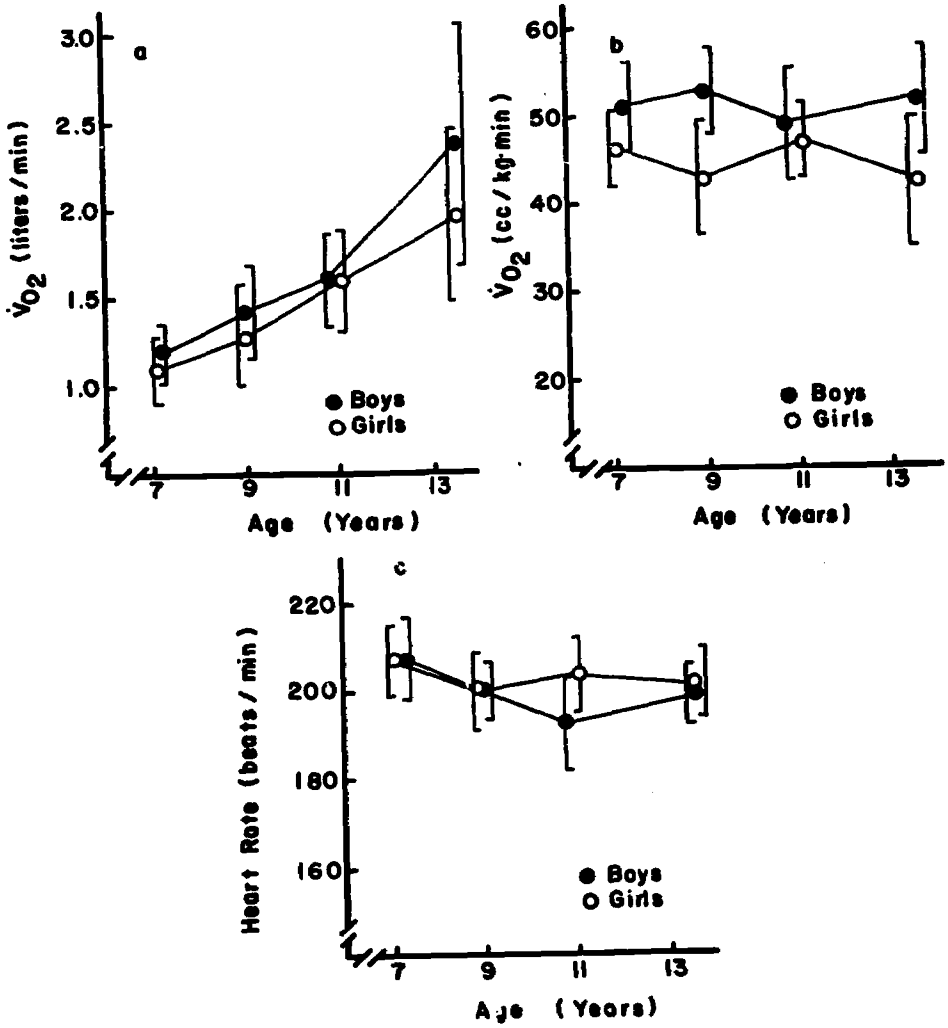


Figure 9. Exercise oxygen consumption ($\dot{V}_{O_2}$) and heart rate for boys and girls in relation to chronological age.



When the other data obtained during maximal exercise were compared (Figure 10), boys had a significantly lower RQ, extracted more oxygen per liter of air ventilated, and circulated a greater amount of oxygen per heart beat.

The data on maximal oxygen intake (considered to be the best single indicator of the physiological capacity for work) of the subjects were then compared with the values reported in the literature. It can be seen in Figures 11 and 12 that the aerobic power of the subjects in the present investigation is well within the range of values reported on normal children of different ages and nationalities.

There was a low but significant correlation between IQ and maximal values for oxygen intake (cc/kg min) and heart rate in the boys (r = 0.32 and 0.41, respectively) but not in the girls. When all data were combined there were significant correlations for the total group of subjects (r = 0.21 and 0.30, respectively).

During submaximal exercise, several findings are of interest. During the three-minute warm-up period which was given to all subjects, there was a significant correlation between IQ and heart rates during each of the first three minutes of walking (r = -0.35, and -0.39, respectively). Thus, it would appear that the children with the low IQs may have been more nervous or perhaps less efficient while walking on the treadmill. Looking at the data obtained at each work load by each age group, there is a tendency for the heart rate to be lower in the older subjects (Figure 13). The oldest boys had significantly lower heart rates at submaximal work loads than did the youngest boys. While this might be expected since younger children are known to have higher heart rates, there should be little difference in oxygen intake at the same level of submaximal work. There was, however, a significant difference in oxygen intake at all submaximal work loads between the oldest and youngest boys and girls (Figure 14). Thus, it might be that the treadmill speed of 3.5 mph was too fast for the younger subjects, causing an inefficient style of walking.

Physiologically, there appears to be little difference between marginally mentally retarded and normal children based on 1) growth and development, 2) strength and 3) maximal aerobic and cardiovascular capacities.

Figure 10. Respiratory quotient (RQ), ventilation oxygen consumption ratio ($\dot{V}_E/\dot{V}_{O_2}$) and oxygen pulse ($\dot{V}_{O_2}$/HR) for boys and girls in relation to chronological age.

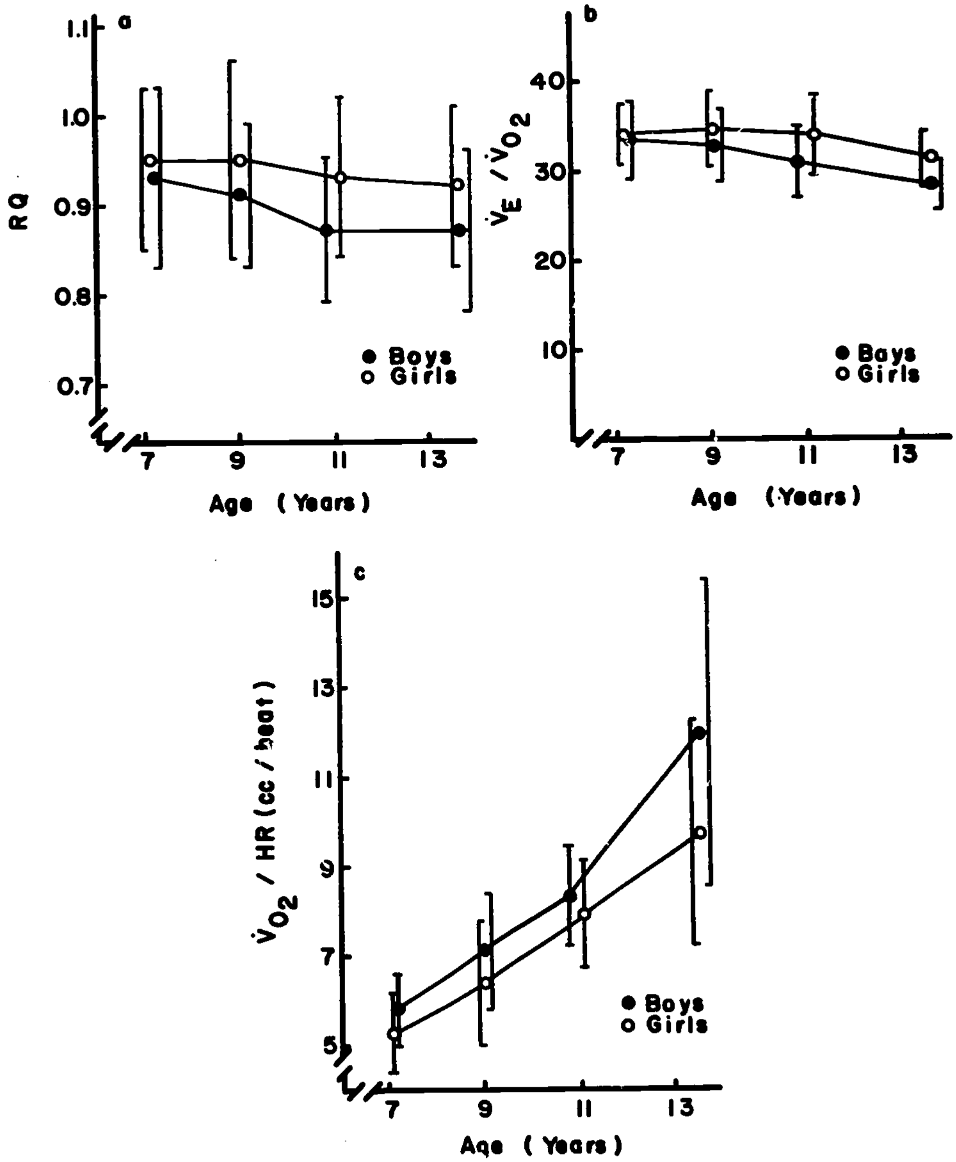


Figure 11. Maximal oxygen intake for boys ($\dot{V}_{O_2}$ cc/kg min) in relation to chronological age. Comparison with data in the literature.

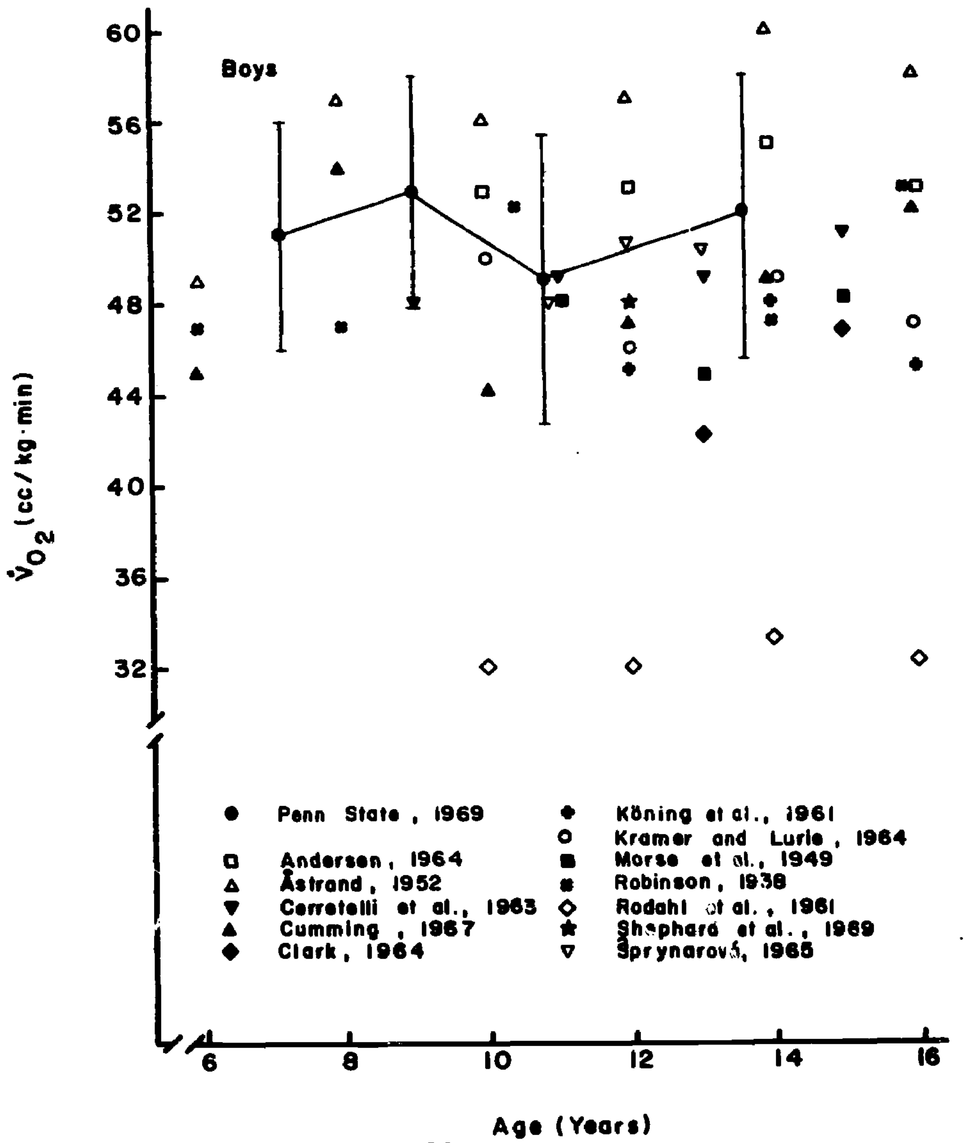


Figure 12. Maximal oxygen intake for girls ($\dot{V}_{O_2}$ cc/kg min) in relation to chronological age. Comparison with data in the literature.

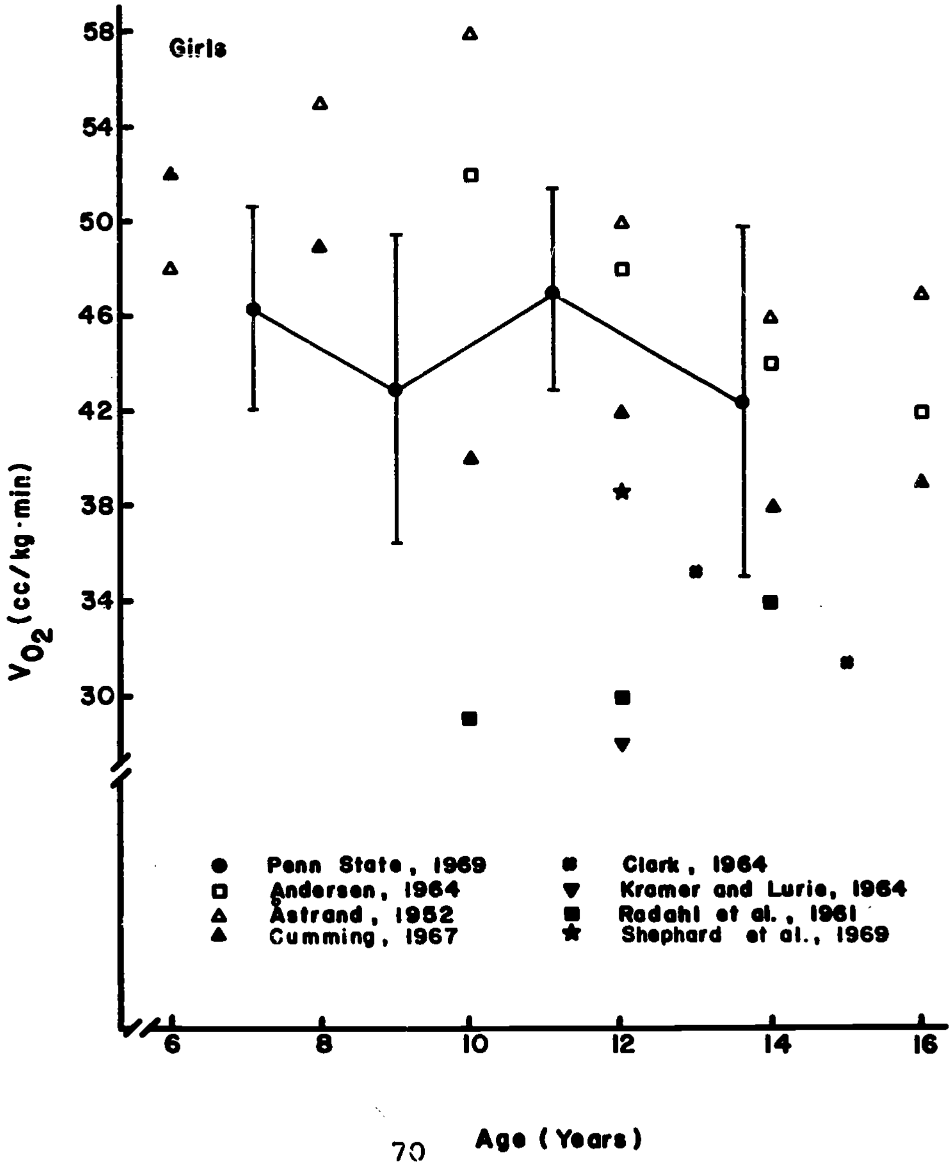
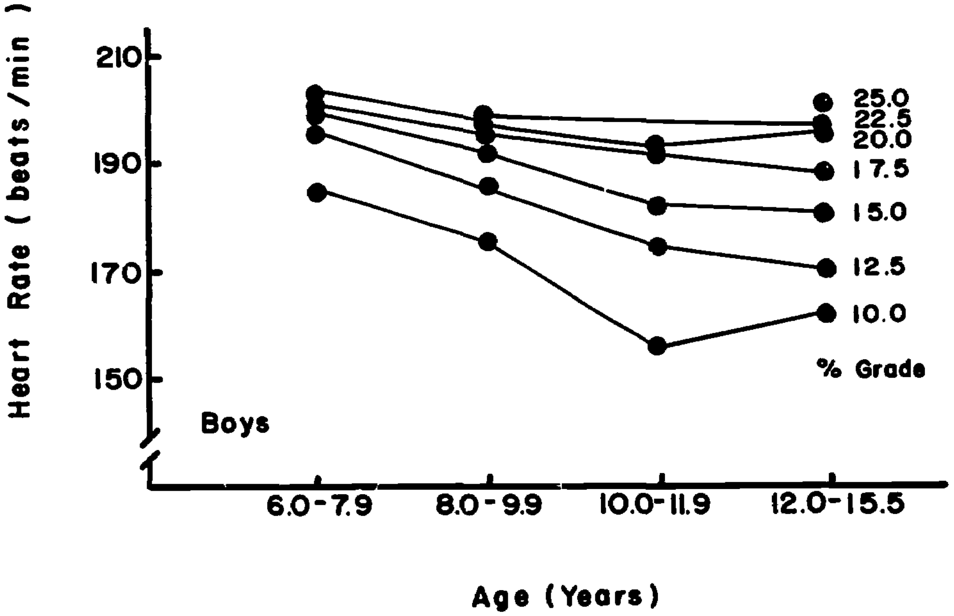


Figure 13. Heart rate of boys and girls of different ages when walking at various grades on the treadmill.



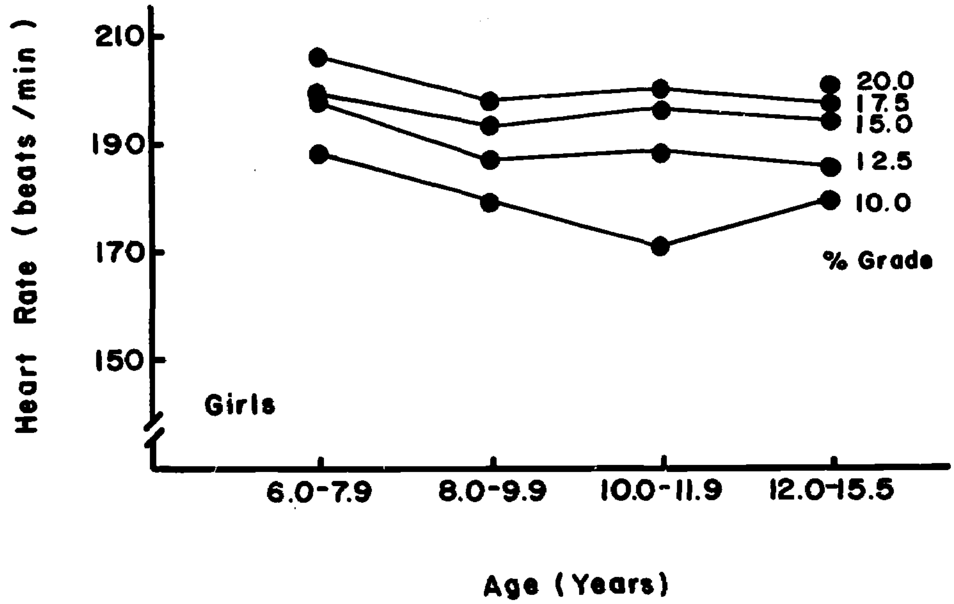
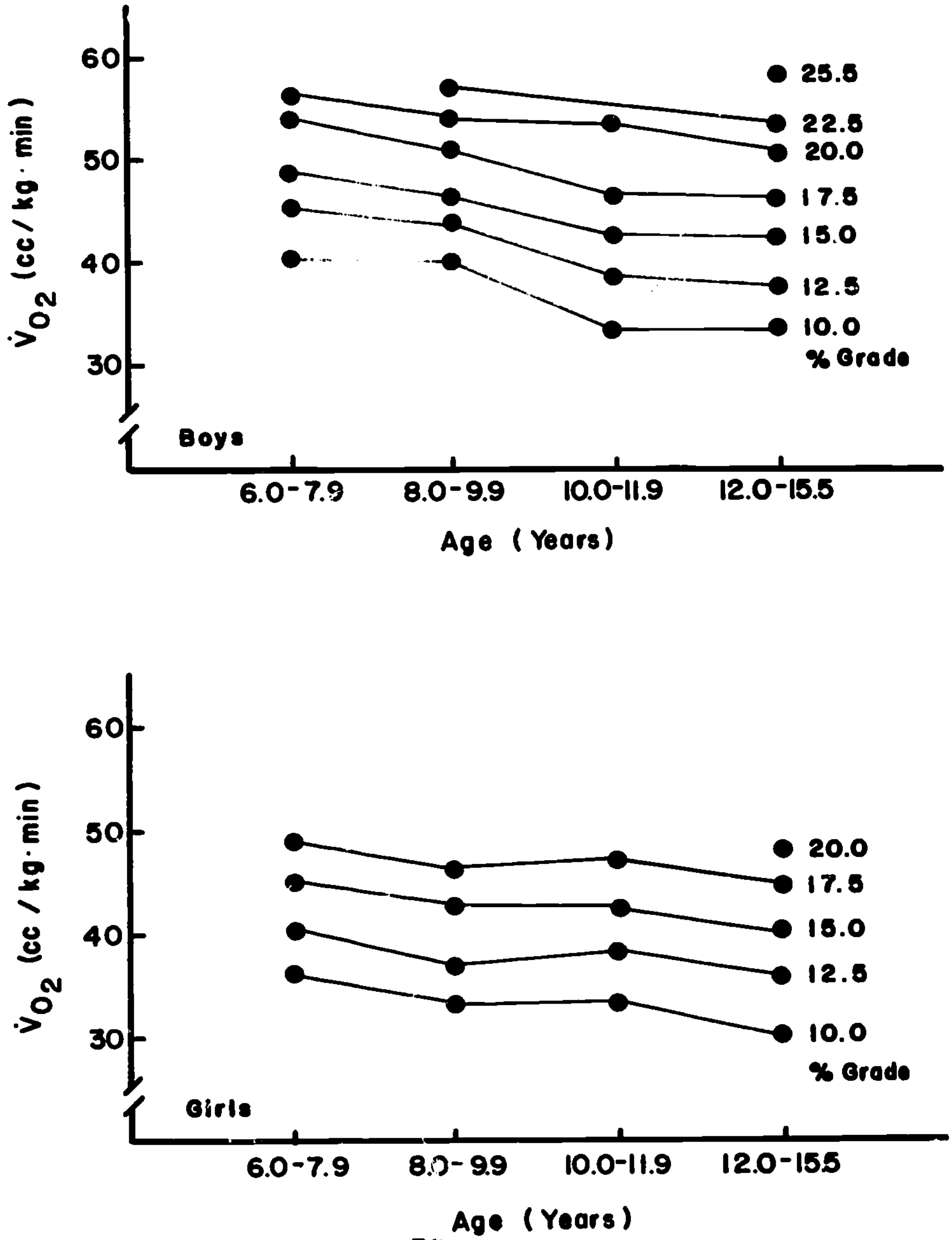


Figure 14. Oxygen consumption ($\dot{V}_{O_2}$ cc/kg min) of boys and girls of different chronological ages when walking at various grades on the treadmill.



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CHAPTER 5

RESULTS AND ANALYSIS

As the data for the study were generated and final analyses planned, it became apparent that not all of the possible original experimental questions would be appropriate, nor were they all mutually exclusive. It seemed advisable to combine them into several areas for presentation of the data and analysis.

The complete raw data on each subject are given in Appendix D.

In the following presentation, the plan is to state the area of interest, to present the data and its analysis, and to indicate appropriate interpretations.

As a preliminary analysis of the data, a computer library program was used to check for linearity of regression.* Had curvilinearity been present, correlation indices more complex than the product moment correlation coefficient would have been called for. Fortunately, no curvilinear trends were evident so the Pearson r was used throughout.

In the following, the sample sizes vary from analysis to analysis. This developed from the data because it was not always possible to complete the battery of tests in all areas with every child. However, all samples represent the major proportion of the total subjects available in the study, and

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* This program, termed <u>Regression Analysis</u>, was devised originally in 1969 by Robert Proctor at the Stanford Center for Research and Development in Teaching. It was revised at Penn State by Richard Kohr for use on the Computation Center S/360 IBM computer. The other statistical analyses done utilized library programs of the Penn State Computation Center.

the conclusions are believed to be valid and generally applicable to the total sample. The factors which eliminated subjects from some of the data collecting were not systematically related to the procedures, but involved such things as illness of a child, equipment breakdown, or unexpected school schedules.

As an initial analysis of the data product moment correlations were computed between each of the pairs of variables. The correlations are reported in Table 8. Inspection of Table 8 indicates a wide range of values. In general, the intelligence variables and age variable tended to be highly intercorrelated, but these variables were much less correlated with hearing and physiological age variables. Hearing measures tended to be correlated highly with other hearing measures based on the same tests but not with other areas of hearing; and physiological age factors tended to be highly intercorrelated among each other but less highly correlated with hearing and mental or chronological age factors. In Table 8 the lowest correlations appear to be between hearing variables and intellectual variables and between hearing variables and physiological variables.

In the speech hearing areas there were low correlations between threshold measures and discrimination measures.* Because these two areas are different aspects of hearing ability, this finding is not surprising.

Relationships between Age and Intelligence Measures, and Hearing

The statistics for this area were the product moment correlation and the regression equation (both obtained from the program which generated the data in Table 8). Table 9 repeats the Pearson product moment correlations of interest, and shows the regression equations between mental age, chronological age, intelligence quotient and physiological age, and speech hearing threshold and speech discrimination scores in children with IQs below 90.

Noticeable in Table 9 are the significant correlations between the mean threshold for speech, as measured by the TIP test and the three age measures (but the lack of a

* In this report the terms intelligibility and discrimination will be used interchangeably, even though the DIP test most properly is of the discrimination type because the subject must chose between a closed set of two items. In a number of instances, the intelligibility curve used to obtain SRT will be referred to because of the underlying rationale used to obtain SRT.

Table 8. Correlational matrix (product moment correlation) for experimental variables in total subject sample.

	CA	MA	Verbal MA	Perf. MA	Verbal IQ	Perf. IQ	Full Scale IQ
Full Scale MA	.682						
Verbal MA	.694	.932					
Perf. MA	.697	.955	.825				
Verbal IQ	-.503	.132	.157	-.006			
Perf. IQ	-.329	.325	.130	.360	.723		
Full Scale IQ	-.447	.244	.151	.186	.923	.922	
TIP Test A	-.239	-.252	-.287	-.240	.017	.017	.024
TIP Test B	-.154	-.190	-.222	-.171	-.002	-.004	.003
TIP Slope	-.130	-.026	-.011	-.028	.062	.061	.053
TIP Mean	-.237	-.240	-.280	-.224	.041	.036	.050
DIP SRT +0	-.193	-.199	-.213	-.185	.066	.065	.067
DIP SRT +5	-.204	-.099	-.115	-.094	.124	.149	.140
DIP SRT +10	-.052	.062	.070	.068	.035	.064	.027
DIP Slope 0-5	.070	.144	.142	.137	-.003	.034	.016
DIP Slope 5-10	.243	.147	.170	.146	-.089	-.090	-.113
Secondary Sex	.648	.513	.487	.539	-.338	-.174	-.272
Bone Age	.874	.680	.699	.672	-.437	-.285	-.388
Dental Age	.875	.690	.672	.677	-.424	-.299	-.392
Strength Age	.713	.655	.662	.653	-.257	-.103	-.190
Relative Wt.	-.053	.019	.021	.024	.106	.115	-.123
Height Age	.815	.650	.662	.660	-.401	-.235	-.345
Weight Age	.702	.599	.604	.611	-.296	-.134	-.226

Table 8. (Continued)

	TIP Test A	TIP Test B	TIP Slope	TIP Mean	DIP SRT +0	DIP SRT +5	DIP SRT +10	DIP Slope 0-5	DIP Slope 5-10
TIP B Test	.761								
TIP Slope	-.011	-.064							
TIP Mean	.920	.873	-.060						
DIP SRT	.224	.041	.044	.113					
DIP SRT +5	.252	.048	.048	.148	.419				
DIP SRT +10	.026	-.109	.076	-.091	.205	.440			
DIP Slope 0-5	-.057	-.000	-.007	-.016	-.780	.232	.091		
DIP Slope 5-10	-.292	-.173	.022	-.275	-.292	-.712	.224	-.184	
Secondary Sex	-.135	-.078	-.094	-.098	-.235	-.180	-.148	.135	.029
Bone Age	-.194	-.128	-.065	-.208	-.226	-.233	-.052	.085	.201
Dental Age	-.286	-.152	-.087	-.275	-.297	-.276	.007	.133	.282
Strength Age	-.232	-.167	-.037	-.205	-.215	-.200	-.014	.090	.221
Relative Wt.	.048	.016	-.200	.032	-.032	-.053	-.127	-.006	-.087
Height Age	-.150	-.084	-.069	-.144	-.217	-.133	.034	.143	.135
Weight Age	-.257	-.215	-.034	-.268	-.184	-.200	-.050	.053	.136
Physio. Age	-.293	-.200	-.138	-.266	-.223	-.254	-.003	.068	.274

Table 8. (Continued)

	Second-ary Sex	Bone Age	Dental Age	Strength Age	Relative Weight	Height Age
Bone Age	.725					
Dental Age	.629	.835				
Strength Age	.595	.761	.732			
Relative Weight	.200	.080	-.015	.121		
Height Age	.725	.862	.802	.746	.214	
Weight Age	.685	.766	.721	.696	.254	.774
Physiol. Age						

significant correlation between TIP mean and intelligence quotatient). The same relationships were found for the discrimination scores at the SRT level. The score on the DIP test at SRT +5 dB is correlated significantly with chronological age and physiological age only. However, at the DIP presentation level of SRT +10 dB no significant correlations were found. This may result from the tendency of DIP test scores at SRT +10 dB to approach a ceiling. Thus, only chance factors were operating to vary test scores.

To follow-up, partial correlations were computed among variables of interest. For the partial correlations IQ was ignored because of the non-significant correlations between IQ and hearing measures. In addition, because IQ is dependent upon age, it would be impossible to make a pure statisical test. Of the remaining age measures, only chronological age is not in some way dependent upon a number of factors. Mental age is not only a function of the subject's natural ability, but is influenced by environmental factors; physiological age would be expected to be influenced by such factors as nutrition and health environment.

For the above reasons, the partial r values were computed between mental age and hearing measures, with chronological age partialed out, and between physiological age and hearing factors, with chronological age partialed out. The results of these partial correlations are shown in Table 9. None of the partial r's are significant. The large decrease in the correlational values when chronological age is partialed out is strong evidence that the factors of physiological age and of mental age are not importantly related to the hearing measures.

Another aspect of the data in Table 9 are that not all of the significant correlations are in the anticipated direction. While increased age is associated with decreased TIP score (better hearing acuity), a finding in the expected direction, the negative correlations between DIP test score and increasing age is opposite to what would be expected (Siegenthaler and Haspiel, 1966). A higher DIP score represents an improvement, which would normally be associated with increased age. There is no readily available explanation for the DIP test correlations being in a non-expected direction. However, for correlations on the order of .20 only about four per cent of the variance between the factors in the DIP correlational statistics are accounted for.

Two general conclusions might be drawn from these analyses: (a) MA, physiological age and IQ are not related to SRT or to speech intelligibility as measured by the TIP and

Table 9. Product moment correlations, regression equations, and partial correlations (in parentheses) between age and intelligence measures, and speech hearing test scores in subjects with IQ below 90.

	MA (N 177)	CA (N 177)	IQ (N 177)	PA (N 125)
TIP Mean	-.232** Y=37.142-.6740X (r_p=-.11)	-.204** Y=37.219-.0491X	-.090 Y=35.138-.4829X	-.202* Y=34.472-.3354X (r_p=-.12)
DIP at SRT	-.195** Y=28.72-.1264X (r_p=-.09)	-.216** Y=31.59-.0116X	.016 Y=16.95+.019X	-.217* Y=27.77-.0828 (r_p=-.14)
DIP at SRT +5 dB	-.094 Y=36.57-.0396X (r_p=.06)	-.191** Y=40.90-.0066	.109 Y=27.20+.0843X	-.231** Y=39.71-.0614 (r_p=-.16)
DIP at SRT +10 dB	.042 Y=39.97+.0135X (r_p=.04)	.045 Y=39.[illegible]+.0012X	-.023 Y=42.06-.0134X	.031 Y=40.36+.0064X (r_p=-.11)

*Significant at .05.
**Significant at .01.

DIP tests for children with below 90 IQ who are in the age range over eight years, and (b) chronological age should be considered a factor in interpreting test performance in such children. Thus, the child's hearing test scores should be evaluated with respect to speech threshold and speech intelligibility against the norm established for his chronological group. (See Siegenthaler and Haspiel, 1966). These data also indicate the probability that the TIP and DIP tests can be used for children with normal as well as with below normal intelligence levels, using chronological age as the critical factor in test interpretation.

Relationships between MA, CA, IQ and PA, and Articulation

Table 10 contains product moment correlations as well as regression equations between mental age, chronological age, intelligence quotatient and physiological age and the slopes of the intelligibility curves for both the threshold (TIP) and the discrimination (DIP) tests.

The threshold test slopes were obtained by graphically displaying the articulation curve both for TIP A and for TIP B, computing the slope (change in word intelligibility per dB of intensity change) of the middle part of the curve, and computing the mean of the two intelligibility curve slopes from which a threshold had been obtained. The DIP slope data were obtained by taking difference between the number of words correct, i.e., DIP test scores at SRT and at SRT +5 dB, and taking the difference in DIP score between SRT +5 and SRT +10 dB. (A per cent change in DIP score per decibel of intensity change was not needed because all subjects were given the same decibel levels, and the score difference is an expression of slope for all subjects.)

A first impression of Table 10 is that the TIP test slopes do not correlate significantly with any of the age factors, nor with IQ. Also, the correlations are not significantly different from zero for DIP slope between SRT and SRT +5 dB for any of the age or IQ factors.

However, significant correlations are present in the case of the DIP slope between SRT +5 and SRT +10 decibels for both chronological age and physiological age: the more mature children, according to chronological and physiological age, tended to have more steep DIP slopes at the higher presentation levels. At least two interpretations are possible: (a) DIP test scores tended to be at or near the maximum score possible for DIP +10 dB so that there would tend to be a

Table 10. Product moment correlations and regression equations between age and intelligence measures, and intelligibility curves on speech reception tests.

	MA (N 177)	CA (N 177)	IQ (N 177)	PA (N 125)
TIP Slope	.017	-.008	.021	-.122
	Y=.36152+.1018X	Y=37.434-.0039X	Y=.35337+.2266X	Y=.41882-.4334X
DIP Slope at SRT to SRT +5dB	.144	.100	.056	.058
	Y=17.76+.0879X	Y=19.21+.0050X	Y=20.40+.0626X	Y=22.04-.0205X
DIP Slope at SRT +5 to SRT +10 DB	.122	.213**	-.114	.278**
	Y=14.31+.0458X	Y=1-.52+.0066X	Y=23.79-.0788X	Y=11.75+.278X

*Significant at .05
**Significant at .01

steeper slope at those two presentation levels; and (b) although the correlations are significant, they are low and produce large errors of estimate. For correlations as high as .30 only about nine per cent of the variance is accounted for by the correlational value.

To summarize the analysis regarding speech hearing test intelligibility curve slopes: it appears that because of the relatively low correlations, the relationships between various age or intelligence measures, and hearing test slopes are of minimum importance. For the present it is concluded that the slope of intelligibility curves for SRT (using the TIP test) or the slope of the intelligibility curve when testing for discrimination (the DIP test) need not be considered as a factor when testing children with lower IQ values in the range included in this study.

Comparisons of Hearing Test Scores and Intelligibility Curve Slopes between above and below 90 IQ Subjects

In the present study a sample of subjects with IQ above 90 were contrasted with subjects with IQ below 90.

An important variable for interpretation of the following findings is the chronological age factor. That is, chronologically older children tended to have better test scores, especially for threshold, than chronologically younger children. In the present grouping of children the average age of the subjects with IQ above 90 was 8.1 years; the average chronological age for the children with IQ below 90 was 11.4 years.

Table 11 presents the mean scores for the various hearing tests and the t test results comparing the two subject subgroups. The t tests were based upon the Fisher-Behrens t-Test modified procedure (Games and Klare, 1967), designed to take into account large differences in sample sizes.

The mean threshold scores for above 90 IQ children tended to be worse than for the below 90 IQ children, but as a group they were three years younger than the other subjects. The increased threshold, poorer speech hearing acuity for the older subjects, suggests that acuity continues to improve somewhat beyond the age of eight years. However, the standard error of measurement for TIP test is approximately three decibels with normals, so that the differences of approximately four to five decibels in acuity between the above 90 and below 90 IQ groups in the present study are close to the error of test measurement.

On the discrimination (DIP) test, the above 90 IQ subjects achieved higher mean scores, but even the largest difference was approximately five items (ten per cent), the error of estimate for discrimination testing. In these comparisons no consistent trend was seen which would allow a firm conclusion as to difference in the test scores for speech hearing between the two types of children divided on intelligence level.

Intelligibility Test Curve Slopes for Subjects with IQ above and below 90 IQ

Table 12 gives mean TIP and DIP test slopes (DIP slopes between SRT and SRT +5, and SRT +5 and +10 dB for children with IQ above 90 and below 90. The TIP and DIP slopes were computed as previously. The t-test results indicated nonsignificant differences. It may be concluded that the two groups do not differ in test slope and that it is appropriate to use the same intelligibility curve slopes for normal and for intellectually subnormal children.

Comparison of Above 90 and Below 90 IQ Subjects, with Respect to Relationships between Hearing and Age Variables

For subjects with IQ 90 and over product moment correlations were computed between each of the four main hearing test scores and CA, MA, and PA. The same correlations were computed for the below 90 IQ subjects. These product moment correlations are shown in Table 13. The question here is whether or not the regression equations for these two types of subjects are significantly different. The F test for parallelism of regression was used. (Edwards, 1961), as shown in Table 13. None of the F values are significant.

Table 11. Means and standard deviations on speech reception tests for subjects with IQ above 90 and for subjects with IQ below 90, and t test results.

	IQ Above 90 (N 20)		IQ Below 90 (N 160)				
	Mean	Std. Dev.	Mean	Std. Dev.		df	t
TIP A	35.15	4.57	31.55	6.11	1.114	26	3.231**
TIP B	34.05	6.96	30.83	5.75	2.598	22	1.986
TIP Mean	36.68	4.30	31.62	5.58	1.058	28	4.783**
DIP at SRT	23.10	10.42	18.38	12.45	2.529	26	1.866
DIP at SRT +5 dB	38.75	3.78	33.32	8.09	1.059	45	5.123**
DIP at SRT +10 dB	42.85	4.30	41.08	6.11	1.075	30	1.645

**Significant at .01.

Table 12. Means and standard deviations of intelligibility curve slopes on speech hearing tests for subjects with IQ above 90, and for subjects with IQ below 90.

	IQ Above 90 (N 20)		IQ Below 90 (N160)				
	Mean	Std. Dev.	Mean	Std. Dev.		df	t
TIP Slope	.404	.137	.370	.115	.0319	26	1.064
DIP Slope at SRT to SRT +5 dB	22.880	8.260	24.960	14.960	.4560	37	0.948
DIP Slope at SRT +5 to SRT +10 dB	16.240	5.070	18.060	8.060	1.3070	33	1.399

Note: No t value significant at .05.

Table 13. Correlations between age measures and speech hearing test scores, regression equations, and F-tests for significance of difference between correlations for subjects with IQ above 90 and for subjects with IQ below 90.

	Chronological Age			
	IQ Above 90 (N 20)	IQ Below 90 (N 160)	*F*	*df*
TIP Mean	r=-.196 Y=.41126-.0517X	r=-.204 Y=37.219-.0491X	0.001	1/173
DIP at SRT	r=-.145 Y=31.34-.0097X	r=-.216 Y=31.59-.0116X	0.011	1/176
DIP at SRT +5 dB	r=-.000 Y=36.75-.000X	r=-.191 Y=40.90-.0066X	0.334	1/176
DIP at SRT +10 dB	r=.306 Y=77.40+.0672X	r=.045 Y=39.74+.0012X	1.433	1/176

Table 13. (Continued)

	Physiological Age			
	IQ Above 90 (N 20)	IQ Below 90 (N 160)	F	df
TIP Mean	r=-.422 Y=.48808-1.7015X	r=-.202 Y=34.472-0.3354X	0.974	1/127
DIP at SRT	r=-.152 Y=35.24-0.1601X	r=-.217 Y=27.77-0.0828X	0.077	1/130
DIP at SRT +5 dB	r=-.021 Y=37.10-0.0077X	r=-.231 Y=39.71-0.0614X	0.084	1/130
DIP at SRT +10 dB	r=.202 Y=37.80+0.0732X	r=.031 Y=40.36+0.0064X	0.203	1/130

Table 13. (Continued)

	Mental Age IQ Above 90 (N 20)	Mental Age IQ Below 90 (N 160)	F	df
TIP Mean	r=-.200 Y=.41221-.5746X	r=-.232 Y=37.142-.6740X	0.012	1/173
DIP at SRT	r=-.108 Y=29.21-.0780X	r=-.195 Y=28.72-.1264X	0.059	1/176
DIP at SRT +5 dB	r=.016 Y=36.42+.0043X	r=-.094 Y=36.57-.0396X	0.118	1/176
DIP at SRT +10 dB	r=.440 Y=32.52+.1318X	r=.042 Y=39.97+.0135X	1.459	1/176

Note: No F values significant at .05.

It may be concluded that the children with IQ below 90 and those with IQ above 90 do not differ with respect to relationships between measures of age and measures of hearing for speech. The tests for speech hearing appear to be equally applicable to both subgroups of subject in that age effects occur equally for both subgroups.

Reliability of Tests for below 90 IQ Subjects

The experimental design provided TIP test A scores and TIP test B scores. According to previous research, these two tests are essentially equivalent. Thus, Form A and Form B provide alternate-form test scores (in effect, test-retest data) for which reliability coefficients were computed.

The DIP test, however, was not repeated for each child. Fortunately, the format of the DIP test is such that a Kuder-Richardson type of internal consistency analysis is appropriate. The Instructional Services Program at The Pennsylvania State University provided reliability analyses using Kuder-Richardson formula 20 for the DIP tests. The reliability was computed only for DIP test scores at SRT +5 dB.

For this analysis all subjects were divided into two subgroups at the mean of the total group. Table 14 shows the reliability coefficients obtained. To test for significance of difference between these reliability coefficients for subjects above the mean and subjects below the mean, the Fishers r to z transformation t test was used (Blomers and Lindquist, 1960). These t-values also are shown in Table 14.

For the SRT test no significant differences were found. This suggests that speech reception threshold is equally reliable for the upper level IQ and age children and for the lower level children, using the TIP test as the measure. The reliability values are of a magnitude indicating acceptable test reliability.

On the intelligibility test the pattern is somewhat different in that correlations for subjects in the upper group for chronological age, IQ, and physiological age were higher.

Although the differences in DIP test reliability were significant the reliabilities for the below mean subgroups compare favorably with reliabilities for the DIP test found previously: Siegenthaler and Haspiel (1966) found DIP test reliabilities at SRT +5 dB with normals to be .42 to .59;

Table 14. Speech hearing test reliability for IQ and age measures, and t test results between upper and lower subject sub-groups.

	MA (N 160)	CA (N 160)	IQ (N 160)	PA (N 125)	t Test Values MA	CA	IQ	PA
SRT test Reliability								
Above Mean	.741	.746	.793	.734	.456	.957	.883	.595
Below Mean	.768	.803	.738	.782				
Discrimination Test Reliability								
Above Mean	.891	.893	.963	.889	1.345	3.038**	5.000**	2.359*
Below Mean	.883	.734	.836	.776				

*Significant at .05
**Significant at .01

Note:
Mean MA 8.1 years
Mean CA 10.8 years
Mean IQ 77
Mean PA

Haspiel and Siegenthaler (1968) found DIP test reliabilities at SRT +5 dB for hypacusic children to be .596.

Relationship between Hearing Test Scores, and Verbal and Performance Intelligence Measures

The WISC is divided into a verbal and a performance section. Each section yields an IQ score. Table 15 indicates the product moment correlations between each of the WISC IQ measures and speech hearing tests. Table 15 shows low correlational values and small numerical differences between the r values for the verbal IQ and the r values for the performance IQ. No t-tests were necessary to compare r values because of non-significance, and lack of evidence for a difference in the relationship of verbal and performance IQ to hearing abilities. Even though full scale IQ is considered more reliable than either section in the WISC, it will be recalled from earlier data that there was a high correlation between verbal and performance IQ in the present study.

Judging from the present study, there is no advantage in using the verbal or in using the performance part of the WISC for subjects similar to those in this study.

Comparison of Institutionalized and of Organically Impaired Subjects, with other Subjects

Thirty-three subjects were from residential institutions. There were eleven subjects with organic signs, most of whom also were included among the 33 institutionalized children. The eleven organically impaired children presented documentation in their case files, of organic involvements. Table 16 shows point bi-serial correlations between organic status and hearing test scores, and between institutional status and hearing test scores for the total sample of subjects with IQ below 90. None of the correlations were significant. Thus the speech hearing abilities for threshold and for discrimination, as measured

Table 15. Product moment correlations between speech hearing test scores, and verbal and performance intelligence quotient (N 160).

	Verbal IQ	Performance IQ
TIP A	.018	.016
TIP B	-.015	-.008
TIP Mean	.041	.036
DIP at SRT	.066	.064
DIP at SRT +5 dB	.124	.149
DIP + SRT +10 dB	.035	.064

Note: No correlation significant.

Table 16. Point bi-serial correlations between speech hearing test scores and organic status, and between speech hearing test scores and institutionalization of subjects.

	Subjects Divided Organic (N 11) vs Non-Organic (N 149)	Subjects Divided Institutionalized (N 33) vs Non-Institutionalized (N 128)
TIP Mean	.129	.236
DIP at SRT	-.039	-.207
DIP at SRT +5 dB	-.042	-.167
DIP at SRT +10 dB	.019	-.034

Note: No correlation significant.

by the TIP and DIP tests respectively, were not demonstrated to be related to either the factors of organic involvement or institutionalization among subjects tested in this study. (It may be. of course, that a child with strong organic signs is so involved that he is not testable. Such a child would have been eliminated from the present subject sample.)

Although the sample sizes of the organically involved and of the institutionalized subjects were small in comparison to the non-organic or non-institutionalized samples, the correlations were so low as to suggest that even though larger samples might have produced significant r values, the relationships of interest are weak. This finding is in contrast to reports in the literature that there is a higher incidence of hearing loss, including loss for hearing of speech, among institutionalized and other retarded children. In the present study there was not a heavy loading of children with extremely low intelligence levels. The institutionalized children in the present sample had a mean IQ of 61.7. The organically involved children had a mean IQ of 67.4. While these scores are somewhat lower than the overall mean IQ for the total sample, they do not represent as severely impaired children as might be expected from a more random or representative sample from institutions. Further, it should be recalled that all of the subjects demonstrated essentially normal hearing according to pure tone and audiometrics. Thus, at least some of the difference between the present findings air other findings regarding hearing ability of institutionalized children may be explained.

CHAPTER 6

CONCLUSIONS AND COMMENTS

This project was designed to investigate relationships between various age and intelligence measures, and speech reception threshold and speech discrimination among children in the educable range of below normal intelligence. In general, it was expected that older children, in terms of chronological age, mental age, and physiological age, and children who achieved higher IQ scores in contrast to children who were younger in these aspect and showed lower IQ's, would show better hearing test scores.

Related questions regarded steepness of the slopes of the intelligibility curves used to obtain speech reception threshold, and of the curve for speech discrimination as a function of intensity of word presentation. In addition, it was suspected that there would be significant differences in speech-hearing test performance depending on whether or not a child presented organic signs as a basis for his mental retardation, and whether or not he was institutionalized.

While the experimental data appeared to give positive statistical support in some areas, in other instances this was not the case, or the analysis indicated statistical significance but little clinical or practical significance.

On the basis of the data and related statistical analyses given earlier in this report, the following conclusions appear warranted for children in the approximate chronological age range six through sixteen years, in the intelligence quotient range of approximately 50 through 95, and who as a group more typically are able to accommodate to and be accommodated in special education or regular classrooms in the public schools or other educational programs:

1. Speech reception threshold is better among children who are older in terms of mental age, chronological age, and physiological age, than among younger children. However, the effect is largely due to chronological age. Thus, the interpretation of speech reception threshold scores in children of lower than normal intelligence should take into account the chronological age norm.

2. Speech discrimination, especially at lower sensation levels, shows a low but statistically significant negative correlation (not in the expected direction) with increased mental age, chronological age and physiological age. The preponderance of the effect is due to chronological age, but the observed correlations are so low as to lead to the conclusion that the effect need not be taken into account in clinical application of tests for speech discrimination.

3. Children in the educable mentally retarded range do not differ from children in the lower portion of the normal intelligence range with respect to slope of the articulation curve used to obtain speech reception threshold or the intelligibility curve slope for speech discrimination measures. Thus, the slope of the intelligibility curve for speech reception threshold (using the TIP test) or the slope of the intelligibility curve for speech discrimination (using the DIP test) need not be considered as a significant factor when testing or when interpreting test results for such groups of children.

4. There is not a reliable and consistant difference in speech reception threshold or in speech discrimination between children in the educable mentally retarded range and children in the lower portion of the normal intelligence category.

6. For speech reception threshold, test reliability is not a function of mental age, chronological age, IQ or physiological age within the range of subjects studied in this project.

7. Retarded children who are in the upper IQ, CA, and physiological age range of their group show a trend toward higher test reliability than do children in the lower portion of the range. However, in both instances test reliability is within what is considered, even among adults, as acceptable discrimination test reliability.

8. There are not significant correlations (a) between verbal IQ, and speech reception threshold or speech discrimination score, nor (b) between performance IQ, and speech reception threshold or speech discrimination score among children of the educable mentally retarded range.

9. Whether or not a child shows organic impairment signs, and whether or not he is institutionalized (within the range of organic involvement among subjects utilized in this study and within the types of institutionalization experience by the subject in this study) is not related to speech hearing threshold nor to speech discrimination score, as measured by the TIP and DIP tests.

The initial overall impression from the above conclusions is that various age, intelligence, and organic or instituionalized status factors are related neither to speech intelligibility or to speech reception threshold among educable mentally retarded children. On the other hand, positive findings were that of the factors considered, chronological age has more influence than the others on test performance.

Both the speech reception threshold and the speech discrimination tests used in this experiment have acceptable test reliability (and presumed test validity) for the type of subject included in this experiment. This judgement of test acceptability is based upon comparisons between children within the normal range of intelligence and children in the educable retarded range, comparisons with data previously reported in the literature on speech threshold and speech discrimination tests with normals, and on other research reports that speech hearing tests have better validity than pure tone tests for the retarded. (Lloyd, 1965; Siegenthaler and Haspiel, 1966; Lloyd and Melrose, 1966; Lloyd and Reid, 1966; Fulton and Gribbon, 1967).

The bulk of the literature reporting poorer hearing for speech threshold and discrimination, and greater incidence of hearing loss among the retarded was based upon children or adults in institutions and on subjects who typically had either greater organic signs or who tended towards lower levels of intelligence and mental ages than did subjects in this study (Myatt and Landis, 1963; Schlanger and Galanowsky, 1966; Clausen, 1966). However, consistent with the present findings were the data of Webb, Cowie, and Beedle (1963) showing that length of stay in an institution was not related to hearing test score.

The physiological age measures of interest to this study did not appear to be significantly related to speech-hearing ability. This finding among the present group of retarded children is consistent with data of Kugel and Mohr (1963). The implication is that for hearing tests physiological age need not be considered a significant factor in test interpretation.

Throughout this study the orientation has been to arrive at conclusions applicable to the retarded and their ability to hear speech. However, to generalize to all retarded and to all speech hearing would be in error because the retarded are not a homogeneous population (hence the limiting of subjects to rather well defined sub-groups in this study), and the factors of effect of the specific hearing test and the specific testing conditions on the obtained results need to be considered. Because test procedures must be suitable to the subject the results obtained here, in effect, indicate what hearing performance can be obtained when the hearing test procedures are designed to meet the needs of the test subjects, as is the case with the TIP and DIP tests.

The two speech hearing tests utilized in this research (namely the TIP test and the DIP test) are given support by the results of this study so far as their use with educable retarded children is concerned. That is, because test results were of acceptable reliability with the retarded subjects, and because significant difference in reliability were not found among subject sub-groups, the use of TIP and DIP tests is supported by the data at hand.

When using the TIP and the DIP tests with children in the educable category, essentially the same test interpretation guideline can be used as with normals: chronological age should be an important factor, in contrast to IQ, physiological age, or mental age. Stated differently, the lack of highly significant correlations between speech reception threshold and speech discrimination (intelligibility) test scores on the one hand, and mental age, intelligence quotient, and physiological age, on the other hand, suggests that the TIP and the DIP tests are relatively independent of MA, IQ and physiological age influences (for children not severly retarded or below the educable range). Thus it may be inferred that the tests are useful for children over a wide range of intellectual ability and physiological ages, and that chronological age only need be utilized as a modifier when interpreting test performance in such children.

This general conclusion has implications for the audiologist, as well as for other professional workers who must evaluate the mentally retarded and advise programs for them. The TIP and DIP tests appear to be satisfactory for use with educable retarded children, and have reason to be added to the range of procedures used for their benefit.

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APPENDIX A

RELEASE FORM

RELEASE AND ASSUMPTION OF RISK
SPEECH AND HEARING CLINIC
AND
LABORATORY FOR HUMAN PERFORMANCE RESEARCH
THE PENNSYLVANIA STATE UNIVERSITY

Studies of man and his reaction to stress

I hereby freely volunteer my child to act as a subject in a scientific investigation as an authorized part of the educational and research program of The Pennsylvania State University. I acknowledge that I have read and concur in the procedures and objectives of this investigation as summarized on the reverse side of this sheet.

I further acknowledge that the detailed nature of my child's part in this investigation and the physical and mental effects, both probable, have been fully explained to me by ____________________ and that I understand the explanation.

I certify that to the best of my knowledge and belief, the above mentioned child has no physical or mental illness that would increase the risk to him (or her) of participation in this investigation.

I futher certify that my child has been examined by ____________________ address_________________, a qualified physician, and has been found fit to participate in this investigation.

I hereby understand that there is some small risk (probable and improbable) to my child as a result of participation in this investigation, but feel that exposure to this risk is worthwhile and in keeping with the objectives of the program.

I hereby consent to the participation of _______________ (full name) age _______and a minor, as a subject in the scientific investigation described, and request the test results be sent to his school for educational purposes.

_________________________ Date	_________________________ Signature of minor subject's parent or guardian
_________________________ Signature of Examining Physician	_________________________ Signature of physician participating in the Investigation

Procedures of the study:

The following measures and tests will be performed under professional supervision:

ADDITIONAL INFORMATION

1. Can he run and play games, keeping up with other children? YES____ NO_____ If NO explain.____
   ____

2. Has the child had a heart disease? YES______ NO_____ If YES explain.______________________

3. Does the child ever become blue in the lips? YES_____ NO_____ If YES explain.________________
   ____

4. Does the child have fainting spells? YES__________ NO_____ If YES explain.______________________
   ____

5. Is he/she ever short of breath other than after hard exercise? YES_____ NO_____ If YES explain.______________________________________
   ____

6. Is he/she on any medication for seizures or convulsions? YES_____ NO_____ If YES explain.
   ____

7. Do you consider the child to be in general good health? YES_____ NO_____ If NO explain.__________
   ____

10/31/68

APPENDIX B

TIP TEST PROTOCOL

(Note there are five pictures per test card, but for some cards only four different items are called because of the random selection of items to be called for each card determined by the prepared test protocol.)

FORM A

Practice A	audiometer setting	A-1	A-2	A-3	A-4	A-5	NUMBER CORRECT
chair	______	hands	house	horse	clock	eyes	______
shoe	______	dog	flag	ball	mouse	train	______
chair	______	truck	dress	cat	drum	milk	______
bread	______	stove	bus	fish	cup	eyes	______
cap	______	hands	kite	ball	clock	spoon	______

TOTAL CORRECT______

Form B

Practice B	audiometer setting	B-1	B-2	B-3	B-4	B-5	NUMBER CORRECT
shoe	______	door	bed	lamb	skates	tree	______
chair	______	pie	boat	corn	clown	knife	______
car	______	cow	hand	top	comb	doll	______
swing	______	socks	gum	lamb	gun	tree	______
dog	______	pie	bed	frog	clown	blocks	______

TOTAL CORRECT______

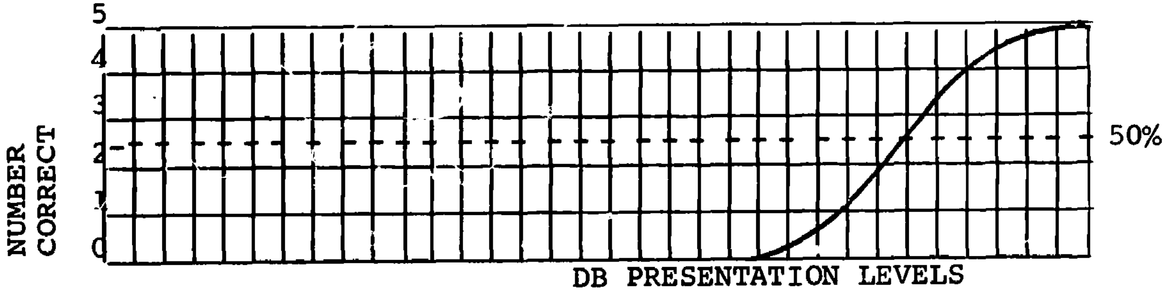
THRESHOLD

Right______dB

Left______dB

Bin.______dB

SCORING GRID



APPENDIX C

DIP TEST PROTOCOL

	DIP 1 ___db			DIP 3 ___db		DIP 2 ___db	
Practice							
A	dog			dog		cat	
B	chair			chair		boat	
C	kite			kite		kite	
D	coat			coat		kite	
VI							
1	bear			pear		pear	
2	deer			deer		tear	
3	bees			peas		peas	
4	fan			man		man	
5	coat			coat		goat	
I							
6	key	8	goat	key	goat	pea	boat
7	pup	9	pea	cup	tea	cup	tea
P							
10	meat	14	cheese	meat	keys	beet	keys
11	saw	15	wing	saw	ring	paw	ring
12	chain	16	rat	cane	rat	cane	bat
13	wheel	17	sail	wheel	tail	seal	tail
VI							
18	coat	22	cat	coat	cat	boat	bat
19	bow	23	pot	toe	dot	toe	dot
20	toy	24	bone	boy	bone	boy	cone
21	back	25	bee	back	bee	tack	key
VP							
26	nail			sail		sail	
27	men			men		pen	
28	sun			sun		gun	
29	feet			feet		beet	
IP							
30	cat	34	dog	hat	log	hat	log
31	fire	35	can	fire	can	tire	fan
32	horn	36	peas	horn	peas	corn	cheese
33	pear	37	shoe	hair	shoe	hair	two
VIP							
38	light	44	log	kite	log	kite	hog
39	cheese	45	four	bees	four	bees	door
40	rose	46	man	rose	can	toes	can
41	rain	47	suit	rain	suit	cane	boot
42	hat	48	bear	bat	hair	bat	hair
43	gum			gum		thumb	

APPENDIX D

EXPERIMENTAL DATA OF SUBJECTS

Table 17 Subject number, sex, chronological age, and intelligence measures.

Sub. No.	Sex	Chron. Age	WISC IQ Verbal	WISC IQ Perf.	WISC IQ Full Scale	WISC MA Verbal	WISC MA Perf.	WISC MA Full Scale
300	M	10.8	63	71	64	6.8	7.6	6.9
301	M	10.4	65	75	67	6.8	7.5	7.0
302	M	10.6	74	79	74	7.8	8.2	7.8
303	M	9.7	65	79	69	6.2	7.7	6.7
304	M	7.6	82	80	80	6.2	6.1	6.0
305	M	10.4	79	85	80	8.2	8.8	8.3
306	M	9.3	69	85	74	6.5	7.9	6.9
307	M	9.1	79	64	69	7.2	5.8	6.4
308	F	9.5	70	92	78	6.7	8.8	7.4
309	F	9.9	62	72	64	6.2	7.2	6.4
311	F	11.9	60	62	57	7.2	7.3	6.7
312	F	9.2	65	61	59	6.0	5.6	5.5
313	M	9.7	79	82	78	7.7	7.9	7.7
315	M	9.4	65	69	64	6.1	6.5	6.1
316	M	11.2	84	86	83	9.4	9.6	9.3
317	M	8.5	74	71	70	6.3	6.1	6.0
318	F	6.6	81	71	74	5.3	4.7	4.9
319	F	11.7	76	93	83	8.9	10.9	9.7
320	F	12.2	80	70	80	10.8	8.5	8.8
321	F	12.4	61	61	57	7.6	7.6	7.1
322	F	11.0	69	69	66	7.6	7.6	7.3
323	M	12.1	72	72	70	8.7	8.7	8.5
324	M	12.0	72	93	80	8.6	11.2	9.6
325	M	12.1	66	79	70	8.0	9.6	8.5
326	M	12.1	71	80	73	8.6	9.7	8.8
328	F	14.0	61	58	56	8.5	8.5	7.7
329	F	14.3	53	71	58	7.6	10.2	8.2
330	F	13.7	66	76	68	9.0	10.4	9.1
331	F	14.4	72	86	77	10.4	12.4	11.0
332	M	11.1	70	68	66	7.8	7.5	7.4
333	M	13.3	69	71	67	9.2	9.5	8.8
334	F	12.3	69	72	67	8.5	8.9	8.2
336	F	11.7	62	69	62	7.2	7.5	7.3
337	M	12.3	81	93	85	10.0	11.5	10.3
339	M	14.8	76	90	81	11.2	13.3	11.9
340	M	13.5	77	83	78	10.4	10.3	10.4
341	M	12.2	86	75	79	10.5	9.1	9.5
342	M	12.8	86	90	87	11.0	11.5	11.0
344	M	13.9	85	87	85	11.8	12.2	11.7
345	M	13.7	74	79	74	10.2	10.8	9.9
346	M	13.7	81	100	89	11.1	13.7	12.0
348	M	13.8	82	86	83	11.4	11.9	11.3
349	M	14.3	63	83	70	9.0	11.9	9.8
351	M	14.7	72	82	75	10.6	12.1	11.0
352	F	13.7	80	100	88	11.0	13.7	11.8
354	F	12.6	80	89	83	10.1	11.3	10.3
327	M	13.2	60	53	52	7.9	7.0	6.9

Table 17 (Continued)

			WISC IQ			WISC MA		
Sub. No.	Sex	Chron. Age	Verbal	Perf.	Full Scale	Verbal	Perf.	Full Scale
356	M	13.5	84	85	83	11.3	11.5	11.0
357	M	12.6	86	83	83	10.8	10.7	10.3
358	M	13.9	84	84	84	11.7	11.7	11.7
359	F	14.8	76	86	79	11.2	12.8	11.7
360	F	13.1	79	89	82	10.3	11.7	10.6
361	F	14.1	74	97	83	10.4	13.8	11.6
362	F	13.6	81	86	82	11.0	11.8	11.0
363	M	6.6	86	94	89	5.7	6.2	5.8
364	F	7.6	87	80	83	6.6	6.1	6.2
365	M	8.2	81	79	78	6.6	6.5	6.4
366	M	8.0	74	57	62	5.9	4.6	5.0
368	F	7.2	94	86	89	6.8	6.2	6.4
369	F	6.6	91	90	89	6.0	5.9	5.9
370	F	6.6	81	99	88	5.3	6.5	5.7
371	F	6.3	95	92	93	6.0	5.8	5.8
372	F	6.8	94	94	93	6.4	6.4	6.3
373	F	8.2	86	103	93	7.0	8.4	7.4
374	M	7.4	84	82	81	6.2	6.1	5.9
375	F	7.9	90	78	83	7.2	6.2	6.4
376	F	7.5	91	97	93	6.8	7.3	7.0
377	F	7.7	96	90	93	7.3	6.9	7.1
381	M	13.8	74	67	67	10.2	9.2	9.1
382	F	14.1	80	85	80	11.3	12.0	11.1
383	M	14.1	82	78	78	11.6	11.0	10.9
384	M	14.5	72	86	77	10.5	12.5	11.0
385	M	9.4	84	94	88	7.9	8.8	8.2
386	M	9.1	77	79	76	7.0	7.2	6.8
387	F	8.8	89	89	88	7.8	7.8	7.7
390	F	9.2	87	94	90	8.0	8.6	8.2
391	M	10.1	92	96	93	9.2	9.7	9.4
393	F	9.4	81	89	83	7.6	8.3	9.1
404	F	6.6	86	92	88	5.7	6.2	5.7
406	M	9.8	100	79	89	9.8	7.8	8.7
414	M	8.5	80	83	80	6.8	7.1	6.7
415	M	8.5	89	100	93	7.6	8.5	7.9
416	F	8.6	70	90	77	6.0	7.8	6.6
417	M	8.0	66	82	72	5.3	6.6	5.8
418	M	10.6	70	86	75	7.4	9.1	7.9
419	F	9.9	75	83	77	7.4	8.2	7.0
420	M	8.2	71	90	78	5.8	7.3	7.3
421	M	10.8	60	68	60	6.4	7.3	5.9
422	M	10.2	75	64	67	7.7	6.5	6.8
423	F	9.9	70	65	64	7.0	6.5	6.3
424	M	8.6	92	86	88	7.9	7.4	7.5
425	M	8.8	85	99	91	7.5	8.8	8.0
395	M	10.4	76	90	81	7.9	9.4	8.4

Table 17 (Continued)

			WISC IQ			WISC MA		
Sub. No.	Sex	Chron. Age	Verbal	Perf.	Full Scale	Verbal	Perf.	Full Scale
426	M	9.3	70	85	75	6.6	7.9	6.9
429	M	8.2	74	75	72	6.1	6.2	5.9
430	M	10.5	80	75	75	8.4	7.8	7.9
431	M	8.0	74	79	74	5.9	6.3	5.9
433	F	11.6	57	69	59	6.6	8.0	6.9
434	F	11.6	72	85	76	8.3	9.8	8.7
436	F	10.3	75	82	76	7.8	8.5	7.8
439	F	8.6	90	96	92	7.8	8.2	7.8
441	M	6.8	94	74	83	6.4	5.1	5.7
443	F	8.7	95	92	93	8.2	8.0	8.0
445	F	10.4	94	90	91	9.8	9.4	9.4
448	M	9.4	96	90	93	9.0	8.5	9.2
453	M	10.3	68	63	75	7.0	6.5	6.8
456	F	14.4	70	72	68	10.1	10.4	10.9
458	F	12.0	56	53	50	6.7	6.3	6.0
460	M	12.1	60	47	49	7.2	5.7	5.9
461	F	11.2	58	57	54	6.5	6.4	6.0
462	F	10.4	80	79	77	8.3	8.3	8.0
463	M	14.2	61	90	72	8.6	12.8	10.3
464	M	15.0	48	44	45	7.2	6.6	6.8
465	M	15.2	55	58	52	8.3	8.8	7.9
467	M	12.9	72	68	67	9.3	8.8	8.7
468	M	14.5	71	72	69	10.3	10.5	10.0
469	F	13.2	72	101	85	9.5	13.3	11.7
163	M	10.7	82	72	75	8.8	7.7	7.6
170	M	11.3	65	76	67	7.3	8.6	7.1
171	F	10.7	74	79	74	7.9	8.4	7.4
172	F	10.8	66	92	76	7.2	10.0	7.7
173	F	8.4	74	72	70	6.3	6.1	5.5
164	F	8.6	76	86	80	6.6	7.4	6.4
472	M	10.8	82	78	78	8.9	8.4	8.4
473	M	11.0	75	74	72	8.3	8.2	7.9
474	M	11.8	89	89	88	10.5	10.5	10.5
475	M	11.8	91	92	87	10.8	10.9	10.3
476	M	11.8	67	89	75	7.9	10.5	8.9
480	M	12.0	66	68	64	7.9	8.2	7.8
483	M	12.1	76	72	72	9.2	8.7	8.7
479	M	12.4	70	80	75	8.7	9.7	9.1
481	M	12.5	79	103	89	9.9	12.9	11.2
405	M	9.8	91	92	94	9.9	9.0	9.1
482	M	12.7	83	103	91	11.2	13.0	11.5
477	M	14.8	80	81	82	11.6	12.0	12.2
478	M	15.0	67	83	72	10.1	12.5	10.8
485	F	12.6	66	76	68	8.2	9.6	8.5
487	M	13.4	56	61	54	7.5	8.2	7.3
490	M	12.9	67	61	61	8.7	7.9	7.9
489	M	11.5	65	68	63	7.5	7.7	7.3

Table 17 (Continued)

			WISC IQ			WISC MA		
Sub. No.	Sex	Chron. Age	Verbal	Perf.	Full Scale	Verbal	Perf.	Full Scale
491	M	13.6	56	71	59	7.6	9.7	8.0
488	M	12.5	51	55	48	6.4	6.9	6.0
493	M	12.2	82	94	87	10.0	11.5	10.6
494	F	14.6	63	96	77	9.2	14.0	11.2
495	F	13.2	67	60	60	8.7	7.9	7.9
496	M	12.5	81	79	78	10.2	9.9	9.8
497	M	12.6	75	47	58	9.5	6.0	7.2
498	M	13.5	70	67	65	9.5	9.0	8.8
499	F	11.8	50	65	53	5.9	7.7	6.2
500	F	9.1	71	80	70	6.5	7.2	6.5
501	F	9.6	62	55	55	6.5	5.3	5.3
502	F	8.4	63	57	56	5.3	4.8	4.7
503	F	13.9	61	68	61	8.5	9.4	8.5
504	M	11.6	62	65	60	7.2	7.5	7.0
335	F	11.8	71	76	71	8.3	8.9	8.4
343	M	13.1	77	90	82	10.1	10.6	10.6
347	M	12.9	85	76	79	12.8	9.8	10.0
350	M	13.6	75	71	70	10.4	9.7	9.3
353	F	13.9	77	94	84	10.8	13.2	11.5
367	F	6.8	81	90	84	5.5	6.1	5.7
378	M	14.5	65	64	61	9.4	9.2	8.7
379	F	13.9	71	86	76	9.9	12.0	10.5
380	F	14.4	57	78	64	8.2	11.2	9.1
394	M	11.8	66	72	66	7.8	8.4	7.7
310	F	7.6	71	72	69	5.4	5.5	5.3
314	M	8.5	86	78	80	7.2	6.5	6.9
457	M	9.5	61	60	56	5.8	5.7	7.3
459	M	14.9	74	62	65	11.1	9.3	9.8
438	F	8.0	77	99	86	6.2	7.9	6.8
338	M	14.8	72	79	73	10.8	11.8	10.6
355	F	13.0	80	82	79	10.4	10.7	10.1
388	M	9.8	80	92	84	7.7	9.0	8.3
427	F	9.0	63	65	61	5.7	5.8	5.5
452	M	6.6	63	69	63	4.2	4.6	4.4
484	F	13.1	45	53	46	5.9	6.9	6.0
486	F	14.5	45	44	44	6.5	6.4	6.4
435	F	11.6	69	80	72	8.0	9.0	8.3
444	F	11.0	85	74	77	9.3	8.2	8.4
446	F	12.6	74	100	85	9.3	12.6	10.7
101	M	12.7	77	82	77	9.8	10.4	9.8
103	F	9.7	69	74	68	6.7	7.2	6.5
104	M	11.0	80	74	75	8.8	8.2	8.3
105	F	13.8	72	68	67	10.0	9.4	9.2
106	F	6.5	89	99	93	5.8	6.4	5.9
107	F	6.9	92	90	91	6.3	6.2	6.3
108	M	10.7	56	60	54	6.0	6.4	5.8
109	F	13.7	65	60	59	8.9	8.2	8.1

Table 18 Subject number, and physiological measurements.

Subject Number	Strength	Weight	Height	% Fat	Breast-Genitalia	Pubic Hair	Axillary Hair	Bone Age	Larynx	Dental Age	Menarche
300	205	35.7	138	25.0	2	1	0	12.2	0	12.5	
301	175	29.7	134	15.5	2	1	0	11.7	0	9.5	
302	190	26.1	132	15.0	2	1	0	10.0	0	10.0	
303	135	23.4	128	14.5	1	1	0	9.1	0	10.0	
304	140	23.1	121	16.5	1	1	0	6.4	0	7.0	
305	195	30.5	132	15.0	2	1	0	9.9	0	11.0	
306	135	23.4	138	14.5	2	1	0	10.2	0	10.3	
307	125	25.8	136	16.5	2	1	0	9.9	0	10.0	
308	145	22.4	128	22.0	2	1	0	10.1		9.5	0
309	120	32.0	136	30.0	2	1	0	9.9		10.0	9.9
311	230	46.6	161	27.0	3	4	1	13.2		10.3	0
312	105	24.3	125	24.5	2	1	0	9.9		9.3	0
313	120	24.0	130	17.5	2	1	0	8.3	0	8.5	
315	80	78.6	122	13.5	2	2	0	8.0	1	8.3	
316	260	43.1	150	23.0	1	1	0	12.2	0	11.8	
317	105	25.3	130	19.0	2	1	0	7.7	0	9.5	
318	90	22.2	117	29.0	2	1	0	7.5		8.0	0
319	175	35.0	146	29.0	2	2	0	11.1		12.0	0
320	175	36.5	148	29.5	3	2	0	12.9		11.5	0
321	195	38.8	144	29.0	4	3	0	13.0		15.0	0
322	200	33.7	146	27.5	3	3	0	12.3		11.5	0
323	205	34.4	139	21.0	2	1	0	11.8	0	14.0	
324	245	31.7	137	14.5	2	1	0	12.2	1	11.8	
325	240	31.9	143	18.5	2	1	0	11.6	0	12.5	
326	195	31.8	136	18.5	2	1	0	10.3	0	12.5	
328	250	56.9	157	27.0	4	4	1	13.1		11.3	0
329	175	33.7	149	21.0	4	3	0	13.0		11.5	0
330	185	32.0	147	12.0	1	1	0	10.4		11.3	0
331	280	47.9	157	18.0	4	4	1	13.8		13.8	12
332	195	29.3	129	17.0	2	1	0	10.2	0	11.0	
333	150	25.8	130	16.0	2	1	0	10.0	0	12.5	
334	205	35.9	145	28.5	2	2	0	12.3		13.8	0
336	165	36.0	144	28.0	1	1	0	11.4		11.5	0
337	275	39.1	149	15.0	3	1	0	12.8	0	14.0	
339	320	43.3	158	11.0	4	4	0	14.5	1	15.3	
340	245	36.4	148	14.0	3	1	0	13.7	1	11.8	
341	235	36.5	151	19.5	2	1	0	12.4	0	12.5	
342	285	60.5	159	32.5	2	1	0	13.5	0	12.5	
344	360	48.8	164	14.0	4	4	1	14.5	1	13.3	
345	450	62.0	168	13.5	5	5	1	15.5	1	14.0	
346	210	42.5	140	29.0	2	1	0	12.4	0	15.3	
348	355	49.3	162	14.5	4	4	1	14.1	1	15.3	
349	170	35.1	149	19.0	2	2	0	13.0	0	13.3	
351	415	74.5	165	26.0	5	5	1	16.1	1	15.3	
352	365	79.8	166	31.0	5	5	1	15.2		15.0	10
354	185	58.2	155	37.0	5	5	1	13.2		12.8	10
327	195	38.9	153	10.0	3	3	0	14.1	1	11.5	

Table 18 (Continued)

Subject Number	Strength	Weight	Height	% Fat	Breast-Genitalia	Pubic Hair	Axillary Hair	Bone Age	Larynx	Dental Age	Menarche
356	170	32.2	146	16.5	2	1	0	12.4	0	12.0	
357	260	36.3	143	14.0	2	1	0	10.8	0	13.3	
358	390	50.8	159	12.5	4	4	1	14.7	1	15.3	
359	210	42.7	162	15.5	4	4	1	14.5		15.0	13
360	145	32.8	136	20.0	3	2	0	11.3		11.3	0
361	280	49.3	160	12.0	4	4	1	12.9		15.3	13
362	325	48.9	152	19.0	4	4	1	13.4		14.0	12
363	105	49.0	112	13.5	1	1	0	5.6	0	6.0	
364	120	25.3	126	21.5	1	1	0	10.0		7.5	0
365	95	20.5	117	11.5	1	1	0	6.4	0	7.5	
366	80	20.4	120	15.0	1	1	0	5.6	0	7.3	
368	135	25.7	123	28.5	1	1	0	8.1		8.3	0
369	110	25.1	127	27.5	1	1	0	7.2		6.5	0
370	105	17.7	117	21.0	1	1	0	5.3		7.5	0
371	120	22.7	122	25.5	1	1	0	6.9		6.5	0
372	115	18.8	119	22.0	1	1	0	8.1		6.8	0
373	115	26.8	128	27.0	1	1	0	9.4		7.5	0
374	100	28.2	121	29.0	2	1	0	5.0		7.5	0
375	100	19.6	118	23.0	1	1	0	6.9		8.0	0
376	100	23.8	133	23.0	1	1	0	7.3		8.0	0
377	130	23.4	122	27.5	1	1	0	7.9		7.0	0
381	200	41.1	150	13.5	2	1	0	12.6	0	15.3	
382		64.5	160	25.5				14.2		15.0	
383	270	69.9	159	18.5	3	2	0	13.9	0	15.3	
384	390	67.7	165	22.0	4	4	1	14.9	0	15.3	
385	160	36.7	142	21.0	2	2	0	10.1	0	8.5	
386	175	25.0	126	15.5	3	1	0	8.4	0	8.5	
387	135	20.7	122	22.0	1	1	0	8.7		8.5	0
390	180	60.4	148	39.0	2	1	0	10.4		9.5	0
391	145	26.5	133	12.0	2	1	0	8.1	0	9.3	
393	155	26.5	137	22.0	1	1	0	10.2		9.3	0
404	110	23.4	114	30.5	1	1	0	7.9		6.0	0
406	185	30.3	140	15.0	2	1	0	9.7	0	9.3	
414	145	28.3	124	23.0	1	1	0	8.9	0	9.5	
415	125	22.3	124	16.5	2	1	0	7.9	0	9.0	
416	80	25.9	116	32.5	1	1	0	10.9		7.3	0
417	120	26.4	129	17.5	2	1	0	6.9	0	9.3	
418	210	36.1	149	21.0	2	1	0	10.5	0	8.5	
419	110	22.3	123	31.0	1	1	0	7.9		8.3	0
420	90	19.5	121	13.5	1	1	0	7.1	0	8.3	
421	145	30.3	139	17.5	2	1	0	8.3	0	9.3	
422	170	32.0	146	15.0	2	1	0	12.2	0	9.0	
423	140	39.8	142	35.0	2	2	0	10.4		8.5	0
424	215	28.9	130	12.0	2	1	0	9.6	0	9.0	
425	110	19.5	119	14.0	1	1	0	6.5	0	9.0	
395	230	29.7	137	14.5	3	2	1	10.1	0	9.0	

Table 18 (Continued)

Subject Number	Strength	Weight	Height	% Fat	Breast-Genitalia	Pubic Hair	Axillary Hair	Bone Age	Larynx	Dental Age	Menarche
426	150	26.6	140	13.5	1	1	0	8.0	0	8.3	
429	135	26.3	125	18.0	2	1	0	6.1	0	8.5	
430	160	31.8	143	14.0	2	1	0	7.8	0	11.3	
431	110	20.0	122	14.0	2	1	0	6.0	0	8.3	
433	240	39.3	155	25.5	4	4	1			11.3	0
434	165	31.3	138	28.0	2	1	0			12.0	0
436	150	34.9	143	24.0	3	2	0			10.5	0
439	120	32.5	129	35.0	1	2	0	8.4		8.0	0
441	115	22.2	113	16.0	1	1	0	4.6	0	6.8	
443	130	29.2	136	26.0	1	1	0	9.2		9.0	0
445	120	26.4	132	29.5	2	2	0	10.3		10.0	0
448	175	28.7	131	19.0	2	1	0	7.9	0	9.3	
453	210	39.7	147	21.5	2	2	0	10.1	0	12.8	
456	210	38.9	158	12.0	4	4	1	16.5		13.8	10
458	115	30.9	133	25.5	3	4	1	12.6		11.3	0
460	125	29.6	144	13.0	2	2	0	13.5	0	11.5	
461	110	26.0	139	26.0	3	2	0	11.1		11.0	0
462	185	35.3	140	28.0	2	1	0	10.2		9.0	0
463	280	42.4	157	10.0	4	4	0	13.9	0	13.3	
464	155	49.4	158	17.5	3	2	0	14.1	0	15.3	
465	270	53.8	159	23.5	5	5	1	14.2	0	15.3	
467	210	37.7	150	15.0	4	4	0	13.9	0	14.0	
468	435	61.5	173	13.5	5	5	1	14.5	1	14.0	
469	250	45.0	152	20.0	4	4	1	12.9		12.8	0
163	130	32.4	135	22.5	2	1	0	8.0	0	12.8	
170	245	30.1	143	15.5	2	1	0	10.3	0	12.8	
171		43.3	150	30.0	3	2	0			10.8	0
172	140	23.2	122	27.0	2	1	0	8.7		9.3	0
173	110	30.9	132	31.0	1	1	0			8.5	0
164	105	26.2	131	27.5	2	2	0	8.9		8.5	0
472		27.6	131		2	1	0	9.6	0	11.5	
473		30.7	132		3	2	0	11.5	0	9.3	
474		45.0	152		2	2	1	12.9	0	14.0	
475		49.1	152		2	2	1	12.8	0	12.8	
476		31.8	139		2	2	0	9.8	0	9.0	
480		28.1	139		3	2	0	10.4	0	14.0	
483		53.2	156		2	1	0	9.5	0	11.8	
479		43.9	150		3	2	0	12.6	0	10.3	
481		39.4	154		3	2	0	13.0	0	12.5	
405	115	23.5	125	13.5	2	2	0	8.2	0	9.0	
482		38.7	159		3	2	0	12.7	0	15.3	
477		44.7	155		4	4	1	13.5	0	15.3	
478		50.0	163		5	5	1	16.3	1	13.3	
485		32.0	148		2	1	0		0	12.8	0

Table 18 (Continued)

Subject Number	Strength	Weight	Height	% Fat	Breast-Genitalia	Pubic Hair	Axillary Hair	Bone Age	Larynx	Dental Age	Menarche
487		40.8	140		2	1	0	9.6	0	12.8	
490		28.3	132		2	1	0	15.2	0	9.3	
489								11.8			
491		41.9	145		3	2	0	12.6	0	12.0	
488		47.4	152		3	3	1	12.1	0	9.0	
493		31.0	150		2	1	0	11.8	0	10.5	
494		62.8	165		4	4	1	13.9		12.3	13
495		44.5	164		3	3	1	13.1		13.8	12
496		38.4	142		2	2	0	11.8	0	13.3	
497		36.0	146		3	3	1	11.9	0	12.8	
498		48.3	162		4	4	1	13.8	0	12.5	
499		32.6	145		3	2	1			11.0	11
500		34.5	136		1	2	0	9.9		10.8	0
501		32.0	127		1	1	0	9.1		9.0	0
502		29.3	135		1	1	0	8.2		8.5	0
503		42.6	157		4	4	1	12.8		15.0	10
504		39.4	144		2	1	0	10.1	0	12.8	
335	185	30.6	140	27.5	2	2	0	11.5		12.0	0
343	290	44.3	152	15.5	3	3	0	12.6	0	15.3	
347	395	63.3	171	23.6	4	4	0	14.3	0	15.3	
350	210	36.9	150	12.5	4	4	0	12.8	1	14.0	
353	325	47.6	165	15.5	3	3	1	13.4		12.8	0
367	140	24.0	120	24.5	1	1	0	8.5		6.8	0
378	350	42.8	153	11.0	4	4	0	14.7	1	15.3	
379	200	45.5	155	15.5	4	4	0	13.2		15.0	0
380	365	92.0	162	34.5	3	4	1	13.7		15.0	13
394	190	35.2	142	16.0	3	2	0	11.8	0	12.5	
310		25.4	131	25.5				9.4		9.0	
314	145	27.0	125	14.5	2	1	0	7.7	0	8.3	
457		34.8	149	14.0				11.8		12.5	
459		34.2	151	10.5				14.1		14.0	
438	100	20.5	121	23.0	1	1	0	6.2		7.5	0
338	335	43.4	159	12.0	3	3	0	14.9	1	15.3	
355	185	30.6	140	27.5	2	2	0	12.6		12.0	0
388	145	24.8	124	15.5	3	2	0	10.3	0	9.3	
427	105	20.0	124	23.0	1	1	0	7.7		9.0	0
452	105	18.9	117	13.5	1	1	0	6.6	0	9.0	
484		45.1	156		3	3	1	12.5		11.5	12
486		57.0	154		4	4	1	13.6		12.8	10
435	275	42.4	155	25.5	4	4	1	13.1		11.0	0
444	90	26.3	135	27.5	1	1	0	9.8		10.8	0
446	130	32.8	146	25.5	3	2	1	12.8		12.3	0

Table 19 Physiological analysis data (derived test scores.

Subject Number	Bone Age	Dental Age	Secondary Sex	Strength Age	Relative Weight	Height Age	Weight Age
300	12.2	12.5	2	10.0	1.03	9.5	9.3
301	11.7	9.5	2	8.8	.88	8.7	8.5
302	10.0	10.0	2	9.5	.76	8.4	7.2
303	9.1	10.0	1	7.2	.74	7.7	6.3
304	6.4	7.0	1	4.0	.88	6.5	6.0
305	9.9	11.0	2	9.7	.91	8.4	8.0
306	10.2	10.3	2	7.2	.76	9.5	6.3
307	9.9	10.0	2	6.7	.86	9.1	7.0
308	10.0	9.5	2	8.9	.74	8.0	5.4
309	9.9	10.0	7	7.7	1.01	9.5	6.8
311	13.2	10.3	13	12.3	1.18	15.0	14.6
312	9.9	9.3	2	6.9	.82	7.4	5.9
313	8.3	8.5	2	6.4	.75	8.0	6.3
315	8.0	8.3	5	4.2	2.54	7.7	18+
316	12.2	11.8	1	12.2	1.20	12.0	11.7
317	7.7	9.5	2	5.3	.88	8.0	6.4
318	7.5	8.0	2	5.3	1.10	6.2	4.7
319	11.1	12.0	4	10.4	.91	11.2	8.8
320	12.9	11.5	6	10.4	.90	11.5	9.1
321	13.0	15.0	12	11.2	.93	10.0	9.8
322	12.3	11.5	9	11.3	1.05	11.2	8.6
323	11.8	14.0	2	10.1	.89	8.7	9.4
324	14.5	12.2	3	11.8	.83	8.3	9.4
325	11.6	12.5	2	11.6	.90	9.7	8.9
326	10.3	12.5	2	9.7	.90	9.1	8.8
328	13.1	11.3	17	12.8	1.16	13.0	9.9
329	13.0	11.5	12	10.4	.68	11.6	9.5
330	12.4	11.3	1	10.8	.67	11.3	10.0
331	13.8	13.8	19	13.8	.96	13.0	13.0
332	10.2	11.0	2	9.7	.89	7.8	8.2
333	10.0	12.5	2	7.7	.58	8.0	8.1
334	12.3	13.8	4	11.5	.87	11.0	9.1
336	11.4	11.5	1	10.0	.94	11.0	9.2
337	12.8	14.0	3	12.6	.99	12.0	11.8
339	14.5	15.3	17	13.6	.81	13.4	13.3
340	13.7	11.8	4	11.8	.80	11.7	11.2
341	12.4	12.5	2	11.4	.93	12.3	10.3
342	13.5	12.5	2	13.8	1.46	13.5	13.7
344	14.5	13.3	18	14.4	1.01	14.3	13.9
345	15.5	14.0	27	16.1	1.32	15.0	16.8
346	12.4	15.3	2	10.3	.91	10.0	10.7
348	14.1	15.3	18	14.3	1.04	14.0	13.9
349	13.0	13.3	4	8.6	.69	12.0	9.9
351	16.1	15.3	27	15.4	1.41	14.5	17.8
352	15.2	15.0	30	18+	1.66	18.0+	18.0+
354	13.2	12.8	30	10.8	1.36	12.6	12.4
327	10.4	14.1	10	9.7	.80	12.6	12.4

Table 19 (Continued)

Subject Number	Bone Age	Dental Age	Secondary Sex	Strength Age	Relative Weight	Height Age	Weight Age
356	12.4	12.0	2	8.6	.71	11.3	9.3
357	10.8	13.3	2	12.3	.89	10.7	11.1
358	14.7	15.3	18	15.1	1.06	13.5	14.3
359	14.5	15.0	18	11.7	.84	15.8	12.3
360	11.3	11.3	6	8.9	.72	9.5	9.3
361	12.9	15.3	18	13.8	1.00	14.3	14.1
362	13.4	14.0	19	17.3	1.03	12.1	13.0
363	5.6	6.0	1	5.3	2.09	5.1	13.9
364	10.0	7.5	1	7.7	1.00	8.6	6.6
365	6.4	7.5	1	4.7	.74	6.0	5.5
366	5.6	7.3	1	4.2	.75	6.4	5.1
368	8.1	8.3	1	8.5	1.06	7.1	6.0
369	7.2	6.5	1	7.2	1.11	7.8	5.8
370	5.3	7.5	1	6.9	.78	6.2	3.8
371	6.9	6.5	1	7.7	1.04	7.0	5.2
372	8.1	6.8	1	7.4	.62	6.5	4.1
373	9.4	7.5	1	7.4	1.00	8.0	6.5
374	5.0	7.5	2	4.9	1.10	6.5	6.3
375	6.9	8.0	1	6.5	.75	7.3	4.3
376	7.3	8.0	1	6.5	1.06	10.0	5.9
377	7.9	7.0	1	8.2	1.02	7.0	5.2
381	12.6	15.3	2	9.9	.87	12.0	12.6
382	14.2	15.0			1.42	14.3	18+
383	13.9	15.3	6	12.5	1.42	13.5	18+
384	14.9	15.3	17	15.1	1.31	14.5	16.5
385	10.1	8.5	4	8.1	1.18	10.4	10.2
386	8.4	8.5	3	8.8	.83	7.3	6.8
387	8.7	8.5	1	8.5	.73	7.0	4.8
390	10.4	9.5	2	10.6	2.05	11.5	12.4
391	8.1	9.3	2	7.5	.81	8.5	7.8
393	10.2	9.3	1	9.5	.88	9.7	7.0
404	7.9	6.0	1	7.2	1.03	5.7	4.9
406	9.7	9.3	2	9.3	.94	10.0	8.8
414	8.9	9.5	1	7.5	.99	7.0	7.1
415	7.9	9.0	2	6.7	.78	7.0	5.7
416	10.9	7.3	1	4.8	.93	6.0	5.5
417	6.9	9.3	2	6.4	.97	7.8	7.1
418	10.5	8.5	2	10.3	1.06	12.0	10.0
419	7.9	8.3	1	7.2	.70	7.1	4.5
420	7.1	8.3	1	4.5	.70	6.5	4.9
421	8.3	9.3	2	7.5	.87	9.7	8.5
422	12.2	9.0	2	8.6	.97	11.3	9.4
423	10.4	8.5	4	8.7	1.26	10.6	9.2
424	9.6	9.0	2	10.5	1.00	8.0	8.6
425	6.5	9.0	1	5.7	.66	6.2	4.8
395	10.1	9.0	7	11.2	.88	9.3	8.6

Table 19 (Continued)

Subject Number	Bone Age	Dental Age	Secondary Sex	Strength Age	Relative Age	Height Age	Weight Age
426	8.0	8.3	1	7.7	.87	10.0	9.7
429	6.1	8.5	2	7.2	.95	7.2	7.0
430	7.8	11.3	2	8.1	.94	10.7	9.4
431	6.0	8.3	2	5.7	.73	6.7	5.1
433		11.3	17	12.5	1.03	12.6	10.4
434		12.0	2	10.0	.82	10.0	7.7
436		10.5	6	9.2	1.06	10.7	9.4
439	8.4	8.0	2	7.7	1.16	8.2	7.1
441	4.6	6.8	1	6.1	.93	5.3	5.7
443	9.2	9.0	1	8.2	1.04	9.5	7.3
445	10.3	10.0	4	7.7	.79	8.9	6.0
448	7.9	9.3	2	10.4	.93	8.2	7.7
453	10.1	12.8	4	10.3	1.19	11.5	11.1
456	16.5	13.8	21	11.7	.78	13.4	11.8
458	12.6	11.3	13	7.4	.78	9.0	10.0
460	13.5	11.5	4	6.7	.77	10.0	8.8
461	11.1	11.0	6	7.2	.71	10.1	6.3
462	10.2	9.0	2	10.8	1.06	10.2	9.0
463	13.9	13.3	16	12.7	.85	13.3	13.2
464	14.1	15.3	6	7.9	.91	13.4	13.7
465	14.2	15.3	5	12.5	.97	13.5	13.7
467	13.9	14.0	16	10.3	.90	12.0	11.4
468	14.5	14.0	27	15.8	1.19	16.7	16.6
469	12.9	12.8	17	12.8	.98	12.1	12.2
163	8.0	12.8	2	7.0	.94	8.9	8.5
170	10.3	12.8	2	11.8	.83	10.7	8.7
171		10.8	6		1.25	11.8	10.7
172	8.7	9.3	2	8.7	.67	7.0	9.2
173		8.5	1	7.2	1.13	8.9	7.2
164	8.9	8.5	4	7.9	.94	8.6	6.2
472	9.6	11.5	2		.80	8.2	
473	11.5	9.3	6		.87	8.4	
474	12.9	14.0	5		1.19	12.4	
475	12.8	12.8	5		1.30	12.4	
476	9.8	9.0	4		.84	9.7	
480	10.4	14.0	6		.73	9.7	
483	9.5	11.8	2		1.38	13.1	
479	12.6	10.3	6		1.10	12.0	
481	13.0	12.5	6		.98	12.8	
405	8.2	9.0	4	6.1	.73	7.2	6.5
482	12.7	15.3	6		.94	13.5	
477	13.5	15.3	17		.84	13.0	
478	16.3	13.3	27		.92	14.1	
485	[illegible]	12.8	2		.75	11.5	
487	9.6	12.8	2		.91	10.0	
490	15.2	9.3	2		.68	8.4	

Table 19 (Continued)

Subject Number	Bone Age	Dental Age	Secondary Sex	Strength Age	Relative Age	Height Age	Weight Age
489	11.8						
491	12.6	12.0	6		1.13	11.1	
488	12.1	9.0	10		1.18	12.4	
493	11.8	10.5	2		1.87	12.0	
494	13.9	12.3	18		1.24	18+	
495	13.1	13.8	11		.97	18+	
496	11.8	13.3	4		.95	10.4	
497	11.9	12.8	10		.89	11.3	
498	13.8	12.5	9		1.06	13.9	
499		11.0	9		.87	11.1	
500	9.9	10.8	2		1.18	9.5	
501	9.1	9.0	1		1.04	7.8	
502	8.2	8.5	1		1.07	9.4	
503	12.8	15.0	2		.87	13.0	
504	10.1	12.8	2		1.06	11.0	
335	11.5	12.0	4	10.8	.79	10.2	7.6
343	12.6	15.3	9	13.0	1.03	12.4	13.1
347	14.3	15.3	16	15.1	1.51	15.8	15.2
350	12.8	14.0	17	10.3	.80	12.0	11.5
353	13.4	12.8	10	17.3	.98	18+	13.2
367	8.5	6.8	1	8.7	1.03	6.6	5.5
378	14.7	15.3	17	14.2	.83	12.6	13.2
379	13.2	15.0	16	11.3	.93	12.6	13.8
380	13.7	15.0	14	18+	1.84	15.8	18+
394	11.8	12.5	6	9.5	.93	10.4	10.4
310	9.4	9.0			1.00	8.6	6.0
314	9.7	8.3	2	7.5	.94	7.2	7.6
457	11.8	12.5			1.11	11.9	10.6
459	14.1	14.0			.63	12.3	10.9
438	6.2	7.5	1	6.5	.78	6.8	4.6
338	14.9	15.3	10	13.9	.81	13.5	13.2
355	12.6	12.0	4	10.8	.68	10.2	7.6
388	10.3	9.3	6	7.5	.74	7.0	6.8
427	7.7	9.0	1	6.9	.69	7.3	4.5
452	6.6	9.0	1	5.3	.90	5.9	4.7
484	12.5	11.5	12		.99	12.8	
486	13.6	12.8	21		1.13	12.4	
435	13.1	11.0	17	13.6	1.11	12.6	11.1
444	9.8	10.8	1	5.8	.74	9.4	6.3
446	12.8	12.3	6	8.2	.76	11.2	8.6

Table 20 Subject number and speech hearing test scores

	TIP Measure				DIP Measure				
Subject Number	Form A	Form B	TIP Mean	TIP Slope	SRT	SRT +5dB	SRT +10dB	Slope 0-5	Slope 5-10
300	38.5	30.0	34.3	.393	30	27	35	-3	8
301	36.5	32.5	34.5	.534	20	31	40	11	9
302	35.0	37.0	37.5	.534	21	40	44	11	4
303	29.0	31.0	30.0	.500	11	36	39	25	3
304	35.5	34.5	35.0	.366	23	38	35	15	-3
305	28.5	26.5	27.5	.450	27	31	42	4	11
306	32.5	30.5	31.5	.366	24	42	42	18	0
307	32.5	30.5	31.5	.325	22	37	39	15	2
308	29.0	32.5	30.8	.333	24	32	32	8	0
309	34.5	32.5	33.5	.416	26	33	43	7	10
311	35.0	38.5	36.8	.325	39	43	45	4	2
312	30.5	30.5	30.5	.268	14	33	40	19	13
313	29.5	27.5	28.5	.416	23	36	38	13	2
315	40.5	44.0	42.3	.300	31	30	29	-1	-1
316	42.5	37.5	40.0	.416	28	39	43	11	4
317	41.0	31.5	36.3	.393	34	38	46	4	8
318	31.5	28.5	30.0	.375	26	29	34	3	5
319	32.5	30.0	31.3	.236	31	41	43	10	2
320	25.5	27.5	31.5	.643	41	46	48	5	2
321	39.5	30.0	34.8	.286	39	44	48	5	4
322	33.0	32.0	32.5	.325	24	29	40	5	11
323	25.5	25.5	25.5	.333	27	24	35	-3	11
324	30.5	26.5	28.5	.450	31	40	43	9	3
325	31.5	25.5	28.5	.416	29	31	47	2	16
326	26.5	27.5	27.0	.375	0	30	44	30	14
328	29.5	30.5	30.0	.254	0	32	43	32	11
329	32.5	31.0	31.8	.591	22	27	43	5	16
330	36.5	32.0	34.2	.310	32	40	45	8	5
331	37.5	31.5	34.5	.286	26	35	41	9	6
332	35.0	40.0	37.5	.476	40	36	46	-4	10
333	39.5	39.0	39.3	.415	26	37	42	11	5
334	33.0	30.0	31.5	.393	11	35	44	24	9
336	32.5	32.5	32.5	.393	26	33	43	7	10
337	36.0	32.5	34.3	.286	0	0	43	0	43
339	26.5	29.0	27.8	.268	28	24	41	-4	17
340	23.5	27.5	25.5	.700	17	28	43	11	15
341	29.5	25.5	27.5	.450	28	34	41	6	7
342	28.5	26.0	27.3	.400	22	44	45	22	1
344	24.5	28.5	26.5	.450	36	38	44	2	6
345	29.5	25.5	27.5	.416	29	41	46	12	5
346	17.5	24.5	21.0	.750	3	43	47	40	4
348	24.5	28.5	26.5	.450	1	13	40	12	27
349	23.5	27.5	25.5	.416	19	12	45	-7	33
351	39.0	29.0	34.0	.416	0	0	0	0	0
352	30.5	25.5	28.0	.450	18	44	41	26	-3
354	25.5	30.5	28.0	.400	0	28	35	28	7
327	32.5	30.5	31.5	.366	24	33	39	9	6

Table 20 (Continued)

	TIP Measure				DIP Measure				
Subject Number	Form A	Form B	TIP Mean	TIP Slope	SRT	SRT +5dB	SRT +10dB	Slope 0-5	Slope 5-10
356	23.5	27.5	25.5	.450	9	30	44	14	19
357	19.5	20.5	20.0	.366	8	22	41	14	19
358	24.5	21.0	22.8	.333	8	28	38	20	10
359	20.5	26.5	23.8	.292	0	37	47	37	10
360	27.5	27.0	27.2	.309	9	31	42	22	11
361	28.5	27.0	27.8	.216	0	24	46	24	22
362	37.0	32.5	34.8	.666	0	34	38	34	4
363	32.5	35.5	34.0	.333	28	36	44	8	8
364	35.5	38.5	37.0	.325	19	32	39	13	7
365	37.5	30.5	34.0	.343	33	40	43	7	3
366	30.5	36.5	33.5	.400	24	40	44	16	4
368	31.5	30.5	31.0	.416	30	41	46	11	5
369	40.0	40.5	40.3	.292	28	45	42	17	-3
370	29.5	33.0	31.3	.309	21	34	40	13	6
371	33.5	37.5	35.5	.643	19	41	34	22	-7
372	44.5	40.0	42.3	.534	33	40	47	7	7
373	34.5	36.5	35.5	.416	22	37	43	15	6
374	36.5	33.5	35.0	.343	19	34	43	15	9
375	35.5	38.0	36.8	.219	24	26	33	2	7
376	40.5	36.0	38.3	.333	21	32	42	11	10
377	43.5	44.0	43.8	.277	23	36	35	13	-1
381	32.5	24.0	28.3	.333	0	24	41	24	17
382	30.5	26.5	28.5	.416	0	20	38	20	18
383	31.5	31.0	31.3	.236	11	35	46	24	11
384	20.5	21.5	21.0	.366	3	20	36	17	16
385	28.5	32.5	30.5	.700	27	33	45	6	12
386	23.5	28.0	25.8	.292	22	35	38	13	3
387	30.5	29.5	30.0	.416	26	35	44	9	9
390	35.5	33.0	34.8	.292	35	41	47	6	6
391	28.5	37.5	33.0	.341	31	34	46	3	12
393	29.0	39.0	34.0	.220	31	44	45	13	1
404	34.5	31.0	32.8	.254	19	35	41	16	6
406	20.5	29.5	25.3	.416	28	27	37	-1	10
414	31.5	30.5	31.0	.390	26	31	35	5	4
415	40.5	42.5	41.5	.375	35	31	45	-4	14
416	33.5	32.5	32.0	.311	31	40	42	11	2
417	32.5	33.5	32.0	.310	0	44	43	44	-1
418	30.5	24.5	27.5	.450	16	31	36	15	5
419	45.0	40.5	43.3	.206	26	34	37	8	3
420	25.5	27.5	26.5	.333	2	38	44	36	6
421	29.5	28.5	29.0	.366	26	38	45	8	7
422	24.5	31.5	28.0	.375	28	42	47	14	5
423	36.5	34.0	35.3	.667	34	40	48	6	8
424	25.5	33.0	27.8	.393	1	25	38	24	13
425	32.5	34.5	33.5	.450	16	34	48	18	14
395	24.5	33.5	29.0	.310	28	44	48	16	4

Table 20 (Continued)

	TIP Measure				DIP Measure				
Subject Number	Form A	Form B	TIP Mean	TIP Slope	SRT	SRT +5dB	SRT +10dB	Slope 0-5	Slope 5-10
426	25.5	26.5	34.8	.366	0	37	40	37	3
429	27.5	35.5	31.5	.333	26	42	44	16	2
430	30.5	35.0	32.8	.500	39	45	43	6	-2
431	27.0	32.5	29.3	.611	31	37	45	6	8
433	47.5	41.0	44.3	.350	0	32	37	32	5
434	30.5	31.5	30.0	.533	16	36	43	20	7
436	36.0	36.5	36.3	.366	17	28	25	11	-3
439	29.5	33.5	31.5	.450	24	38	45	14	7
441	35.5	29.5	32.5	.450	0	29	35	29	6
443	33.5	35.5	34.5	.375	18	37	45	19	8
445	25.5	34.0	29.8	.450	0	29	41	29	12
448	24.5	32.0	34.3	.343	41	42	46	1	4
453	30.5	33.5	32.0	.366	0	21	31	21	10
456	30.0	30.5	30.3	.400	1	31	41	30	10
458	33.0	35.5	34.8	.343	6	9	31	3	22
460	34.0	39.5	36.8	.311	2	40	47	38	7
461	27.5	32.5	30.0	.333	0	41	45	41	4
462	35.0	39.5	37.8	.375	25	31	41	6	10
463	33.5	38.5	36.5	.211	24	36	40	12	4
464	28.0	27.0	27.5	.182	35	25	35	-10	10
465	28.5	27.0	27.8	.310	0	27	41	27	14
467	36.0	34.5	36.3	.341	19	20	45	1	25
468	32.5	31.5	32.0	.416	0	32	41	32	9
469	42.5	42.5	42.5	.416	20	38	44	18	6
163	17.5	20.5	19.0	.400	27	33	48	6	15
170	18.5	19.5	19.0	.310	32	35	46	3	11
171	35.5	37.5	36.5	.434	17	35	41	18	6
172	19.5	26.5	23.0	.416	37	40	45	3	5
173	20.5	27.5	24.0	.416	31	37	43	6	6
164	22.5	28.0	25.3	.343	31	39	46	8	7
472	28.5	37.5	33.0	.643	0	30	46	30	16
473	44.0	42.0	43.0	.366	37	42	45	5	3
474	33.0	35.0	34.0	.236	0	26	42	26	16
475	41.5	31.0	36.3	.254	0	38	45	38	7
476	38.5	40.0	39.3	.286	27	40	41	13	1
480	26.5	32.0	29.3	.416	28	35	45	7	10
483	26.5	39.5	33.0	.366	11	42	44	31	2
479	30.5	33.5	32.0	.277	20	42	45	22	3
481	32.5	28.8	33.0	.310	39	44	35	5	-9
405	34.0	33.5	33.8	.235	18	36	43	18	7
482	41.5	45.5	43.5	.375	23	41	46	18	5
477	35.0	35.0	35.0	.250	24	37	40	13	3
478	29.5	35.0	32.3	.310	0	38	37	38	-1
485	29.5	34.5	32.0	.450	0	21	44	21	23
487	32.5	32.0	32.3	.333	0	26	46	26	20
490	30.0	31.5	30.8	.277	18	22	44	4	22
489	34.5	29.5	32.0	.310	40	45	44	5	-1

Table 20 (Continued)

	TIP Measure				DIP Measure				
Subject Number	Form A	Form B	TIP Mean	TIP Slope	SRT	SRT +5dB	SRT +10dB	Slope 0-5	Slope 5-10
491	25.5	28.0	26.8	.311	0	34	37	34	3
488	22.5	22.0	22.3	.666	16	19	43	3	24
493	34.5	33.0	33.8	.333	0	40	47	40	7
494	32.5	32.5	32.5	.266	26	30	44	4	14
495	33.5	27.0	30.3	.583	37	32	45	-5	13
496	40.5	50.0	40.3	.667	28	34	45	6	9
497	42.5	34.5	38.5	.310	7	33	37	26	4
498	47.5	37.5	42.5	.225	22	36	38	14	2
499	43.5	43.5	43.5	.500	0	40	45	40	5
500	42.5	39.5	41.0	.500	0	41	43	41	2
501	42.5	42.5	42.5	.250	8	29	24	21	-5
502	37.5	37.0	37.3	.286	21	26	38	5	12
503	36.5	40.5	38.5	.310	30	28	38	-2	10
504	35.5	37.5	36.5	.268	8	29	40	21	11
335	25.5	28.5	27.0	.310	9	26	40	17	14
343	20.0	25.5	22.2	.209	0	26	43	26	17
347	20.0	25.0	22.5	.250	2	36	47	34	11
350	24.0	32.0	28.0	.236	20	45	46	25	1
353	46.5	44.5	45.5	.236	22	47	47	25	0
367	39.0	40.5	39.8	.310	20	33	41	13	8
378	20.0	23.5	21.8	.234	25	38	43	13	5
379	37.0	41.5	39.3	.250	14	24	36	10	12
380	27.5	28.5	28.0	.309	20	36	43	16	7
394	33.0	37.5	35.2	.310	9	33	42	4	9
310	29.5	30.5	30.0	.268	5	16	42	11	26
314	39.0	37.5	38.8	.343	20	28	42	8	14
457	33.3	36.5	35.0	.250	17	35	46	18	11
459	22.0	27.5	24.8	.292	8	33	40	25	7
438	30.5	33.5	32.0	.292	20	38	46	18	8
101	16.5	19.0	17.8	.366	28	35	45	7	10
102	22.5	28.0	25.3	.450	22	40	42	18	2
103	23.5	24.0	23.8	.236	26	35	44	9	9
104	27.5	24.0	25.8	.236	22	31	38	9	7
105	27.5	32.0	29.8	.250	39	44	43	5	-1
106	39.5	42.5	41.0	.750	26	38	42	12	4
107	35.0	39.0	37.0	.234	18	35	33	17	-2
108	40.5	35.0	32.8	.450	20	33	42	13	9
109	28.5	28.5	28.5	.666	4	33	35	29	2