An evaluation of non-verbal tests of intelligence for use with deaf children

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AN EVALUATION OF
NON-VERBAL TESTS OF INTELLIGENCE
FOR USE WITH DEAF CHILDREN

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ABSTRACT

The effects of prelingual deafness on language development, and its bearing on intelligence are described. The special problems in testing deaf children, and the need to ascertain the suitability of intelligence tests for use with the deaf are explained. Four non-verbal tests of intelligence were selected for evaluation, the Performance Sub-scale of the Wechsler Intelligence Scale for Children, Raven's Coloured Progressive Matrices, the Columbia Mental Maturity Scale and the Goodenough-Harris Drawing Test. Two criteria of educational progress and attainment were devised. The tests were administered to 125 children in a school for the deaf, aged five to twelve years. Tests of pure-tone hearing loss were also applied. Educational progress and attainment were recorded over a period of from four to eight years after the original testing. The test results were examined with regard to reliability, distribution, relationship with WISC (Perf.) (in the case of the three other tests), predictive validity and relationship with hearing loss. It was found that, within this group of deaf children, degree of hearing loss was unrelated to any of the tests. It was concluded that the WISC (Perf.) and the G-HDT were both suitable for use with deaf children over the age range five to twelve years, that the CPM was suitable for use with children aged nine to twelve years, and that the CMMS was not satisfactory for use with deaf children.

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THE PROBLEM

1.1 Purpose of the research

The educational development of deaf children is affected by various factors associated with the hearing handicap, in addition to those which have a general bearing on development in normal children. These special factors include causation of deafness, age of onset, type and degree of hearing loss, amount and quality of pre-school guidance and the age of entry to full-time educational training. To help in planning educational treatment it is important to have as thorough as possible assessment of the extent and nature of the handicap and the educational potential.

The ascertainment of deafness requires a team approach, involving the co-operation of the otologist, psychologist, teacher of the deaf and audiologist, with help frequently from a social worker, paediatrician, neurologist and psychiatrist. There are, however, two main components of the continuous assessment of the abilities and potential of deaf children in the educational setting. These are the audiological and the psychological aspects. Audiometry, having an essential central role in the measurement of the handicap, is now established and uses reliable techniques, but there is need for refinement of specialized psychometric measures. In this respect, the provision of information on the suitability of tests for use with deaf children will contribute to the development of complete and reliable assessment procedures.

The overall purpose of this research is to evaluate a number of tests of intelligence for use with deaf children. The aims are to examine the suitability of the tests for ease of administration, the reliability, and also the validity for predicting future educational progress. In view of the latter aim, this investigation centres on children in the age range five to twelve years when originally tested, to allow follow-up of progress in school over a number of years.

In the selection of tests for use with deaf children, it is clear that those which depend upon a verbal response on the part of the child are of limited value. It should not be assumed, however, that all 'non-verbal' tests are necessarily suitable. There is the possibility that some non-verbal tests involve a type of ability which is influenced by language in its growth.

The performance sub-scale of the Wechsler Performance Scale for Children (Wechsler, 1949) is frequently used with deaf children, and is suitable with regard to its administration and also the general comparability of the level of the results with the norms for hearing children. Some problems are encountered in using this test with deaf children. The very young children find difficulty in understanding the task in the Picture Completion sub-test. Physically handicapped or cerebral palsied children might have difficulties in speed tests or timed items involving motor-coordination. (There is, of course, a tendency for deafness in children to be accompanied by additional handicaps).

Although the WISC (Perf.) test is now widely used, there is limited information available on its reliability when used with deaf children, and virtually none concerning its value for predicting success in school work. There is an urgent need to investigate these aspects of the suitability of the WISC (Perf.) test. It would seem important, in addition, to evaluate other tests which might be potentially more appropriate for administration to deaf children in that they avoid the difficulties for the very young or physically handicapped deaf children. Such tests should be relatively short, intrinsically interesting tests which do not rely on speed or fine motor-coordination as an essential part of the response.

1.2 Problems to be investigated

The problems with which the research is concerned might be summarized by stating the main questions, in respect of each of the tests studied, that the investigation sets out to answer. These questions are

(1) How do the results obtained with deaf children compare with the norms for hearing children? This involves the comparison of distributions of results, in addition to means and standard deviations.

(2) What reliability do the tests have when used with deaf children?

(3) What predictive validity do the tests have for forecasting future educational progress?

A further important question is the extent to which degree of hearing loss might influence the test results.

In addition to the selection of potentially suitable intelligence tests to be evaluated, it will be necessary to devise criteria of educational progress with which to relate the test results in order to estimate predictive validity.

(The specific aims formulated for study are set out in the description of the method of the investigation, in Chapter 7).

1.3 Definitions of the terms used

In the study of children with defective hearing there is a problem of definition. The dictionary meaning of 'deaf' is 'wholly or partly without hearing', and as a generic term this can include the whole range of children with impaired hearing. However, different people might attach different values to the term, and the problem is confounded by the changes that have occurred in the accepted definitions and the differences between countries.

For the accurate description of deaf children, some precision is required in the terms used. Deafness might be defined in various aspects, in terms of aetiological background, anatomical type, physical dimensions, linguistic effect and educational need. The meanings of the terms used in this study are given in the definitions which follow.

Hereditary deafness. Inherited deafness, transmitted from one generation to another.

Congenital deafness. Deafness from birth.

Prelingual deafness. Deafness dating in onset from before the development of spoken language. (In general from before the age of three years).

<u>Adventitious deafness</u>. Deafness acquired, through disease or injury, after the natural development of speech and language.

<u>Low frequency hearing loss</u>. Hearing loss mainly in the lower frequencies of the speech range. (For speech reception the most important frequencies are 500 Hz. * to 2000 Hz. In this context the lower frequencies are those below 1000 Hz.).

<u>High frequency hearing loss</u>. Hearing loss mainly in the higher frequencies (above 1000 Hz.). The higher frequencies are important for the reception of the consonant speech sounds.

<u>Severe hearing loss</u>. Hearing loss (usually in the speech range) of about 75 db. upwards. (The decibel is a logarithmic unit of measurement of intensity. Hearing loss is measured in relation to the normal threshold of hearing which is found empirically and referred to as 0 db.). With this degree of hearing loss normal unamplified speech can not be heard.

<u>Profound hearing loss</u>. Hearing loss of 95 db. and above. With this degree of hearing loss little, if any, of speech can be identified, even with powerful amplification.

<u>Conductive deafness</u>. Deafness due to dysfunction of the outer ear or the middle ear (usually 'partial' or 'moderate' hearing loss up to 60 db.).

* Since the United Kingdom Government adopted the metric system, frequencies have been described in Hz. (Herz). The term c.p.s. (cycles per second) has therefore been changed to Hz. throughout this study.

Sensori-neural (or Perceptive or Nerve) deafness. Deafness due to pathology in the inner ear or along the pathway to the brain stem (characteristically producing irreversible severe or profound high frequency hearing loss).

There are two educational categories of children with impaired hearing, 'deaf' and 'partially hearing'. Educational classification takes into account the effect, rather than the degree, of hearing loss. The official definitions currently in use (Department of Education and Science, 1962) are

> 'deaf pupils, that is to say, pupils with impaired hearing who require education by methods suitable for pupils with little or no naturally acquired speech or language;
>
> partially hearing pupils, that is to say, pupils with impaired hearing whose development of speech and language, even if retarded, is following a normal pattern, and who require for their education special arrangements or facilities, though not necessarily all the educational methods used for deaf pupils'.

Impaired hearing. This term is frequently used to describe any degree of hearing loss. The term 'children with impaired hearing' is used to include both deaf and partially hearing children.

As far as is possible, the terms used in this investigation describe deafness and deaf children within the meanings given above. However, in referring to other research, particularly earlier investigations carried out in the United States, differences might exist in the meanings of the terms used. For instance, the definition of the 'deaf' in use in the United States from 1937 included children who would be separated into the two categories 'deaf' and 'partially hearing' under the current definitions in this country (Burnes, 1958). Later, a more comprehensive American definition for 'deaf' children corresponded more closely with that now in use here (Meyerson, 1955). More recently, however, the American Academy of Ophthalmology and Otolaryngology (1960) defined 'deafness' as severe or complete impairment of hearing to be used only if the hearing loss for speech is greater than about 80 db. This definition corresponds more closely to 'severe hearing loss' as used in this investigation.

It is important to be aware of these differences when interpreting the results of previous researches with deaf children.

1.4 Scope of the investigation

The investigation was carried out with children in a school for the deaf. This was a non-maintained residential school taking children from local education authorities from a 'regional' catchment area. The school, one of the largest of its type in the country, had approximately 200 pupils on roll at the time the investigation began. Of these, approximately 40 per cent were daily pupils and 60 per cent residential pupils (most of whom were weekly boarders). All children in the school are classified as educationally 'deaf'. They are, predominantly, children with severe or profound hearing losses - dating from birth or before the acquisition of natural language. A proportion of the children have additional handicaps.

The age range is 2 years to 16 or 17 years. The school was organised into four teaching departments, Nursery, Infant, Junior and Secondary. This research was concerned with children who were in the Infant or Junior Departments, in the age range five to twelve years, at the time of commencement of the investigation.

Tests of intelligence and hearing loss were administered to 125 children in the age range, and records were kept of educational progress and attainment over a period of up to eight years. Thus, although the main examination of suitability and immediate reliability was based upon the initial testing, the evaluation of predictive validity was extended into a medium term longitudinal study.

1.5 The population affected by the problem

The extent of the population affected by the problem studied in this investigation might be determined, with regard to the position in England and Wales, with reasonable accuracy from the figures relating to the incidence of deaf children. The Department of Education and Science publishes yearly figures of children in special schools. In January 1967 (the first school year of the investigation) there were 6,402 pupils receiving full-time educational treatment on account of impaired hearing (Department of Education and Science, 1968).

More than half of the pupils in this total were classified as partially hearing, and it should not be assumed that the results of this study will have valid application for these children.

The number of children classified as educationally deaf was 2,923. This represents a rate of 4 deaf pupils per 10,000 of the total school population of England and Wales. A small number of the schools for the deaf are selective secondary schools, but there are also a number of schools for educationally sub-normal deaf children, so that, on the whole, the investigation sample might be regarded as representative of the population of pupils in the schools for the deaf in England and Wales. Of the total number of deaf pupils, it might be estimated that approximately two-thirds are in the age range five to twelve years.

It would be reasonable to assume that (in the educational system of England and Wales) the results of this investigation will affect a population of approximately 2,000 deaf children of primary school age.

Chapter 2

BACKGROUND OF INFORMATION ON DEAFNESS IN CHILDREN

2.1 The handicap of deafness

The basic physical problem of deafness is, of course, the lack of hearing, but in educational terms this is by no means the whole extent of the handicap, as deafness has far reaching effects on development.

Severe prelingual hearing loss of a sensori-neural type prevents hearing and understanding of speech, particularly the high frequency consonant sounds, and this results in lack of natural acquisition of speech by hearing and imitating the speech of others. The absence of normal receptive and expressive communication impairs the development of language and linguistic skills. There might be retardation of those intellectual abilities which are related to language development. Inadequacy of linguistic communication can interfere with emotional adjustment and social development. The combination of those problems present considerable obstacles to educational progress.

The handicap (or handicaps) of deafness might, therefore, be summarized in terms of the adverse consequential effects that prelingual hearing loss has on the communicative, linguistic, cognitive, personal and social, and educational aspects of development.

2.2 The problem of communication

As the problem of communication is central to the development and training of deaf children, a vital aspect of the educational treatment is the provision of auditory techniques to aid residual hearing, and training in the use of visual and manual media of linguistic communication.

With the use of modern amplifying equipment, almost all children with impaired hearing can be enabled to respond to sound, particularly in the lower frequencies of the speech range. Wide use is made of appropriate hearing aids which provide some hearing for speech which can help in the child's own speech development and also assist lipreading.

<u>Individual hearing aids</u> are compact and allow mobility, but have limitations for classroom use. Apart from the narrow range of frequencies amplified, due partly to the restrictions imposed by the insert receiver, the effects of reverberation of sound in a classroom interferes with the understanding of speech when listening at any distance from the teacher.

<u>The group hearing aid</u> provides amplification of higher intensity over a wider frequency range than the individual aid. As the child wears headphones wired to the amplifier the effects of reverberation are minimised. Modern group aids have the facility to adjust both the amount of amplification and the frequency response to meet the needs of the individual.

For the very young children, who need mobility, the <u>inductance loop system</u> is particularly useful, as this combines the freedom of the individual aid with the partial benefits of the group aid. With this system, the child uses the individual hearing aid, but, with the accoustic microphone switched off, a special inductance coil receives the signals from a magnetic field which is created within an area looped by a wire connected to the amplifier output.

Lipreading (or speechreading) is, for children with severe or profound hearing loss, the prime means of receiving speech, but unfortunately it is far less accurate than normal auditory reception of speech. There is not a one-to-one association between the auditory phonemes of speech and the corresponding 'visual units'. Some speech sounds are virtually invisible as they are articulated at the back of the mouth, whilst some are similar or identical to other phonemes in the same visually homophenous group.

Fortunately, the auditory and visual patterns of speech are to some extent complementary, so that the combination of aided listening with lipreading usually provides better reception of speech than either media on its own (Prall, 1957; Hutton, 1959; Hudgins, 1960; Evans, 1960; Reeves, 1961).

There are two main modes of manual communication, signing and fingerspelling.

In signing, gestures do the usual work of spoken words, and the term 'chereme' is used to describe the units corresponding to the phonemes of spoken language (Stokoe, 1960, p.30). The American Sign Language, which is widely used by deaf people in the United States, is the main systematic sign language. It does not, however, follow the grammatical structure of the English language. It is a wholly different language from English, with its own grammar and syntax. There are also a number of systems of 'signed English', in which signs are put together by the rules of English language syntax.

Fingerspelling is a visual-manual medium using hand positions and configurations which have one-to-one equivalence with the alphabetic symbols of written English. In this country two-handed fingerspelling has been used in the past, but the deaf people of North America use a one-handed form.

In the education of deaf children, fingerspelling has usually been introduced to children who have already developed the use of language within the limits of their individual abilities. Having learnt to read, they then use fingerspelling as a means of rapid communication within the structure of their developed language. There is now growing interest in the possibility that fingerspelling might be used, as a visual substitute for hearing, for the reception of language by young deaf children, before they have learnt to read. The important distinction can therefore be made between fingerspelling (in the traditional sense of 'spelling' the letters of written language) as a linguistic communication code, and fingerspelling (in terms of a 'chirographical' visual-manual system) as a language acquisition medium.

The various media of communication might, of course, be used in combination. The term 'method' is usually used to describe the medium or combination of media used for communication and teaching, and the term 'system' is used to describe the method or combination of methods in use in a particular school.

In the <u>oral method</u>, the aim is to communicate exclusively by speech and lipreading, with the use of amplifying equipment to aid residual hearing.

In the <u>combined methods</u>, fingerspelling or signing (or both) are used in conjunction with speech and lipreading. In the Rochester method, grammatical fingerspelling is used to reinforce speech and lipreading. This method was first advocated by Dr. Zenas F. Westervelt at the Rochester School for the Deaf, New York State, in 1878 (Scouten, 1942). More recently, the term Visible English has been applied to this method to emphasise that it always uses completely grammatical English. The simultaneous method uses a combination of speech, lipreading, signing and fingerspelling. This method has been used for over a century at Gallaudet College, Washington D.C., the college for deaf students (Atwood, 1964).

Recently, a method of communication has been devised (Cornett, 1967) in which hand configurations are used in conjunction with lip patterns in such a way that the combinations have one-to-one correspondence with auditory phonemes. This method, called 'cued speech', is similar to the older 'mouth-hand' method used with the Danish language (Forchhammer, 1903).

In a survey of current practices in schools in North America (Evans, 1969), all these methods were observed in use. Some schools use exclusively oral methods, whilst others use the Rochester method throughout. There are schools which have combined systems, in which the oral method is used for younger children, followed by a combined method with older children. The term 'total communication' is now used in the United States to describe a philosophy which prescribes the use of any forms of communication available to meet the individual needs of children (Denton, 1969).

There has been virtually no systematic use of visual-manual methods of communication in schools in this country in the past, but following the recommendation of the Report on Education of the Deaf (Department of Education and Science, 1968), that research should be carried out to determine whether or not manual methods might help in the development of deaf children, experimental work has been planned.

2.3 Special considerations in testing deaf children

The complexities of the problem of communication serve to emphasise the difficulties in working with deaf children and indicate the need to have relevant experience and skills as a prerequisite to test administration. The child might respond in the test situation using the means of communication that comes naturally at the time. This could be by signing or fingerspelling. The tester therefore needs to be competent in these modes of communication, as well as experienced in listening to the speech of deaf children.

Ewing (1957) has stressed the need to have special knowledge, training and experience in establishing rapport with deaf children in order to test their abilities. The tester should encourage speed, where necessary, by the example of his own brisk manner. He must ensure that the child is correctly positioned for lipreading and for the efficient use of any hearing aid equipment.

In carrying out audiometric tests, it is also important to ensure that the child does not receive any visual clues that the signal key is being depressed, either by seeing movement direct or reflected in windows.

2.4 Factors influencing the intelligence level of children in a school for the deaf

Many of the researches carried out with deaf children have been restricted to relatively small samples of subjects, usually the pupils in an age range in a school for the deaf. Caution must be exercised in making conclusions with regard to the total population of deaf children on the basis of results of tests carried out in a particular school, as conditions might vary from school to school, from one period of time to another, and in the educational systems of different countries. It is likely that in most non-selective schools for the deaf in England and Wales at the present time the mean intelligence level will be slightly below normal (in tests which validly measure the general ability of deaf children). The three main factors which account for this are described below.

(1) The effects of brain injury.

Some children have deafness resulting from diseases which can cause brain injury. The brain injury might also have some effect on mental development.

Kernicterus (jaundice) in babies, which is associated with haemolytic disease that results from blood-group incompatibility, can cause injury to the brain. Rh incompatibility may be one cause of congenital hearing impairment of the sensori-neural type (Newby, 1959), but, strictly speaking, sensori-neural hearing losses occur because of damage to the inner ear or the VIIIth nerve to the brain stem, and interference with the pathways from the brain stem to and including the cerebral cortex produces a central auditory disorder. Such injury interferes with the ability to perceive or interpret sound at the cortical level (Goodhill, 1956). Kernicterus may cause cerebral palsy (usually athetosis), auditory disorder, and also mental deficiency (Newby, 1959).

Maternal rubella, if contracted by the mother during the early part of pregnancy, can produce in the child deafness which might be accompanied by such additional handicaps as defective vision, cardiac disorders or mental impairment.

At the time that many of the early researches into the intelligence of deaf children were being carried out, meningitis was a major cause of deafness. Murphy (1952) in a study of the intelligence of 300 deaf children, found that those children who were known to have had meningitis had a mean IQ that was significantly lower than the mean for the whole sample.

These three causes account for a substantial proportion of cases of deafness in children. Fraser (1963) made a study of 2,355 deaf children in this country. The cause of deafness was known for 1,509 cases and of these over a third were due to maternal rubella, haemolytic disease or meningitis. Vernon (1968) carried out a survey of 1,468 cases in America and found that 40 per cent of the children had deafness resulting from these same three conditions or prematurity. Vernon concluded that

> 'four of the five leading causes of deafness are also major aetiological factors in brain damage. In the neurophysiological residua of these four conditions can probably be found the explanation for many of the learning, behavioural and secondary handicaps'.

It is reasonable to assume that some children with deafness resulting from brain injury will have some mental impairment, and therefore a 'reduced' level of intelligence.

(2) <u>Placement of borderline partially hearing children.</u>

In the educational placement of children with impaired hearing, the type and degree of hearing loss is a main consideration, but other factors are taken into account, particularly the capacity to acquire speech and language.

Children in schools for the deaf tend to have severe or profound hearing losses, and children in partially hearing units tend to have moderate hearing losses, but there are exceptions. In the case of 'borderline' children, the more intelligent they are the more likely they are to be able to cope in a partially hearing unit, whereas those with low ability are more likely to require placement in a school for the deaf. The presence of these dull borderline children in schools for the deaf adds to the proportion of children with low intelligence.

(3) <u>Transfer of deaf children with good attainment</u>

Some deaf children make such good progress in schools for the deaf that their attainments in speech and language enable them to be transferred to partially hearing units. These children tend to be above average intellectually. This transfer results in a slight reduction in the number of children with high intelligence in the school for the deaf.

Taking these factors into account, it would be reasonable to expect that when an intelligence test, that validly measures the general ability of the total population of deaf children, is applied to children in a school for the deaf, the mean test result will be below normal and there will be a cluster of low IQs. This effect on the level and distribution of intelligence of children in a school for the deaf is a vital consideration in the interpretation of the findings in the research review that follows and the results of the present investigation.

Chapter 3

A REVIEW OF RELEVANT RESEARCH INTO THE INTELLIGENCE OF DEAF CHILDREN

For more than half a century psychologists have been interested in measuring the intelligence of deaf children. The aim of the early research was to compare the general level of intelligence of deaf and hearing children, in order to discover whether deaf children are retarded in their mental development. The various investigations carried out in different countries produced apparently conflicting results which gave rise to a controversy as to the intellectual status of deaf children.

The early quantitative comparison of the general mental levels of deaf and hearing children gave way to interest in qualitative differences between types of mental ability in deaf children, leading to the study of the restrictions imposed by pre-lingual deafness on the development of language and abstract reasoning ability.

More recently some studies have been made of the relationship between intelligence in deaf children and their linguistic skills and educational progress.

This review of research relevant to the present investigation examines the comparative study of the intelligence of deaf and hearing children, the suitability of non-verbal performance tests for use with deaf children, the effect of deafness on verbal mental ability and abstract reasoning, the relationship between degree of hearing loss and intelligence and the influence of intelligence on communication and educational development. The aim is to present a picture of the position at the time the present investigation commenced, but where it is pertinent to do so reference is made to a small number of later studies.

3.1 <u>The general level of intelligence of deaf children and the comparison with hearing children</u>.

Following the pioneering work of Binet and Simon (1905) in mental testing to discriminate between normal and mentally defective children, the American psychologist Professor Rudolph Pintner of Teachers College, Columbia University became interested in the possibility of applying mental tests to deaf children in order to compare their intelligence with hearing children. In his first important investigations with deaf children (Pintner and Paterson, 1918; Pintner and Reamer, 1920) the mental test scores obtained were inferior to the scores for hearing children. Pintner suggested that deaf children were on average at least two years retarded in mental development.

Pintner was quick to recognise, however, that his tests were of a highly linguistic nature, and that this might account for the inferiority of deaf children who were severely handicapped in their language development. He constructed a non-verbal scale of performance tests for use with the deaf (Pintner and Paterson, 1923). This scale was included by Pintner in a large scale national survey carried out in association with Professor Herbert Day and Professor Irving Fusfeld of Gallaudet College, Washington D.C. (a college for deaf students). Testing was carried out in 41 schools for the deaf in the United States, and a total of 4,432 subjects were involved. The average level of the results for the large sample of deaf children was again lower than the level for hearing children (Day, Fusfeld and Pintner, 1928).

Pintner had set out to make allowance for the linguistic handicap in deaf children by using a non-language test. He concluded, therefore, that deaf children are below normal in intelligence, and suggested that diseases which cause deafness might also cause mental retardation.

Two Dutch researchers, Zeckel and Van der Kolk (1939), designed an investigation that took account of the possibility that some cases of deafness might be caused by diseases which injure the brain and might in addition produce some effect on mental development. They restricted their research sample to deaf children with known aetiology of hereditary deafness, among whom the chance of brain injury would be no higher than in the sample of hearing children with whom they were compared. The Porteus Maze Test was applied to the experimental group of 100 hereditary deaf children aged between seven and fourteen years and a similarly aged control group of 100 hearing children. They found a mean test quotient of 86 for the deaf group, compared with a mean test quotient of 99 for the hearing children.

Due to the careful control of the aetiology of the sample, the inferiority of these deaf children could not be explained in terms of the effects of brain injury. Zeckel and Van der Kolk suggested that the discrepancy in the level of intelligence compared with hearing children was the result of the adverse effect of lack of hearing and speech on mental development.

In contrast to these findings of inferiority of deaf children, studies carried out in Britain produced results to suggest that deaf children attain intelligence test results within normal limits.

Drever and Collins (1928) tested deaf children between the ages of five and sixteen years with their performance scale which was considered to be specially suitable for use with the deaf. They found that the level of scoring was not below the level for hearing children.

Ewing and Stanton (1943) later carried out an investigation which confirmed the findings of Drever and Collins. They used the Alexander Performance Scale with 150 deaf children, and obtained a mean IQ of 96.

Hood (1949) also obtained a similar result using the same test. For his sample of 400 deaf children aged between eight and twelve years he found a mean performance IQ of 99.

A study of the mental development of very young deaf children was carried out by Kendall (1953). Using the non-verbal items of the Merrill-Palmer Scale and the Atkins Object-Fitting Test, Kendall compared a group of deaf children between the ages of eighteen months and sixty-five months with a group of hearing children matched for age. No significant difference was found between the general levels of performance of the two groups, and Kendall concluded that deaf children of pre-school age are not handicapped in solving simple sensori-motor problems.

Up to the time of the Drever and Collins (1928) investigation in Britain, only the early study by Newlee (1919) had contrary findings to the American Surveys. The claim by Drever and Collins that the performance type of test is more suitable for use with deaf children, as opposed to the paper and pencil non-language type, set off a chain of American investigations using performance tests.

Studies by Peterson and Williams (1930), Heider (1940), Heider and Heider (1940), Myklebust and Burchard (1945), Templin (1950), Birch and Birch (1956) and Myklebust (1958) have tended to indicate that the deaf are within normal intellectual limits when measured by performance scales.

Lane (1948), in reviewing research into the intelligence of deaf children, summarized and explained findings of the earlier work, up to about 1930, in the following statement (p.93)

> 'psychologists who were pioneering in measuring the intelligence of the deaf reported a mental retardation of the deaf of from two to three years. The assumption was made that deafness and mental retardation were due to the same causes. Observations of the behaviour of the deaf did not support this conclusion as a valid one. Careful examination of the tests indicated that the tests used were non-verbal in instructions; that experiences not possible for the deaf were included as test items; and that in many schools children were enrolled whose greatest affliction was mental retardation and not deafness. With better selection of tests and some elimination of the extremely low mental cases, the trend of recent test results has been toward a normal distribution of test scores'.

Lane summarized the results of twenty-two studies with intelligence tests carried out from 1930 to 1947 and concluded that these suggested that there is less than one year retardation or no retardation in deaf children compared with hearing children.

Alathena Smith (1960) brought the survey of the comparative study of the intelligence of deaf and hearing children more up to date, and substantiated the relationship between the nature of the tests used and the findings of normality or retardation in deaf children.

The apparently conflicting results of the various investigations certainly indicate the need, when making conclusions about the intelligence of deaf children, to take account of the type of tests used.

3.2 The use of performance tests of intelligence with deaf children

By the 1950's the search for suitable means of measuring the general intelligence of deaf children became centred on individual performance tests requiring minimal use of language for administration by the tester or response by the subject. Three investigations carried out from the University of Manchester provided information on the value of the Wechsler performance tests for use with deaf children in the British Isles.

Gaskill (1952) selected the performance sub-tests of the Wechsler-Bellevue Intelligence Scale and applied these to 465 children in schools for the deaf aged between ten and fifteen years. The mean performance IQ for this sample was 97, with standard deviation 21·7 points.

K.P. Murphy (1956) used the same test in a study of twelve-year pupils in schools for the deaf in England, Wales and Eire. The mean IQ for his large sample of 513 children was 100, with standard deviation 16·0 points.

L.J. Murphy (1952) was interested in the testing of younger children, and used the Performance Sub-Scale of the Wechsler Intelligence Scale for children. He selected thirteen schools as being representative of schools for the deaf in England and Wales, and tested all pupils in the age range six to ten years. The sample of 300 children represented 17 per cent of the population of all schools for the deaf, within the age range. The mean IQ obtained was 99, with standard deviation 15·9 points. Murphy concluded that the results for deaf children were not significantly different from the norms for hearing children (i.e. the American standardization based upon a mean IQ of 100 and standard deviation 15·0 - Wechsler, 1949).

Two American studies carried out with the WISC (Performance) test also found deaf students to be within normal limits (Goetzinger and Rousey, 1957; Brill, 1962).

3.3 The effect of prelingual deafness on verbal ability and abstract reasoning

In the studies which indicated the suitability of the Wechsler tests for use with deaf children, only the Performance parts of the total scale were involved. The Verbal scale is not considered to be appropriate for measuring the general intelligence of deaf children, not only because of the problem of administration of a verbal test but also the effect of language retardation on the score. However, there is value in using both performance and verbal scales in order to study the discrepancy between the two types of ability. A number of investigations have been carried out along these lines, all of which found substantial difference between mean performance and verbal IQ.

Myklebust (1953) applied the Performance and Verbal items of the Wechsler-Bellvue Scale to a group of 85 deaf children in the age range twelve to seventeen years. Their mean performance IQ was 102, but their mean verbal IQ was only 67.

Glowatsky (1953) found a comparable discrepancy between Performance and Verbal IQs. The means obtained with a sample of deaf children were 97 in the Performance Sub-Scale and 67 in the Verbal Sub-Scale.

Bates (1956) administered Wechsler performance and verbal scales to 89 pupils in a selective secondary school for the deaf. These children had been selected for entry to the school on the results of highly competitive examination of educational attainment at the age of twelve years. They were drawn from schools for the deaf throughout the country, and represented a highly selective population with, presumably, superior intelligence. Their mean performance IQ was 121. In comparison, their mean verbal IQ was only 99. Bates examined the results in relation to degree of hearing loss, and found that the discrepancy between performance and verbal IQs was greater for the severely deaf cases than it was for the partially hearing children (who had some degree of naturally acquired speech and language).

Simpson-Smith (1962) made a study with partially hearing children. For a sample of 104 subjects he found a mean performance IQ of 96,but a mean verbal IQ of 77.

Hine (1969) also tested children in a school for the partially hearing. In his study the mean Performance IQ for 100 children aged eight to sixteen years was not significantly different from the standardization norm (Wechsler, 1949). The verbal IQ, however, was depressed by 21 points.

De Marco (1970), also studying children in the eight to sixteen years range, found a similar difference of 19 points between Wechsler Performance IQ and Verbal IQ.

Differences such as these between results in the performance and verbal scales provide some measure of the effect of congenital or early deafness on the development of language and verbal ability. The findings support the earlier work of Gaskill (1952), who compared the results of the Wechsler Performance Scale and the Otis Beta Mental Ability Scale, as a basis for studying the linguistic handicapped imposed by deafness.

The inferiority of deaf children in tests of verbal ability is understandable. However, some of the investigations in which deaf children were found to be below normal in intelligence used non-verbal tests. This calls for closer examination.

Mackane (1933) had examined the apparently conflicting findings of Pintner and his associates in the United States and Drever and Collins in Britain. He concluded that the two sets of non-verbal tests were measuring different mental abilities.

L.J. Murphy (1957), in discussing theoretical considerations in the selection of intelligence tests for the deaf, emphasized that

> 'since language is developed in highly varying degrees in different deaf individuals (depending on a host of conditions), an impartial test of general intelligence for the deaf should not measure verbal ability; that is, the test should be non-verbal in nature as well as in administration'. (p.214)

This is a most important point. There has been a tendency for intelligence tests to be considered suitable for use with deaf children on the basis of minimal verbal administration, without careful reference to the possibility that successful performance is related to verbal processes. Raven's Progressive Matrices (1938, 1947) is an example. It has been reported that this test has been widely regarded as an appropriate non-verbal test of particular usefulness with deaf children (Burke, 1958; Buros, 1965), but psychologists working with deaf children have found through investigation that this test repeatedly shows the majority of deaf children to be well below the average for the normal population.

In contrast to the findings which have indicated the normality of deaf children when tested by the Wechsler Performance Scales (Gaskill, 1952; L.J. Murphy, 1952; K.P. Murphy, 1956; Bates, 1956; Goetzinger and Rousey, 1957;

Brill, 1962; Simpson-Smith, 1962) deaf children have been found to be substantially retarded when measured by the Progressive Matrices in studies in Britain (Ewing and Stanton, 1943; Gaskill, 1952; Denmark, 1952) and in France (Oléron, 1950). These studies produced positively skewed distributions of results with excessive numbers of below normal scores. According to the norms for the Progressive Matrices (Raven, 1938, 1947), 25 per cent of normal (hearing)children score below normal (i.e. equivalent IQs below 90). The studies of deaf children have shown proportions of below normal scores ranging from 43 per cent to 63 per cent.

Ewing and Stanton (1943) offered, as a possible explanation for the inferiority of deaf children in the Progressive Matrices test, that mental manipulation of percepts is facilitated by verbalization, and further suggested that facility in symbolic thought is the basis of verbalization.

L.J. Murphy (1957), however, makes the suggestion that it is verbalization that is the basis of symbolic thought. He considered that the verbal factor is essential in higher thought processes, and that the development of language is a necessary condition for the development of abstract reasoning (p.215).

Oléron (1950)explained the inferior performance of deaf children in the Progressive Matrices in terms of the abstract nature of the ability measured by the test. He suggested that the tests in which deaf children did well measured 'concrete' ability that is largely restricted to the handling of the immediately perceived stimulus; whereas the tests in which deaf children performed poorly involved a more 'abstract' type of ability which assumes deduction from the observable aspects of the stimulus.

Myklebust (1960 a) examined a range of tests used with deaf children, with reference to whether they were more dependent upon the perceptual level of behaviour or entailed a more abstract level of behaviour demanding deductions and generalizations. He classified the tests along a continuum according to the level of performance of deaf subjects compared with normal, from those tests in which the deaf were not significantly different from normal to those in which the deaf showed increasing inferiority. When the tests were analyzed according to their concrete-abstract nature, Myklebust observed that the test results related closely to the concrete-abstract continuum, with the inferior performance occurring mainly on the tests requiring abstraction. The test in which the deaf did best was Block Design, and the test in which they scored lowest was the Progressive Matrices.

The Progressive Matrices test (Raven, 1938) was designed to measure Spearman's (1904) general factor of intellectual ability, and requires the

'eduction of relations among abstract items'.

Spearman (1939, 1946; Spearman and Jones, 1950) considered the Progressive Matrices to be a good non-verbal test of the general factor, 'g', as did Vernon and Parry (1949). Work by Vernon (1947 a, 1947 b, 1947 c, 1950), Adcock (1948) and Burt (1954) produced evidence on the Progressive Matrices in relation to 'g'. Burke(1958), after reviewing the literature, concluded that the evidence was not convincing as to the validity of the Progressive Matrices as a pure measure of Spearman's construct of the general factor of intellectual ability.

Deaf children have been shown repeatedly to be inferior in the Progressive Matrices test and psychologists experienced in working with deaf children have explained this in terms of linguistic retardation having an adverse effect on the development of abstract ability. However, the assumption of a discrepancy between the concrete and abstract abilities of deaf children has been based upon the indirect evidence of results of the Wechsler Performance tests and results of the Progressive Matrices obtained by different investigators who applied the tests quite independently to different samples of deaf children at varying periods in time and in the educational systems of different countries. None of the studies reported made a direct comparison of the two tests with the same sample. The possibility could not, therefore, be excluded that some difference might be due to factors within the samples (for instance, samples might vary in the proportion of children with deafness associated with brain injury which could influence intelligence). Ewing and Stanton (1943), in reporting the low level of scoring in the Progressive Matrices test, were aware of the possibility that their sample of deaf children might have contained a larger proportion of mentally sub-normal than in the standardization sample of hearing children.

In order to ensure a direct comparison, in which any obtained discrepancy between test scores could be attributed only to the tests themselves, it is necessary to administer the two tests to the same sample of deaf children by the same tester. Such a direct comparative study of the WISC (Performance) Scale and the Progressive Matrices was carried out by the writer, working from the University of Liverpool (Evans, 1966). Both tests were applied to a sample of 100 children in the age range six to fifteen years in a school for the deaf.

The results showed a substantial discrepancy between the two tests. The WISC (Perf.) mean IQ was 99, with standard deviation 14·3 points. The distribution of IQs was evenly balanced, with 25 per cent of cases above normal (i.e. IQ above 110) and 27 per cent below normal (i.e. IQ below 90). In marked contrast, the Progressive Matrices results were skewed in the positive direction, with only 8 per cent of cases scoring above normal (i.e. equivalent to above 110) but 52 per cent of cases scoring below normal (i.e. equivalent to IQ below 90). There was a low correlation of $r = \cdot 35$ ($p < \cdot 01$) between the two sets of results.

On the basis of the results of this direct comparative study the writer concluded that deaf children are severely retarded in the Progressive Matrices, in contrast to normal ability as measured by the WISC (Perf.), and that this is related to the restrictions imposed by deafness on language as a medium for the development of abstract reasoning.

A re-examination of Oléron's (1950) results provides supporting evidence that deaf children are retarded in abstract reasoning ability because this requires language for its growth. Oléron reported separate Progressive Matrices results for those children in his sample with congenital deafness and those children who had acquired hearing loss after the age of five years. The adventitiously deaf children, with some natural language development, were less retarded in the test than the pre-lingually deaf children (irrespective of degree of hearing loss).

Zorska and Smolenska (1969) also reported a relationship between age of onset of hearing loss and mental development. They found that a group of children with average Leiter Scale Performance IQs showed difficulties in analyzing and synthesizing. The greatest difficulty was experienced by the subjects who had acquired deafness early in life.

Getz (1953), after examining work in the field of concrete and abstract thinking in deaf children, considered that there was some difference of opinions as to whether or not the deaf think 'less abstractly' and 'more concretely'. More recent views generally recognize deficiency in abstract ability in deaf children.

Lewis (1965) considers that language immaturity adversely effects the capacity for 'inner symbolization' (p.58). He emphasizes the importance of communication in development towards abstract thinking, and suggests that the deaf child might be restricted in 'linguistic, pre-linguistic and non-linguistic experiences, as well as his linguistic communication (Lewis, 1966, p.121).

Furth (1964 a, p.144), however, has claimed, on the basis of his experiments, that cognitive development takes place at a normal rate even if spoken language is absent in the environment. He maintains that

> 'language does not influence intellectual development in any direct, general or decisive way'(Furth, 1964 b, p.160).

A number of workers have produced evidence of the special difficulty experienced by deaf children in classification problems. Oléron (1952, 1957) found that the inferiority of young deaf children in some of Piaget's problems became more marked as the problems involved more classification and relationships beyond those which could be directly perceived. Vincent (1957) had similar findings with regard to deaf children's retardation in problems of multiple classification. Blair (1957) provided evidence that the non-verbal items in which deaf children were inferior to hearing children were those that involved classifying and sorting.

However, Darbyshire and Reeves (1969), in their comparison of deaf and hearing children in Piaget type tests, concluded that the deaf children were not inferior when the tests were modified to eliminate or simplify verbal communication. Rosenstein compared deaf and hearing children in their ability to abstract and generalize, and found that the deaf children were not significantly inferior in the tasks involving language within their capacity. (1962)

Lewis (1966) makes the distinction between abstract thinking which takes place by non-verbal symbols and abstract thinking without symbolization. He maintains that there is no simple opposition between concrete and abstract thinking, but that these represent extremes of a continuum, with some modes of thinking being more concrete and some more abstract. Myklebust (1960, p.88) also pointed out that deafness does not have a uniform influence on all abstract processes.

To return to the inferiority of deaf children in the Progressive Matrices, Lewis considered that both deaf children and hearing children have to use language in solving the more difficult problems in this test, and states that there is evidence for this (Lewis, 1968, p.58). MacFarlane Smith (1964) reported that factorial analysis shows a considerable 'verbal loading' in the Progressive Matrices (Smith, 1964, p.82).

The writer found a significent retardation in the Progressive Matrices scores of deaf children in a direct comparison with WISC (Perf.) IQ, and suggested that

> 'linguistic deprivation due to deafness impedes the development of abstract reasoning'(Evans, 1966, p.81)

Raven, commenting on the writer's findings, confirmed that they agreed with Raven's own information on the test when used with deaf children, but suggested the further possibility that

> 'linguistic deprivation due to deafness accelerates the development of form manipulation'. (Raven, 1966)

The combination of these two statements leads to the interesting hypothesis that restricted language of deaf children retards the development of abstract reasoning but actually promotes opportunity for the development of some more concrete abilities. The analysis of WISC (Perf.) Sub-test scatter throws light on this possibility. The sub-tests vary in the type of problems they present, and there is evidence that deaf children are inferior in the kind of task involved in some of these sub-tests. Pintner and Paterson (1916), Getz (1953), L.J. Murphy (1957) and Myklebust (1960) reported difficulties in digit-symbol problems. Bindon (1957) and Myklebust (1960 b) found deaf children to be inferior to hearing children in their effectiveness in arranging pictures to tell a story. These are the type of problems set in the Coding and Picture Arrangement sub-tests of the WISC (Perf.).

The evidence seems to be conclusive that deaf children in general have a mean Wechsler (Perf.) IQ that is not significantly different from the norm for hearing children (Gaskill, 1952; L.J. Murphy, 1952; K.P. Murphy, 1956; Goetzinger and Rousey, 1957; Brill, 1962; Simpson-Smith, 1962; Evans, 1966; Hine, 1969). It follows, therefore, that if deaf children are inferior in certain of the sub-tests in comparison with the norm, they must be superior in one or more other sub-tests. Two investigations presented information on WISC (Perf.) Sub-test scores in sufficient detail to allow a re-examination in the light of the hypothesis that there is a balance of above-normal and below-normal sub-test scores.

In the two investigations (L.J. Murphy, 1952; Evans, 1966) the mean Performance IQs for the deaf children tested were not significantly different from the norm of 100 as defined in Wechsler's (1949) standardization. In both cases, however, the mean scores of both the Block Design and Picture

TABLE 3.1

Comparison of WISC (Performance) IQs and sub-test scores for two studies with deaf children, L.J. Murphy (1952) and Evans (1966)

	L.J. Murphy (1952) N = 300	Evans (1966) N = 100	Norm (Wechsler, 1949)
Sub-test score *			
Block Design	108.0	106.7	100
Picture Completion	104.7	106.2	100
Object Assembly	101.8	99.4	100
Picture Arrangement	95.4	88.6	100
Coding	96.2	82.5	100
Performance IQ:			
Mean	98.8	99.0	100
S.D.	15.9	14.3	15.0

* Sub-test scores converted to equivalent IQs.

Completion sub-tests (when converted to equivalent IQs) were significantly higher than the total performance IQs, whereas the mean scores of both the Coding and Picture Arrangement sub-tests were significantly lower than the total performance IQs. The full sub-test profiles are compared in Table 3.1.

Myklebust (1960) and Luszki (1965) also pointed out this pattern of sub-test scoring. Pickles (1966) obtained similar results in a study of slow-learning deaf children, and also found that the scores in the Picture Arrangement sub-test correlated closely with the measures of language development.

3.4 Relationship between hearing loss and intelligence

The retardation of deaf children in verbal tests has been well established, as has the relationship between age of onset of deafness and the development of abstract ability. The research has not, however, established any relationship between degree of hearing loss and general intelligence as measured by suitable performance tests. Those investigations which included a study of degree of hearing loss in relation to performance test results found no significant correlations.

Glowatsky (1953) used the WISC (Perf.) test and the Arthur Point Scale, and found no relationship with hearing loss.

L.J. Murphy (1957) and De Marco (1969) concluded that degree of hearing loss has no influence on WISC (Perf.) IQ. This is consistent with Kendall's (1957) findings with very young deaf children when tested with the Merrill-Palmer Scale. Zorska and Smolenska (1969) reported lack of significant correlation between pure-tone hearing loss and results in the Leiter International Scale. Gaskill (1957) had obtained similar findings, except that pupils in schools for the deaf with only moderate hearing losses tended to be below average in general intelligence. This, however, was attributed to selective influences on enrolment, such as 'border-line' partially hearing children who had experienced educational failure in ordinary schools being transferred to schools for the deaf.

3.5 Relationship between intelligence in deaf children and communication and educational progress

The retardation in the language development and general educational progress of deaf children is, of course, a consequential effect of restricted communication. Level of educational attainment might, therefore, be expected to be related to ability in the communication skills available to deaf children. It would seem to be appropriate to both these aspects in examining research into the influence of intelligence on development. Considering the value of being able to predict success or failure in communication skills and progress in school work, very little research has been done into the predictive validity of intelligence tests, and even this has not been conclusive.

Many severely deaf children are able to hear and understand something of speech through suitable auditory equipment, but intelligence does not seem to play any significant part in the capacity to understand amplified speech. The writer found a correlation of $r = \cdot 01$ ($p > \cdot 05$) between WISC (Perf.) IQ and speech audiometric results (Evans, 1960).

Deaf children are substantially deprived of the normal means of understanding spoken language. For them visual perception plays a special role in speech reception. Lipreading involves the recognition of lip movements, but the visual reception of speech falls far short of auditory reception, as the auditory phonemes can not all be perceived as corresponding visually discriminative units. There is not a one-to-one association between speech sounds and 'speech shapes' (Woodward and Barber, 1960). The recognition of other visual aspects of speech is involved, and gaps in the lip movements have to be filled on the basis of other information, including, most importantly, response to contextual language cues. Deaf children, as individuals, differ widely in their lipreading ability.

Intelligence might be expected to be related to lipreading, both through the indirect influence on language development, and also in terms of the capacity to use contextual cues. Apart from one substantial correlation in the literature (O'Neill, 1951), the investigations have reported lack of relationship (Pintner, 1929; Reed, 1947; Cavander, 1949; O'Neill and Davidson, 1965; Simmons, 1959; Evans, 1960; Quigley, 1969). A close examination of the tests used reveals that they were comprised largely or completely of words or even more analytical speech units, involving only basic perception of speech units.

The writer constructed filmed tests of lipreading designed to use a wider range of language material and involving the response to contextual linguistic cues (Evans, 1964 b). When applied to 64 deaf children, a correlation of $r = \cdot 38$ ($p < \cdot 01$) was found between WISC (Perf.) IQ and lipreading results.

In order to discover whether abstract reasoning ability might have a greater influence on lipreading, the Progressive Matrices test was also applied. The resultant correlation of $r_{pbi} = \cdot 27$ ($p < \cdot 05$) proved to be lower than the correlation between general performance IQ and lipreading. This result was consistent with the correlations between lipreading and digit symbol scores obtained by O'Neill (1951) and Simmons (1959).

The research into fingerspelling tends to support the view that this is a more complete and accurate media of communicating the English language than lipreading. (Johnson, 1948; Morkovin, 1960; Quigley and Frisina, 1961; Hester, 1963; Meadows, 1967). The most extensive investigation was carried out by Quigley (1969). He concluded that his findings seemed to indicate

> 'that the use of fingerspelling in combination with speech can lead to improvements in the achievement of deaf children in those variables in which meaningful language is involved'. (p.93)

Quigley found that Wechsler Performance IQ had a correlation of $r = \cdot 35$ with fingerspelling ability.

The work in the area of intelligence and educational progress is both extremely limited and inconclusive. Bates (1956) reported that WISC (Perf.) results were not closely correlated with academic achievement in pupils in a selective secondary school for the deaf. As this was in fact a sample of children with superior intelligence within a narrow range, it did not provide a valid basis for such a study.

K.P. Murphy (1957) reported moderate correlations between WISC (Perf.) IQ and attainment in mechanical arithmetic and reading.

In a study to determine the influence that emotional factors versus intellectual status exerts upon educational achievement of deaf children, Caicedo (1967) discovered that academic progress correlated more closely with personality than it did with intelligence.

What little study has been made serves to emphasize that profound deafness is such a barrier to communication that many factors other than intelligence play a part in the development of deaf children.

3.6 Implications of the research for the present investigation

The research reviewed shows that intelligence tests used with deaf children fall into two categories on the basis of non-verbal or verbal content, but within the non-verbal group there are some tests in which deaf children are inferior. Deaf children score poorly in tests of abstract ability, but do well in performance tests of concrete ability. The conclusion to be drawn is that restricted language development due to deafness retards certain 'linguistically-derived' aspects of intelligence, but does not effect, or even promotes, other 'non-linguistically-derived' abilities.

The implications for the present investigation, which sets out to evaluate intelligence tests, are that even if non-verbal tests might show deaf children to score below normal, these tests might still be reliable and valid measures of the ability involved, and as such might have important value for predicting educational progress, particularly those aspects of development which interact with language for their growth.

Although a range of intelligence tests have been used in the research, the emphasis has been on establishing the level of performance of deaf children in comparison with hearing children. Apart from one report on the WISC (Perf.) (L.J. Murphy, 1952), there is very limited information on the reliability of the tests when used with deaf children. There is also an absence of information on the validity of the tests for predicting academic progress. This is a most inadequate basis for using the tests in educational guidance. This indicates the need for considerable weight to be given, in this investigation, to the provision of information on the reliability and predictive validity of the tests evaluated.

Chapter 4

THE INTELLIGENCE TESTS SELECTED FOR EVALUATION

The purpose of the research was to assess the value of a number of tests of intelligence, including the WISC (Perf.), for use with deaf children of primary school age. The WISC (Perf.) has been used widely with deaf children, but there is little evidence as to its reliability and virtually no information on its validity for predicting educational progress in deaf children. Practical experience of using the test with the deaf suggests that the younger children, particularly those with additional physical handicaps, have some difficulties with the items which are scored on speed or involve a degree of motor co-ordination for successful response. It was important that the additional tests selected for evaluation should not repeat these difficulties, and to this extent it was a general requirement that they should not duplicate the type of material and format of the WISC (Perf.).

Apart from tests, such as the Leiter International Scale (1940), which might be considered to be suitable for use with children with language difficulties, a number of individual tests of intelligence have developed with deaf children in mind or specially designed and standardized for use with deaf children.

The Alexander Performance Scale (Alexander, 1946) is a non-verbal response test which has been used with deaf children, but the items involve scoring on speed and motor co-ordination.

The Drever Collins Scale (Drever and Collins, 1946) was standardized on deaf children, but almost all the items are of the 'form board or construction' type which sample only a narrow range of abilities. This test, in common with others such as the Arthur Point Scale of Performance Tests (Arthur, 1930), the Arthur Performance Scale Form II (Arthur, 1947) and the Cornell-Coxe Performance Ability Scale (Cornell and Coxe, 1934) is based largely upon items from the Pintner-Paterson Performance Scale (Pintner and Paterson, 1917), the ancestor of performance scales designed specially for the deaf. The materials used in some of these items would now be considered to be out-dated.

The Nebraska Test of Learning Aptitude (Hiskey, 1941) was standardized on deaf children from four to ten years of age (Hiskey, 1955). This is, however, a time-consuming and rather monotonous scale of eleven sub-tests.

The Snijders-Oomen Non-Verbal Intelligence Scale was standardized in Holland with separate norms for deaf children and hearing children (Snijders-Oomen, 1959). There are eight sub-tests in this scale. The limited information on its use with deaf children in this country suggests that it might be less satisfactory than the WISC (Perf.) (Gaskill, 1966; Reeves, 1966).

All of these performance type tests duplicate, to an extent, the materials and format of the WISC (Perf.).

4.1 Criteria of suitability of tests

In selecting tests for study, in addition to the WISC (Perf.), the following criteria of suitability of test material and administration were considered:

(i) The test task and material should be intrinsically interesting, to attract and maintain the child's attention.

(ii) It should be possible for the child to understand the nature of the task with minimal verbal instruction.

(iii) Only a non-verbal type of response should be required.

(iv) Motor co-ordination should not form an essential element in the response.

(v) The test should not be timed or scored on speed.

(vi) The total test time should be short, preferably not longer than 15 to 20 minutes duration.

(vii) The test should be suitable for use with children over the age range five to twelve years, preferably with the norms directly covering the age range.

Three tests which satisfied these criteria, but which still need to be evaluated to discover their general suitability, reliability and validity when used with deaf children in this country, were selected for the study. The four tests included in the investigation were:

Wechsler Intelligence Scale for Children (Performance Sub-scale)
Raven's Coloured Progressive Matrices
Columbia Mental Maturity Scale
Goodenough-Harris Drawing Test

Descriptions of these tests follow.

4.2 Wechsler Intelligence Scale for Children (Performance)

The WISC is an individual test of intelligence which was developed as a downward extension of the Wechsler-Bellevue Intelligence Scales which had been used with adults and older children (Wechsler, 1941). The WISC items are, in the main, easier versions of the type used in the original test. The full Scale is composed of two sub-scales, one verbal and the other performance, each consisting of six separate sub-tests. The test is so constructed that direct comparison can be made between Verbal and Performance IQs.

The Scale was standardized in the United States with a great amount of care over a five-year period (Wechsler, 1949). The standardization sample consisted of 100 boys and 100 girls at each age level from five to fifteen years, providing a total of 2,200 cases. The distribution of subjects in the sample conformed, as far as was possible, to the census for the United States as a whole in terms of geographical area, urban-rural population and parental occupation.

The raw scores for each of the sub-tests are converted to standard scores which are 'normalized' for the particular age groups. The sub-test scores are expressed in terms of a distribution with a mean of 10 and standard deviation 3 points. The sum of the scaled scores is converted into a deviation IQ. Three separate measures of intelligence can be obtained, the Verbal IQ, the Performance IQ and the Full Scale IQ. In the original American standardization an IQ of 100 was set to equal the mean total scaled score for each age level, and the standard deviation was set to equal 15 points (Wechsler, 1949, p.4).

When the WISC is used with deaf children to obtain an estimate of general ability, only the Performance Scale would normally be used. The Performance Scale was used in this investigation. The five sub-tests of the sub-scale are:

1. Picture completion
2. Picture Arrangement
3. Block Design
4. Object Assembly
5. Coding

(In addition, a sixth sub-test, Mazes, is available for use as an alternative or supplementary sub-test if required).

There is already a basis of information on the use of the WISC (Perf.) with deaf children in this country, at least with regard to the general level of ability measured in comparison with the standardized norms. L.J. Murphy (1952) carried out a 're-standardization' of the test with a sample of 300 deaf children representing 17 per cent of all six to ten year old children in schools for the deaf in England and Wales. On the basis of his findings of a mean of 98 with standard deviation 15·9 points, Murphy concluded that this representative sample did not differ significantly in respect of WISC (Perf.) Intelligence from ordinary children (ordinary children being defined by Murphy as (a) the Wechsler standardization sample and (b) the Australian standardization sample).

Since then the Performance Scale has been used fairly widely by psychologists testing deaf children, although there has been little information on the reliability of the test when applied to deaf children. The writer (Evans, 1966) carried out a study of the reliability of the WISC (Perf.), in which 100 deaf children over the age range six to fifteen years were tested. The subjects were all pupils in one school for the deaf. Three years later the test was again administered, to all those children who remained (i.e. who had not left school or transferred to other schools). The results of this study are given in Tables 4.1 and 4.2.

TABLE 4.1

Internal consistency reliability coefficients of WISC (Perf.) results obtained for two age groups of deaf children

(From Evans, 1966, p.78)

Age range	6-10	11-15
N	45	55
Range of IQs	71-129	68-122
Mean IQ	100.4	97.3
SD	14.3	14.1
Split-half Correlation r_{tt}*	.98	.89
SE_m	2.0	4.7

* based upon four sub-tests (coding omitted).

TABLE 4.2

Retest reliability of WISC (Perf.) results over a three-year period for a group of deaf children

(from Evans, 1966, p.80)

Age range (at 1st testing)		6-13
N		42
1st test:	Mean IQ	97·1
	SD	12·8
Retest (after 3 yrs.)	Mean IQ	98·4
	SD	12·1
Test-retest correlation	r	·98
Significance level	p	·01

Table 4.1 shows that for both the younger and the older age groups there was high internal consistency, and Table 4.2 indicates a high level of correlation between original testing and re-testing after three years. These results offer some evidence of the reliability of the WISC (Perf.) with deaf children, but there is need for further study. There is also a lack of evidence as to the validity of the test for predicting future progress in school work. The provision of information on both these aspects of the suitability of the WISC (Perf.) is included in the aims of the present investigation.

4.3 Raven's Coloured Progressive Matrices

A number of studies have found that deaf children are inferior in the Standard Progressive Matrices compared with the norms for hearing children (Ewing and Stanton, 1943; Oléron, 1950; Gaskill, 1952; Denmark, 1953; Evans, 1966). On this evidence the test should not be considered to be a measure of general ability in deaf children, comparable to the WISC (Perf.), although, of course, this does not necessarily mean that the test has no value as a measure of some aspect of mental development and for predicting future progress.

Whereas the evidence on the Standard Progressive Matrices is now quite substantial, there is much less information on the suitability of the Coloured Progressive Matrices with deaf children. Gaskill used this test on 289 deaf children and obtained a more normal dispersion of scores than those reported for the Standard Progressive Matrices. He converted the scores to equivalent IQs and found the mean to be 98, with standard deviation 20·8. He concluded tentatively (Gaskill, 1957, p.193) that

'when used as an individual test with deaf children the Coloured Progressive Matrices results were satisfactory'.

Gaskill's finding has not been fully followed up, but, to the extent that the two tests do not involve identical stages of mental development, it is possible that the Coloured Progressive Matrices results for deaf children will be closer to normal. Raven (1960, p.1) states that the Coloured Progressive Matrices is designed to assess the level of intellectual development before the capacity to reason by analogy has matured, whereas the Standard Progressive Matrices is more suitable to test the efficiency for clear thinking after the capacity to reason by analogy has developed.

The Coloured Progressive Matrices (Sets A, Ab, B) was selected as one of the tests for evaluation in this investigation. Raven (1960, p.1) claims that this test can be administered satisfactorily to subjects who are deaf, physically disabled, cerebrally palsied or intellectually subnormal. It does not necessarily follow, however, that the results obtained with disordered subjects will be comparable with normal.

The book form of the test consists of three sets of twelve problems, printed in colour to attract the interest of younger children. For each problem the subject chooses a figure, from a selection of six, to complete the design. The order of items provides training in the method of working, the initial problems in each set being so easy as to be self-evident. The published norms cover the age range five and a half years to eleven years. As the age range to be covered in this investigation is five to twelve years, it is necessary in a few cases to convert raw scores into grades by extrapolating from the tables of norms.

4.4 Columbia Mental Maturity Scale

The Columbia Mental Maturity Scale was selected because both the materials and the test response seem particularly suitable for deaf children, and in general it satisfies the criteria set for this investigation. This test was developed in an effort to provide a satisfactory means for estimating the mental ability of children with cerebral palsy or other handicaps involving motor or verbal functioning (Burgemeister, Blum and Lorge, 1954). The prime criterion for the material for the test was that it should require no verbal or motor response. The test can be used satisfactorily with children whose response is limited to pointing or gesturing (British Psychological Society, undated mimeographed report).

The test is based upon a pictorial classification type of task. It consists of 100 items, each printed on a large card. The subject selects from a series of drawings the one that is different from, or unrelated to, the other drawings. The level of difficulty of discrimination ranges from the perception of gross differences of colour or form to the recognition of relations in two pairs of pictures so as to exclude a fifth picture. The items are arranged in order of progressive difficulty. Many of the drawings are in colour.

The subject is asked to point to the picture which 'does not belong'. No verbal response is necessary. For severely physically handicapped children the examiner may point to each picture in turn, whilst the child gives a nod of the head or some similar indication. There is no time limit for the test, which is usually completed within fifteen minutes. The raw score of correct responses is converted to mental age in the table of norms and from this a mental age IQ may be computed.

The test in its original form was administered to cerebrally palsied children in order to ensure that they could cope adequately with the material (Burgemeister, Blum and Lorge, 1954, p.10). The standardization of the final form of the test was carried out with a sample of nearly a thousand American children in the age range three to twelve years. The internal consistency reliability for the standardization sample was ·9, and correlation of ·8 was found with Standford-Binet IQ.

4.5 Goodenough-Harris Drawing Test

Although there had been considerable interest in the relationship between the drawings of children and their mental growth for many years previously, it was Goodenough's successful demonstration of the intellectual process in the development of children's drawings of a man which laid the foundation for the use of drawings as a measure of intelligence (Goodenough, 1926).

The Goodenough Draw-a-Man Test introduced a method of intellectual assessment which was unusual in its conception and simplicity. The subject is asked to make a drawing of a man. The drawings are scored on a points system, account being taken of the child's accuracy of observation and conceptual development, rather than artistic skill. Scoring takes into account the basic structure of the drawing and inclusion of body parts, proportions, clothing details, and other features. Credit is given for each scorable item correctly included in the drawing. The raw score can be converted into mental age from the table of norms.

The technique has been used extensively, and in the United States the Draw-a-Man Test gained considerable popularity as a non-verbal clinical test (Sundberg, 1961). There is a wealth of information on the test. Findings have varied, but Harris, on the basis of his comprehensive survey of the investigations using the original Goodenough Draw-a-Man Test (Harris, 1963, pp.20-36) concluded that the objectivity and reliability of the analytical scoring method, and satisfactory validity correlation with other tests, have been established. Good validity findings were reported when the test was used with mentally retarded children (Birch, 1949).

At the outset, Goodenough (1926) recognized the possible application of the technique for assessing children limited by linguistic barriers or lacking language. Its potential for use with deaf children was soon realised. Over the years a number of studies have been carried out in schools for the deaf in the United States, which provide information on the Goodenough Draw-a-Man Test for use with deaf children.

In two of the earliest studies deaf children were found to be inferior in the test compared with the norms for hearing children. Peterson and Williams (1930) reported a Goodenough IQ of 80 for 330 subjects between the ages of five and fourteen years in five schools for the deaf in Pennsylvania and West Virginia. Shirley and Goodenough (1932) tested 229 children in Minnesota schools for the deaf and found a mean Goodenough IQ of 84.

Later studies have placed deaf children closer to normal when tested with the Draw-a-Man technique. Springer (1938) compared 330 deaf children and 330 hearing children in the age range six to twelve years. The mean Goodenough IQ for the deaf children was 96, a few points lower than the mean of 102 for the hearing children.

Myklebust and Brutten (1953) obtained very similar results. They compared 55 children in a school for the deaf in Illinois with a control group of 55 hearing subjects. The mean Goodenough IQ for the deaf group was 97, and for the hearing group 103. The mean Performance IQ for the deaf group (measured with either the Arthur Scale or the Nebraska Test of Learning Aptitude) was 104.

Myklebust and Brutten could find no report in the literature on the reliability of the Goodenough Draw-a-Man Test with deaf children, so they made a small scale study with sixteen of their subjects who had been tested by the school psychologist within two years of their own administration. They found no significant difference between the two mean IQs, and obtained a satisfactory level of test-retest reliability.

Glowatsky (1953) made a comparative study of three tests with a group of children at a school for the deaf in New Mexico. The mean Goodenough IQ for twenty-four subjects was 98, compared with a mean WISC (Perf.) IQ of 97 and a mean Arthur Scale IQ of 100.

Feidler (1954), working at a school for the deaf in Massachusetts, reported favourably on the value of the

Goodenough Draw-a-Man Test for estimating learning capacity.

The latest study (Lavos, 1967) reports deaf children to have an exactly normal distribution of results. The mean Goodenough IQ for 67 twelve year old children in a school for the deaf in Michigan was 100 with standard deviation 15 points, which is exactly the normal distribution for tests, such as the WISC (Wechsler, 1949), standardised on a deviation IQ basis.

In comparing these findings, which show something of a progression towards 'normality' in the more recent studies, it is well to take account of the factors and changes in the educational system which might influence the level of abilities of children in schools for the deaf. The early findings of inferiority of deaf children were at a period when there were comparatively large numbers of 'post-meningitic' children and slow-learning borderline hard-of-hearing/deaf children placed in the large residential schools for the deaf. In the recent study by Lavos the children in the school population with major additional handicaps were eliminated from the sample, so that the finding of a normal distribution should not be regarded as typical of all deaf children in a school for the deaf.

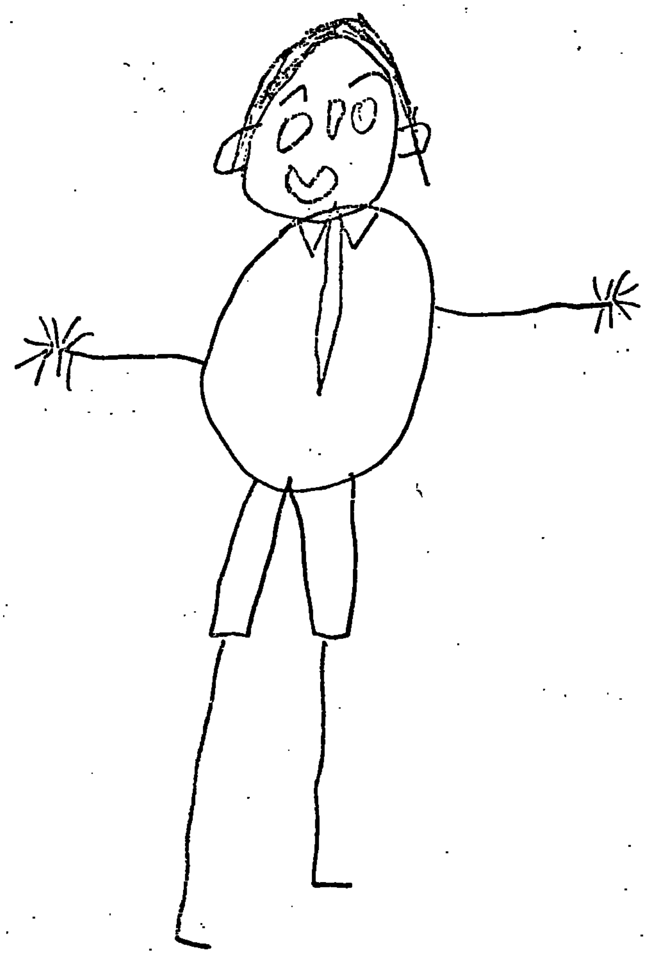
All of these studies were carried out in schools in the United States. In the present investigation of the suitability of tests for use with British deaf children, the drawing technique is included, but not the original Goodenough scoring. A revised scoring method is now available, and this was selected for use.

The Goodenough Draw-a-Man Test had been in use for almost forty years before a major revision and extension was published (Harris, 1963). The Goodenough-Harris Drawing Test was based upon a decade of research and preparation. The 'Man Scale' contains additional scoring features, and the number of items is raised to 73. Harris also developed a scoring system of 71 items for an alternative 'Woman Scale'. The test booklet also has space for a 'Self' drawing, but there is no separate scoring system for this.

Harris adopted for his test the 'standard score' method of measuring performance based on a mean of 100 and a standard deviation value of 15 points, in line with Wechsler's 'deviation IQ' precedent. The standard test booklet provides space for the drawings and also item numbers for recording. The child is given the instruction 'make a picture of a man (or a woman), make the very best picture you can'. Scoring is based upon the number of scorable items correctly included in the drawing according to the criteria set out in the test manual.

Examples of Drawings of a Man and the Goodenough-Harris scoring system are provided in Figures 4.1, 4.2 and 4.3. The drawings are by boys aged five, seven and nine years of normal ability for their age as measured by the test, in that their respective item totals convert to standard scores close to 100. For the sake of illustration, lists of shortened descriptions of the items scored are included (the actual specifications of the items being set out in greater detail in the Manual).

FIGURE 4.1



Drawing A

LIST OF ITEMS SCORED IN DRAWING A

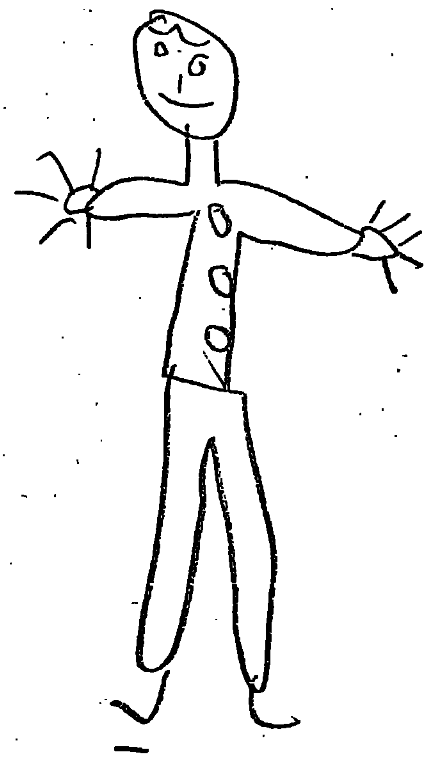
1	head present
4	neck present
9	nose present
10	nose in two dimensions
11	mouth present
18	hair, any indication
22	ears, any indication
24	fingers present
30	arms present
35	legs present
36	hips, crotch indicated
39	feet, any indication
44	arms and legs attached to trunk
46	trunk present
47	trunk in two dimensions, in proportion
48	head in approximate proportion
55	representation of clothing

Drawing of a man by a boy aged 5 yrs. 10m.

Total score = 17 points

Standard score = 104

FIGURE 4.2



Drawing B

LIST OF ITEMS SCORED IN DRAWING B

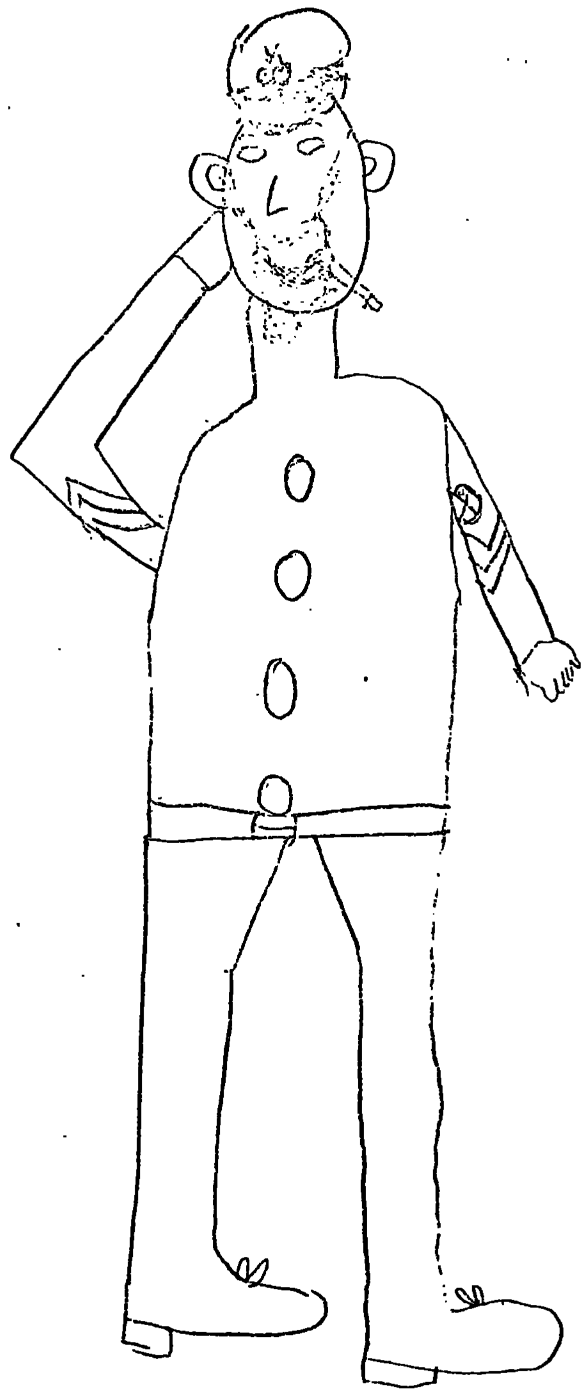
1	head present
2	neck present
4	eyes present
9	nose present
11	mouth present
18	hair, any indication
24	fingers present
25	fingers, correct number
28	hands present
30	arms present
35	legs present
36	hip
39	feet, any indication
44	arms and legs attached to trunk
45	arms and legs attached at correct points
46	trunk present
47	trunk, proportion
48	head, proportion
53	legs, proportion
54	arms and legs both in two dimensions
55	clothing indicated
63	lines firmly drawn

Drawing of a man by a boy aged 7 yrs. 1m.

Total score = 22 points

Standard score = 99

FIGURE 4.3



Drawing C

LIST OF ITEMS SCORED IN DRAWING C

1	head present	35	legs present
2	neck present	39	feet present
3	neck, two dimensions	41	heel present
4	eyes present	43	detail to shoe
5	eyes, brow	44	arms and legs attached to trunk
7	eyes, proportion		
9	nose present	46	trunk present
10	nose, two dimensions	47	trunk, proportion
11	mouth present	48	head, proportion
22	ears present	49	head, fine proportion
23	ears, proportion	50	legs, proportion
24	fingers present	54	arms and legs both two dimensions
25	fingers, correct number		
26	fingers, detail correct	55	clothing represented
28	hands present	58	four articles of clothing
30	arms present		
31	shoulders	64	lines meet at junctures
33	arms, activity		
34	elbow joint		

Drawing of a Man by boy aged 9 yrs. 9m.

Total score = 34 points

Standard score = 105

The revised Goodenough-Harris Drawing Test was standardized on 2,975 children, a sample claimed by Harris (1963, p.100) to be representative of the parental occupational and geographical distribution of the United States. Separate norms are available for scoring the Drawing of a Man and the Drawing of a Woman for boys and girls. Harris (1963, p.106) reports a correlation of ·75 between the two scales. There are no separate norms for the Self drawing, which is offered as a tentative measure only (based upon the Man or Woman Scale as appropriate), with no empirical relationships having been worked out. The Self figure may, however, be of value in individual case study.

Harris does not claim that the Drawing Test yields a measure identical to the IQ derived from an individual performance test, but considers that it involves concepts which grow with intellectual experience and maturity. Although Harris reports quite substantial correlations with individual performance tests, he suggests that normally the Drawing Test should be used with and in support of, rather than in place of, a performance test. This concept of a 'supporting' test, which might be used to complement the WISC (Perf.) when this can be administered, is consistent with the aims of the present research. The Goodenough-Harris system for scoring the Drawing of a Man was selected for evaluation.

4.6 Pilot Trial of the Goodenough-Harris Drawing Test

When individual performance tests are used, the skill of the examiner lies in the objective administration of the test, and recording of the responses, whilst the actual scoring and calculation of the result is something of a clerical process. In the case of the Drawing Technique, however, the situation is to some extent reversed. The actual administration is, essentially, a very simple matter. The expertise of the tester lies in the fine judgement of the detailed items of the scoring system. The reliability of the test depends very much upon the scoring ability of the tester. Harris (1963, p.90) found that there was a satisfactorily high level of agreement between the scoring results of different examiners with adequate training.

The writer had previous experience of using the original Goodenough Draw-a-Man scoring system, but the revised Goodenough-Harris Drawing Test is considerably more extensive and detailed. It was essential, therefore, to have preliminary practice in the scoring technique prior to applying it to the subjects in the investigation. The test manual (Harris, 1963) sets out very detailed descriptions of the criteria for crediting each of the items, with more than 300 guide illustrations for the finer points. A total of 66 practice drawings (35 Man and 31 Woman) are included, and by working progressively through these it is possible to ascertain how closely the scoring compares with the 'accepted' scoring as laid down in the Manual. Further practice was gained by scoring drawings done by children in the age range to be tested in the investigation.

The final step in the preliminary practice stage was a small pilot study carried out with a group of deaf children with the aim of providing information on the reliability of the writer's scoring technique. The test (Man Scale) was applied to the twelve pupils in the leaving class (who would not therefore be included in the sample). They were all aged fifteen years. The WISC (Perf.) was also administered, and the Drawing Test was repeated after an interval of one week.

The two halves of the test (odd and even items) were correlated, using Spearman's rank difference formula for this small sample

$$r_s = \frac{1 - 6\Sigma D^2}{N(N^2 - 1)}$$

The split-half coefficient was corrected for full length by the Spearman-Brown formula

$$r_{tt} = \frac{2r_{hh}}{1 + r_{hh}}$$

The Spearman formula was also used to correlate the test with the retest results and with the WISC (Perf.) results. The significance levels of the rank-difference correlation coefficients were obtained direct from the appropriate tables of significance, as recommended by Guilford (1956, p.288) and Garrett (1958, p.200) for small samples. The results of the pilot trial are presented in Tables 4.3 and 4.4. (The individual test scores are listed as an Appendix).

TABLE 4.3

Internal consistency and retest reliability of Goodenough-Harris Drawing Test results obtained in the pilot trial with deaf children.

Age		15
N		12
1st Test: Mean		101·2
Split-half correlation	r_{tt}	·81
significance level	p	< ·01
Retest: Mean (after 1 week)		100·8
Test-retest correlation	r_s	·88
significance level	p	< ·01

TABLE 4.4

Relationship between Goodenough-Harris Drawing Test and WISC (Perf.) results obtained in the pilot trial with deaf children

Age		15
N		12
G-HDT	Mean	101·2
WISC (Perf.)	Mean	98·4
Correlation coefficient	r	·62
Significance level	p	<·05

The split-half correlation reaches a satisfactory level of internal consistency reliability, and the test-retest correlation is a further indication of reliability. There is also a close relationship with the WISC (Perf.) results, which might be interpreted as a tentative indication of validity.

The results of this small pilot trial tend to suggest that the writer's scoring technique was satisfactory. The writer had also had previous experience in the use of the scoring system for the original Goodenough Draw-a-Man test. This was considered to be a sufficient basis for proceeding with the Goodenough-Harris Drawing Test in the main investigation.

Chapter 5

THE MEASURE OF HEARING LOSS

The measure of hearing loss selected as the criterion for the investigation is based on an average of pure-tone thresholds. The method of averaging is explained. The choice of the frequencies involved is made on the basis of importance for hearing for speech sounds. A detailed explanation is given of the parameters of hearing for speech and the relationship between pure-tone hearing loss and hearing loss for speech, as a rationale for the use of the selected measure of hearing loss.

5.1 Procedure for obtaining pure-tone audiograms

Thresholds of hearing for pure-tones were obtained using a Peters Model BD Audiometer. This instrument measures up to a maximum intensity of 115 decibels above the normal threshold of hearing for pure tones and frequencies in the range important for hearing speech (i.e. 500 - 2000 Hz.).

The instrument was checked for calibration by the Technical Department of the Royal National Institute for the Deaf, both immediately before the commencement of the testing programme and on completion. British Standard for audiometers (BS 2920; 1958) allows variations within the following limits:

Frequency:	a variation of ± 3 per cent
Intensity:	an overall deviation of ± 5 decibels
Harmonic Distortion:	harmonics not less than 30 decibels below the fundamental frequency

The instrument was found to be correctly calibrated in accordance with the above mentioned specifications (and also with regard to attenuator steps and rise and decay time of tones) on both occasions.

The testing was carried out in a suitably treated room having acoustic tiles fitted to walls, ceiling and door to provide a satisfactory level of sound absorption.

All the subjects had previous experience of having their hearing tested, and only a minimal amount of audiometric 'conditioning' was required for the youngest children. The basic procedure is as follows:-

The child is seated comfortably in such a position that the manipulation of the controls by the tester cannot be seen and no movement observed. The headsets are placed on the child.

From the most recent audiogram a preliminary estimate of hearing loss is made, as a guide for selecting an intensity level calculated to be higher than the expected threshold and the most suitable ear with which to start.

Starting at a frequency of 1000 Hz. a tone at the selected intensity is used. The child responds to tones heard by raising the hand, pressing a button to activate a light, or placing a block in a box, according to age and interest.

When the child responds, the intensity is reduced in 10 decibel steps until there is failure to respond.

The intensity is then raised in 5 decibel steps until there is a response.

The intensity is then reduced in 10 decibel steps until there is failure to respond.

The intensity is again raised in 5 decibel steps until there is correct response.

This procedure is maintained until a reliable response has been established on 3 occasions out of four at a particular intensity, always on the rising scale.

The lowest level at which this response is obtained is accepted as the threshold at that frequency.

The procedure is then repeated at other frequencies in the order 500 Hz., 250 Hz., 2000 Hz. and 4000 Hz.

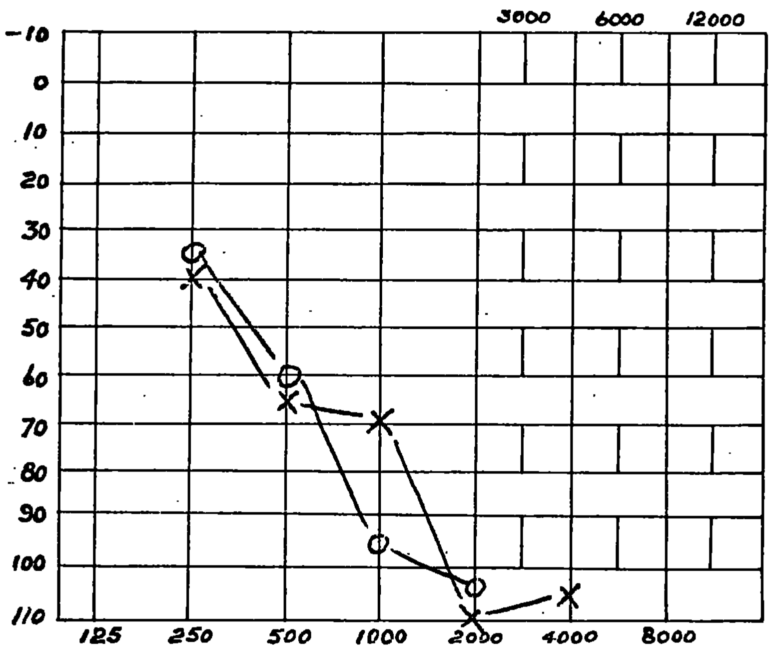
The other ear is then tested, either immediately or after a suitable break in the testing, according to the age of the child and the reliability of the response.

The threshold readings for the various frequencies are plotted on the Audiogram chart.

5.2 Method of computing average hearing loss.

The audiogram provides an accurate and comprehensive graphic representation of hearing loss for pure-tones. For statistical purposes, however, when it is required to correlate hearing loss with other variables, the information of the audiogram is too complex. In order to facilitate statistical procedures, the threshold readings for the

FIG. 5.1



DETAILS OF MASKING

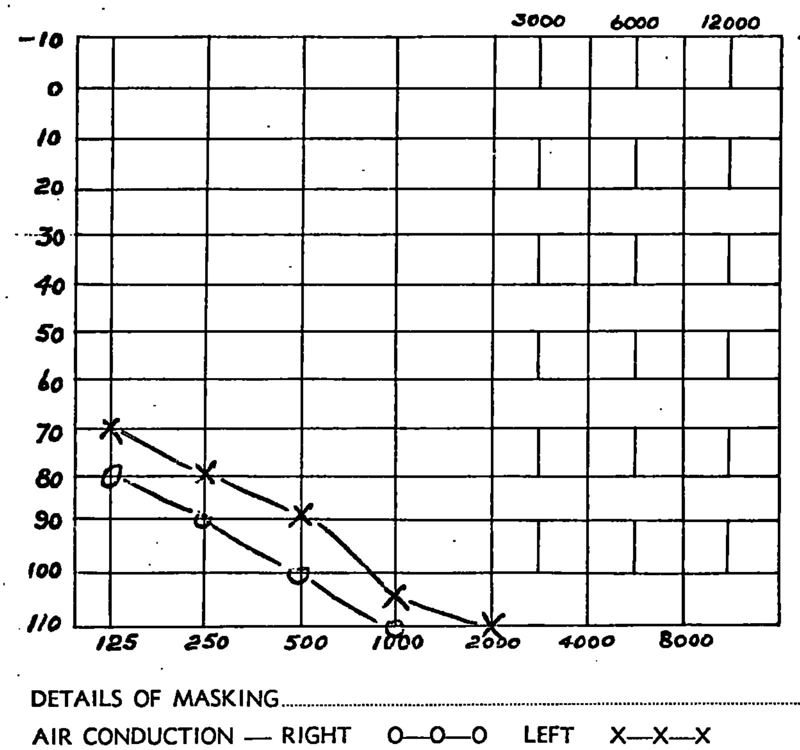
AIR CONDUCTION — RIGHT O—O—O LEFT X—X—X

AUDIOGRAM A (for Subject 104)

		LE	RE
Threshold:	500 Hz	65	60
	1000 Hz	70	95
	2000 Hz	110	105
Average		82	87

Average Hearing Loss = 82 db. (for LE)

FIG. 5.2



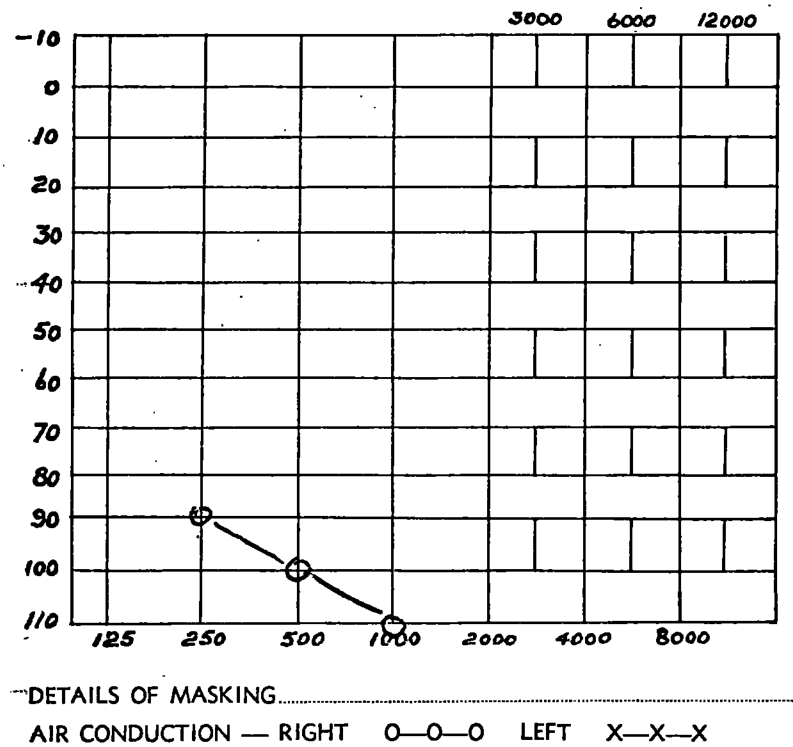
AUDIOGRAM B (for Subject 118)

		LE	RE
Threshold	500 Hz	90	100
	1000 Hz	105	110
	2000 Hz	110	120*
Average		102	110

Average Hearing Loss = 102 db. (for LE)

* Estimated threshold - no response up to 115 db. at this frequency.

FIG. 5.3



AUDIOGRAM C (for Subject 112)

		LE	RE
Threshold:	500 Hz	100	NR
	1000 Hz	110	NR
	2000 Hz	120*	NR
Average		110	NR

Average Hearing Loss = 110 db. (for LE)

* Estimated threshold - no response up to 115 db. at this frequency.

various frequencies have to be codified into a single representative value.

The method used in this investigation is based on the three frequencies 500, 1000 and 2000 Hz. These thresholds are averaged, for each ear separately, and the lower of the two resultant figures (i.e. for the better ear) taken as the measure of average hearing loss.

The three audiograms given as examples (Audiograms A, B and C, following) illustrate the method of computing average hearing losses.

5.3 Relationship between pure-tone hearing loss and hearing loss for speech

The measure of hearing loss based upon the average of the thresholds at 500, 1000 and 2000 Hz. is used because these frequencies cover the range particularly important for hearing and understanding speech. For practical purposes knowledge of the capacity to hear speech at supraliminal intensities might be more useful than information on the threshold of sensitivity for pure-tones. However, as Reed states (1966, p.2).

> 'Speech audiometry..... is more complicated than pure-tone audiometry, more difficult to establish norms and therefore is seldom used in routine diagnosis'.

Speech audiometry is not carried out with children in schools for the deaf as widely as pure-tone audiometry. In practice considerable reliance is placed upon the pure-tone audiogram as a guide to the severity of the handicap in terms of hearing for speech and capacity to benefit from amplified sound.

A broad relationship exists between pure-tone threshold and hearing for speech, but this relationship is complex, and varies with the type of deafness (i.e. conductive or perceptive hearing loss) and also with the type of measure involved (i.e. threshold of detectability for speech, threshold of intelligibility, hearing loss for speech and maximum articulation score or discrimination loss). A detailed explanation is given of some aspects of this complex relationship, as a basis for examining evidence of the validity of the average hearing loss for pure-tones for predicting hearing for speech.

Speech audiometry is based upon the procedure for obtaining the 'articulation curve' or the 'articulation-gain function', which is a means of expressing the intelligibility of speech material (i.e. the amount understood by the listener) as a function of its intensity. The subject listens to lists of words or sentences presented at increasing intensities and the responses are plotted on a curve which shows the relationship between percentage of speech identified and intensity.

A close correspondence exists between pure-tone thresholds and <u>threshold of detectability</u> for speech (i.e. the intensity level at which the sound of speech can be heard 50 per cent of the time, though not understood). For normal listeners the threshold of detectability for phonetically balanced monosyllabic words has been found (Davis, 1947) to be 12 decibels above the 'absolute' zero sound pressure level (0·0002 dyne cm^2.), compared with the threshold at 8 decibels for audibility of pure-tones.

Correlation coefficients of ·75 have been reported between thresholds of pure-tone audibility and detectability for speech (Carhart, 1946; Thurlow, 1948).

Raising of the intensity of presentation above the threshold of detectability enables an increasing proportion of the speech material to be understood. The intensity level at which 50 per cent of the items can be identified is termed the threshold of intelligibility for speech. For normal listeners this occurs at about 30 decibels above 0·0002 dyne cm^2. sound pressure (Davis, 1947). A listener with a hearing loss needs to have the intensity increased beyond the normal level to achieve a 50 per cent score, and the difference gives the amount of hearing loss for speech.

High correlations have been found between hearing loss for pure-tones and hearing loss for speech (using spondees, i.e. equal stress disyllabic words). Farrimond (1961), at the University of Liverpool, found a correlation of ·82 between hearing loss and the frequencies 250, 500 and 1000 Hz. and hearing loss for speech (using sentences).

Further increases in intensity beyond the level required for the 50 per cent response lead to corresponding improvements in the articulation score, until the curve levels out. For normal listeners (under suitable conditions) a maximum articulation score of 100 per cent should be reached at a level of about 70 db. (above 0·0002 dyne cm^2.). This is, of course, the level of ordinary conversational speech. Intensities beyond this point might produce uncomfortable loudness levels to the listener, and by about 130 db. the threshold of tolerance for sound is normally reached.

Davis (1947) has shown that the articulation curves for listeners with conductive hearing losses are similar in shape to the normal curve, but displaced along the intensity scale. In order to attain the various criteria of hearing for speech (threshold of detectability, threshold of discrimination, maximum articulation score) the speech material needs to be amplified by an amount corresponding approximately to the degree of hearing loss for pure-tones in the speech range. The problem of conductive deafness is basically one of attenuation, and with suitable amplification of speech a conductively deaf subject might attain a maximum articulation score of 100 per cent.

Conductive type deafness resulting from outer or middle ear disorders tends to be moderate in degree of severity. The limit of purely conductive hearing loss is about 60 db. (Watson and Tolan, 1949; Frisina, 1958). The majority of children placed in schools for the deaf have severe or profound deafness of a perceptive or sensori-neural type deafness resulting from lesions in the inner ear or central nervous system. Defects in the cochlea characteristically result in greater loss of sensitivity for high frequencies than for low frequencies, and, consequently, inability to hear or discriminate between the high frequency components of speech sounds, particularly the consonant sounds. The person with a severe perceptive hearing loss is not able to achieve a high articulation score. Moreover, there is frequently a 'decline' in the articulation curve for such subjects when intensities are increased beyond the optimum level.

The type of deafness is clearly a major factor influencing the capacity to understand amplified speech. Conductively deaf children have comparatively good ability to discriminate amplified speech (Watson, 1960), whereas children with perceptive deafness are able to discriminate little, if anything, of amplified speech.

The relationship between hearing at threshold and at supraliminal intensities is complicated by the phenomenon of 'recruitment'. When this condition is present, for a given increment in the objective intensity the listener experiences a relatively greater increment in subjective loudness. The effect is that of a 'reduction' in the amount of hearing loss as intensity is increased. Harold (1957) (using an audiometric technique which measured objectively the difference limen of small variations in intensity), found recruitment in over 40 per cent of a sample of congenitally deaf children and in over 80 per cent of a sample of children with adventitious perceptive deafness. Although at one time it was considered that recruitment had an adverse effect on auditory discrimination (Fry, 1950; Harris and Myers, 1950), Harold (1957) found no evidence of this in his detailed study, and pointed out that this condition might in some cases be helpful to auditory discrimination.

These factors influence the correlation between pure-tone threshold and the maximum articulation score for speech. Littler (1954) and Watson (1960) have drawn attention to the limits of the pure-tone audiogram as a guide to capacity to understand speech. Hudgins (1960) and Ewing (1962) considered that only in the case of conductive deafness could a direct relationship be expected between pure-tone acuity and speech discrimination. Reed (1966, p.4) concludes that there is still

> 'some controversy on the exact relationship between pure-tone and speech audiograms'.

However, in an experimental study with deaf children the writer (Evans, 1960) found a direct relationship - pure-tone and speech audiometric tests were applied to 50 children in a school for the deaf, the majority of whom were perceptively deaf. The hearing losses of the subjects ranged from 52 db. to greater than 105 db., when averaged over the three frequencies 500, 1000 and 2000 Hz. A high correlation of ·83 ($p < \cdot 01$) was obtained between average hearing loss and maximum articulation score.

In practice, the average hearing loss for pure-tones is now commonly used by audiologists and teachers in schools for the deaf as a quotable measure for classifying children and generally as a guide to hearing for speech and capacity to benefit from amplified sound.

The average hearing loss over the frequencies 500, 1000 and 2000 Hz. has been used satisfactorily in previous psychological investigations carried out in the field of audiology (Gaskill, 1952; Clarke, 1953; L.J. Murphy, 1952; K.P. Murphy, 1956; Evans, 1964). This measure was selected as being suitable for the purpose of the present investigation, where the full information of the pure-tone audiogram requires to be codified to a single representative figure to facilitate the statistical procedures.

Chapter 6

THE CRITERIA OF EDUCATIONAL PROGRESS

Measures of attainment in school work were required, in order to study the relationship with the test results and to ascertain what value the tests have for predicting future educational progress. A straightforward system of ratings of ability for each child by the class teacher was not considered to be satisfactory. Measures were needed which had a more objective basis or took into account broader assessment by a number of teachers over a period of time. Two criteria were devised, one based upon educational streaming as determined by continuous appraisal of progress, and the other based upon external examination results.

6.1 Educational streaming

Pupils in the Junior Department (age range 9 to 12 years) and the Secondary Department (age range 13 to 16/17 years) of the school are placed in streams according to their learning ability and rate of progress in school work. At each age level there are A and B classes, and pupils are distributed in approximately equal proportions in the two streams. The recommendations as to stream placement is made by the teachers who know the children well. Children might be moved between streams, usually at the end of a school year, on the basis of change in their rate of development. The time of transfer into the Junior Department or into the Secondary Department is also an opportunity for a major appraisal of progress which could lead to placement in a different stream.

Over a period of time, the stream into which an individual child has 'settled' might be regarded as providing a functional indication of the level of attainment and progress.

The actual criteria of progress selected was the A or B stream placement four years after the original testing period (i.e. in the fifth school year of the investigation). This is regarded as an optimum period of time to allow before relating test results to educational progress, for the following reasons:

1. Four years corresponds to the length of the educational stages of the school's organisation, and represents one third of the total school career. This is a reasonable amount of time for rate of progress and educational potential to become apparent.

2. By the fifth year of the investigation all pupils will have transferred into a new department (i.e. pupils in the Infant Department, aged 5 to 8 years, at the time of original testing will have moved to the Junior Department, and all pupils who were in the Junior Department, aged 9 to 12 years, at the original testing, will have moved to the Secondary Department). All subjects will, therefore, have undergone a major review of progress.

3. Up to the fifth year of the investigation subjects throughout the age range will still be at school (apart from children who might transfer to other schools in the meantime), but after that the older children will reach school leaving age and the original sample will be progressively reduced in size.

Placement in A or B stream four years later than the year of original administration of the intelligence tests was chosen as a suitable criterion which would include the whole sample.

6.2 Attainment in Certificate of Secondary Education examination

The second criterion of educational progress is based upon the results of an external examination. The Secondary Department of the school prepares pupils for the Certificate of Secondary Education in a range of subjects. Candidates are entered for this examination at the age of 16 or 17 years. The examinations in all subjects are moderated by external examiners and the standard maintained by the examination board.

Children in the 12 year old age level of the sample at the time of the original testing will reach the age when they will be eligible to sit the CSE examination at the end of the fifth year of the investigation. However, only a small number of results would be available, as the average number of pupils in each age level is only 16. It is necessary, therefore, to accumulate results for candidates over a number of years, to form a sufficiently large sample upon which to make conclusions. It would be particularly useful to have information on the value of the intelligence tests for predicting future progress relating to Secondary course work whilst children are still in the Junior stage of education. The subjects in the Junior Department at the time of the original testing (i.e. in the age range 9-12 years) will all have reached CSE year by the end of the eighth year of the investigation. These subjects will represent approximately half the original sample.

The period planned for the accumulation of CSE data was, therefore, from the fourth year to the end of the eighth year of the investigation. The actual criterion of successful performance in the CSE examination is defined as gaining passes at the level of Grade 4 or better in the three subjects English Language and Literature, History and Geography. The Grade 4 is the level of attainment expected for the average (hearing) sixteen year old pupil who has diligently pursued a four year secondary course leading to CSE. The three subjects entail, for deaf children, a considerable test of language competence, and this criterion represents a high level of attainment.

For the statistical procedure of relating examination performance to test results, the subjects who attain the prescribed level are placed in the 'CSE group'. Subjects who do not achieve this level are placed in the 'Non-CSE group'. The later group will include children who are not considered suitable for entry to the examination, those who enter but fail, and those who gain partial success but not up to the standard set or in practical subjects only.

These criteria of educational progress, based upon the data on attainments four to eight years after the initial administration of the tests of intelligence, determines the longitudinal nature of the investigation, but information on the comparitively long-term predictive validity of the tests should add to the value of the findings.

Chapter 7

METHOD OF THE INVESTIGATION

7.1 The subjects of the study

The information required from the research was concerned with the suitability of the tests when used with deaf children of primary school age, between five and twelve years. This age range corresponds to the middle two of the four teaching departments of the school for the deaf in which the testing was carried out. The testing was carried out during one school year and all children were included who had not reached the age of thirteen at the beginning of the year and were five or over by the end of the year. Actually, all pupils in the Infant and Junior Departments were tested, a total of 125 subjects in the age range five to twelve years when tested (70 boys and 55 girls).

Table 7-1 shows the numbers of subjects at each of the eight age levels. These numbers would be rather small upon which to base conclusions on the results in relation to age and so, for the purpose of statistical analysis of the results, the subjects were grouped into either four or two age ranges as appropriate. These are set out in Table 7.2.

A careful study was made of the aetiological background of the subjects and it was ascertained that all had onset of deafness dating from birth or an early age before acquiring natural speech and language. This was, therefore, a sample of prelingually deaf children. There are no official educational 'regions', but the geographical catchment area of the school coincided with the area of a regional hospital

TABLE 7.1

Distribution of subjects, by age at time of original testing and sex (N = 125)

Age	Boys	Girls	Totals
12	2	5	7
11	12	7	19
10	7	6	13
9	13	5	18
8	8	7	15
7	6	10	16
6	8	7	15
5	14	8	22

TABLE 7.2

Distribution of subjects, by age range at time of original testing (N = 125)

Age range	N	Age range	N
11-12	26	9-12 older group	57
9-10	31		
7- 8	31	5- 8 younger group	68
5- 6	37		

authority. All the local education authorities in the area placed their educationally deaf children at the school, either as day pupils or weekly boarders. The subjects might therefore be considered as being closely representative of the population of non-selective schools for the deaf.

Although the subjects might be regarded as a 'typical' sample of children from schools for the deaf, this does not necessarily mean that they will be 'normal' in the results of tests which validly measure intelligence at a comparable level with hearing children. The reason for this is that some of the factors, already outlined, which can influence the general level of intelligence amongst deaf children were present in this sample. Twelve children were known to have had brain-injuring conditions which can cause mental impairment. Four children were 'borderline' partially hearing who had been placed at the school, in preference to a partially hearing unit, on account of severe educational retardation which might be assumed to be associated with low intelligence. Apart from these cases in the sample, a number of bright deaf children,who would otherwise have been in the sample, had already been transferred to partially hearing units after making exceptionally good progress. Three children in this category had transferred during the previous school year. This will be an important point to bear in mind when interpreting the results of the intelligence tests.

Although there were 125 subjects in the sample at the time of administration of the intelligence tests, there were fewer cases for the validation periods. By the fifth year of the investigation 19 subjects had left the school, most of them transferring to schools for the deaf in other parts of the country. There were therefore 106 subjects for this part of the investigation. The later stage, concerned with the relationship with CSE results, involved only children who were originally in the older group. The number of subjects remaining for this aspect of the research was 52.

7.2 The research procedure

The numbers and ages of the subjects are further detailed in Figure 7.1, which illustrates the three phases by which the investigation proceeded over a total period covering eight school years.

Phase I. During the first year the four intelligence tests and the pure-tone audiometry test were administered to the 125 subjects (i.e. all pupils in the Infant and Junior Departments of the school). This is referred to as the 'original testing'.

By the second year, when all test scores were available, it was possible to commence the statistical analysis of the intelligence test results with regard to:

(1) distribution, means and standard deviations
(2) internal consistency reliability
(3) correlation with hearing loss

(and, in the case of the three other tests)

(4) comparison of means and standard deviations with WISC (Perf.)
(5) correlation with WISC (Perf.)

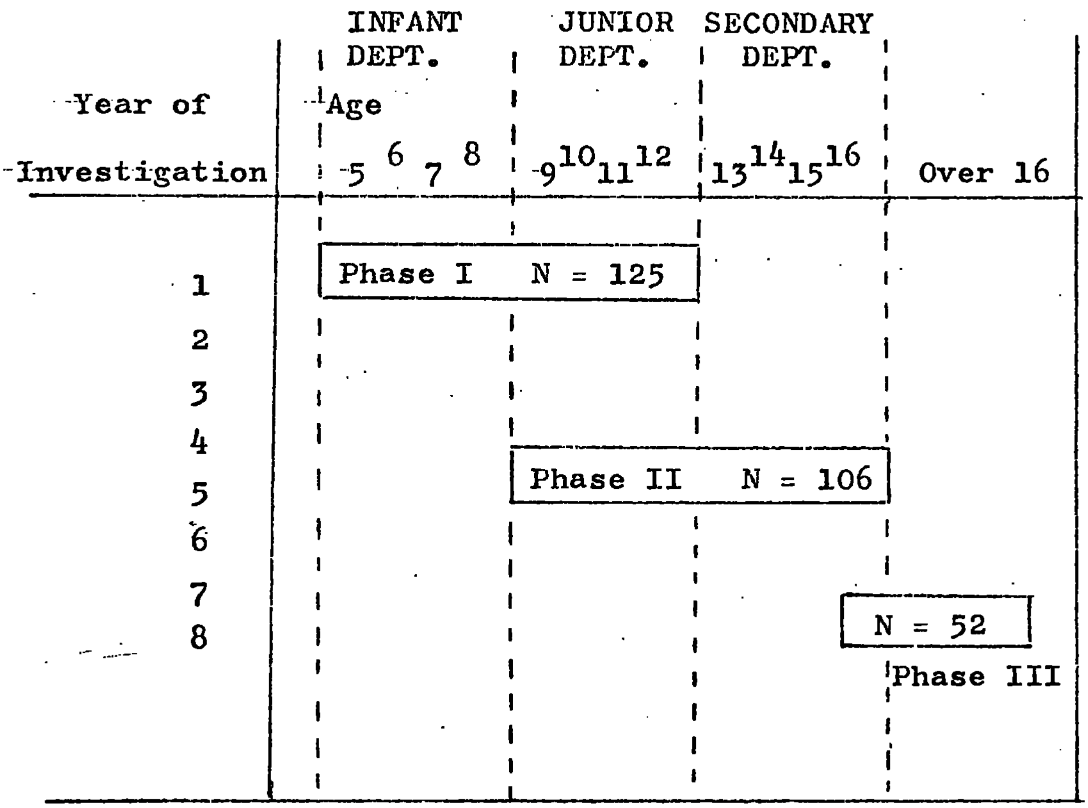


FIGURE 7.1

Ages and numbers of subjects for the three phases of the investigation.

Phase II. By the fifth year all subjects remaining in the sample had moved up into a new department (i.e. pupils in the Infant Department at the original testing were now in the Junior Department, and pupils in the Junior Department at the original testing were now in the Secondary Department). All subjects were by now placed in either A or B stream classes, according to their educational attainment and rate of learning progress. The placement of the subjects at the end of the fifth year, i.e. at least four years later than the original testing in all cases, was recorded. It was then possible to correlate this criterion of educational progress with test results.

Phase III. By the end of the fifth year of the investigation the first of the subjects would reach the minimum age for entry to the CSE examination. Reference to Table 7.1 shows that this was a very small number of cases, only seven (i.e. the children aged 12 years at the time of original testing). It was necessary to accumulate data regarding entry and results in CSE over a number of years. A period of four successive years was selected, and this includes the older half of the original sample, a total of 57 subjects at the outset (see Table 7.2), all of whom were pupils in the Junior Department when originally tested.

The actual length of time between the administration of the intelligence tests and reaching the CSE stage varied for individual children, and ranged from five years (for children aged twelve when tested at the beginning of the first year of the investigation) to seven years (for children aged nine when originally tested towards the end of the first year). The term over which the predictive validity of the tests is measured can therefore be stated as 6 ± 1 years.

The data on CSE status ('CSE group' or 'Non-CSE group') was collected for the successive age levels at the end of the fifth, sixth, seventh and eighth years of the investigation. On completion, information was available on 52 subjects (some from the original sample having transferred from the school in the meantime). It was then possible to correlate CSE performance with intelligence test results.

7.3 Statement of specific aims

The general objectives of the research have been outlined and the tests and criteria of educational progress described. It is now possible to state the specific aims of the investigation, which were to make the following measurements in respect of the sample of deaf children studied (for different age levels wherever appropriate):

1. Distribution of hearing loss
2. Relationship between hearing loss and A or B stream placement
3. Relationship between hearing loss and CSE performance
4. Distribution of WISC (Perf.) IQ
5. Mean and standard deviation of WISC (Perf.) IQ
6. Internal consistency reliability and standard error of measurement of WISC (Perf.) IQ
7. Relationship between hearing loss and WISC (Perf.) IQ
8. Relationship between WISC (Perf.) IQ and A or B stream placement
9. Relationship between WISC (Perf.) IQ and CSE performance

7.4 Administration of the tests

All of the tests were administered by the writer, who, as a member of the school staff, was known to the children in the sample. The writer was experienced in the management of deaf children through teaching and previous psychological testing, and was conversant in communicating with the deaf.

The administration of the pure-tone audiometry tests has already been described, including the details of the audiometer used and the testing conditions.

The intelligence tests were administered, individually, to each subject over a period of two consecutive days. This was possible in all cases, with no interruptions in any child's programme due to absence. The hearing test was carried out as closely as possible to this time, usually within the space of one week. All subjects in the original sample were tested.

The WISC (Perf.) test was administered first and took between 30 and 40 minutes. The sub-tests were applied in the following order:-

(1) Block Design. This is an interesting start to the test. It presents no special difficulties with deaf children.

(2) Picture Completion. This was introduced, if necessary, by using a series of simple drawings of objects with parts missing, which were drawn in to help the child grasp the idea. The tester can not rely on the speech of the deaf child if asked to make a verbal response, and a soft paintbrush was available for the child to point to the missing parts of the test drawings. Some

of the youngest children had difficulty in understanding the idea of this test. A few subjects failed completely.

(3) Picture Arrangement. Deaf children in general do not have special difficulty in understanding the task involved. If necessary, the easier introductory items were used with older children, as well as with the younger children.

(4) Object Assembly. This subtest, which was popular with the children, presented no difficulties in administration.

(5) Coding. This was presented last, as it seems to be lacking in interest to deaf children. There were no difficulties in understanding the task from the sample items.

In the timed tests, speed of response was induced by the use of the sign for 'quickly' where appropriate, and by a brisk manner on the part of the tester.

Sets A, Ab and B of the Book Form (1960) of the Coloured Progressive Matrices were used. Experience in communicating with deaf children is of special value in explaining this test. A few children, of very low ability, failed to score. The test took approximately 15 to 20 minutes.

The Columbia Mental Maturity Scale was presented with no special problems. The older children readily understood the task. The correct responses were indicated and explained for the first three items if necessary, as is allowed in the manual. The very few subjects who failed to understand this test had also failed partly in WISC (Perf.) items. The test took usually 10 to 15 minutes to administer

The Goodenough-Harris Drawing Test was applied with no particular problems. The idea of drawing a man was readily understood by most subjects. Some of the younger children were asked to 'draw Daddy'. Experience in communicating with deaf children was especially helpful in explaining this test. The average time taken was approximately 10 to 15 minutes.

In the interests of consistency in the scoring between drawings, the scoring was done for all drawings at the completion of all the tests at the end of the test year. For this, the drawings were arranged in random order, and scored without reference to the identity or age of the subject.

7.5 Statistical treatment of the data

The statistical analysis of the results was based largely on measuring (i) reliability (ii) means and standard deviations and the significance of differences, and (iii) coefficients of correlation. The main procedures used were as follows.

Reliability

Estimates of internal consistency reliability were obtained by the split-half method. Correlations were computed between totals of raw scores for odd and even test items. The Pearson product-moment coefficient of correlation was calculated from scatter diagrams using the formula for grouped and coded data

$$r_{xy} = \frac{\frac{\Sigma x'y'}{N} - (M_{x'}M_{y'})}{(\sigma_{x'})\,(\sigma_{y'})}$$

Where x' and y' = deviations of the coded values for X and Y from their respective means

$M_{x'}$ and $M_{y'}$ = means of coded values x' and y', respectively

$\sigma_{x'}$ and $\sigma_{y'}$ = standard deviations of coded values x' and y', respectively

The split-half correlations are, strictly, estimates for half the test. The corrections to obtain estimates for the full-test reliability were made by the Spearman-Brown formula

$$r_{tt} = \frac{2r_{hh}}{1 + r_{hh}}$$

Where r_{hh} = self-correlation of half-test

The use of the Spearman-Brown formula assumes comparability of halves of the tests (i.e. similarity of content, means and standard deviations and skewness of distributions). Examinations were therefore made of these characteristics, which proved to be satisfactory. (The means and standard deviations for odd and even halves were available as by-products of the computation of the correlation coefficients). Guilford (1956, p.452) points out that

> 'since comparability of halves is in practice probably never perfect, a Spearman-Brown estimate is probably conservative'

The split-half reliability coefficients might therefore be interpreted as minimal estimates.

Standard errors of measurement were computed from the formula

$$SE_m = \sigma_t \sqrt{1 - r_{tt}}$$

Where σ_t = standard deviation of the distribution of obtained scores

Comparison of means and standard deviations

As a preliminary step towards the measurement of the significance of any differences between means, the standard errors of means were estimated from the formula

$$\sigma_M = \frac{\sigma}{\sqrt{N - 1}}$$

As there was some relationship between the pairs of tests compared, the following formula, suitable for correlated data, was used to estimate the standard errors of differences between means

$$\sigma_{d_M} = \sqrt{\sigma^2_{M_1} + \sigma^2_{M_2} - 2r_{12}\, \sigma_{M_1}\, \sigma_{M_2}}$$

This formula includes the term r_{12}, which is the correlation between the two variables.

The critical ratios were calculated from the formula

$$t = \frac{M_1 - M_2}{\sigma_{d_M}}$$

The probability levels were obtained direct from the table of distribution of t (Baker and Smith, 1964, Table 2, p.16)

The standard error of the standard deviations were obtained by the formula

$$\sigma_\sigma = \frac{\sigma}{\sqrt{2N}}$$

These were required for use in the formula for standard errors of differences between standard deviations

$$\sigma_{d_\sigma} = \sqrt{\sigma^2_{\sigma_1} + \sigma^2_{\sigma_2} - 2r^2_{12}\, \sigma_{\sigma_1}\, \sigma_{\sigma_2}}$$

The critical ratio was calculated

$$t = \frac{\sigma_1 - \sigma_2}{\sigma_{d_\sigma}}$$

Coefficients of Correlation

It was necessary to use four correlation methods for measuring relationships between tests and with the criteria of educational progress

(1)	Pearson product-moment	r
(2)	Biserial	rb
(3)	Point biserial	r_{pbi}
(4)	Tetrachoric	r_{cos-pi}

The actual methods used for the intercorrelations of the variables were as follows

	Hg Loss	WISC (Perf.)	CPM	CMMS	G-HDT
WISC (Perf.)	r_b				
CPM	r_{cos-pi}	r_{pbi}			
CMMS	r_b	r			
G-HDT	r_b	r			
Stream	r_{cos-pi}	r_b	r_{cos-pi}	r_b	r_b
CSE	r_{cos-pi}	r_b	r_{cos-pi}	r_b	r_b

The Pearson product-moment coefficient was used for two variables which were both continuously measurable (using the formula already given).

The biserial coefficient was used when one of the variables had to be treated as a dichotomous variable, the formula used being

$$r_b = \frac{M_p - M_t}{\sigma_t} \times \frac{p}{y}$$

where M_p = mean X values for the higher group in the dichotomous variable

M_t = mean of x values for total sample

σ_t = standard deviation of x values of total sample

p = proportion of cases in higher group

($\frac{p}{y}$ then obtained from tables)

The point-biserial coefficient was used in the case of the Coloured Progressive Matrices, as the results did not satisfy the requirement of normality of distribution for using the biserial coefficient. Guilford (1956, p.303) recommends that when there is doubt as to whether the requirements for the biserial correlation are fulfilled, the point-biserial will serve, even though the variable is not a genuine dichotomy. He further states that the point-biserial method tends to yield a conservative measure (p.304), so that the resultant coefficients might be interpreted as minimal estimates of correlation.

$$r_{pbi} = \frac{M_p - M_t}{\sigma_t} \sqrt{\frac{p}{q}}$$

(the value $\sqrt{\frac{p}{q}}$ is obtained from tables)

The tetrachoric coefficient was used when both variables had to be dichotomized. By placing results in a four-fold table, the ratio ad/bc was calculated and the r_{cos-pi} coefficient obtained direct (Guilford, 1956, Table M, p.550).

For all coefficients of correlation, significance levels were determined by reference to the appropriate table of significance, as recommended by Guilford (1956, p.303) and Garrett (1958, p.382).

The index of forecasting efficiency and percentage of variance accounted for are used in interpreting the validity of the intelligence tests for predicting CSE results.

The <u>index of forecasting efficiency</u> is the percentage reduction in errors of prediction by reason of correlation between variables, and is obtained from the formula

$$E = 100\ (1 - \sqrt{1 - r^2})$$

The percentage of variance in one variable that is associated with variance in another variable is calculated by multiplying r^2 by 100.

Multiple Correlations

In order to discover whether the predictive validity improved with the inclusion of additional tests, multiple correlations were obtained between various combinations of test results and CSE performance. An appropriate computer programme was available for the calculation of the multiple correlations.

The significance of difference between multiple correlations was obtained by the F test, using the formula

$$F = \frac{(R_1^2 - R_2^2)(N - m_1 - 1)}{(1 - R_1^2)(m_1 - m_2)}$$

where R_1 = multiple correlation with larger number of independent variables

R_2 = multiple correlation with reduced number of variables

m_1 = larger number of variables

m_2 = smaller number of variables

In the use of the F table (Guilford, 1956, Table F, p.541) the degrees of freedom are given by

$$df_1 = m_1 - m_2$$

$$df_2 = N - m_1 - 1$$

Chapter 8

PRESENTATION AND INTERPRETATION OF THE RESULTS

The results of the tests are presented in Tables 8.1 to 8.29, with further graphic illustration of some of the findings in Figures 8.1 to 8.8. Each of the tables provides information that relates directly to one of the 29 specific aims, as set out in Chapter 7.

Results of the test of hearing loss

TABLE 8.1

Distribution of hearing losses

Hearing loss in db	N	Per cent	
35 - 44	1	1	50
45 - 54	0	0	
55 - 64	11	9	
65 - 74	4	3	
75 - 84	21	17	
85 - 94	25	20	
95 - 104	29	23	50
105 - 114	20	16	
115 above *	14	11	

* No response up to maximum intensity of the audiometer

The results of the pure-tone audiometric test are presented in Table 8.1, which gives the distribution of average hearing losses (for the frequencies 500, 1K and 2K Hz, in the better ear).

There was a wide spread of hearing losses, but the majority of subjects (87 per cent) had severe or profound hearing loss (i.e. 75 db and above). Some subjects made no response at the maximum intensity of the instrument. In the statistical treatment of the results, these cases did not fit into a class interval of known size, and this, together with the 'tailing off' of the distribution in the lower hearing losses, necessitated the use of the biserial (or point biserial) when correlating with other variables. The subjects were divided equally into two main groups, with profound hearing loss (i.e. 95 db and above) and moderate or severe hearing loss (i.e. below 75 db).

Tables 8.2 and 8.3, and Figure 8.1, indicate that there were no significant correlations between hearing loss and either of the two criteria of educational progress.

TABLE 8.2

Correlations between Hearing Loss and placement in A or B stream

Age range	N	Correlation Coefficient r_{cos-pi}	Significance level p
5 - 12	106	·13	$> ·05$
9 - 12	51	·27	$> ·05$
5 - 8	55	-0.02	$> ·05$

TABLE 8.3

Relationship between Hearing Loss and Certificate of Secondary Education results

N	52
Correlation Coefficient	$r_{cos-pi} = ·23$
Significance level	$p > ·05$
Index of forecasting efficiency	E = 3 per cent
Variance accounted for	6 per cent

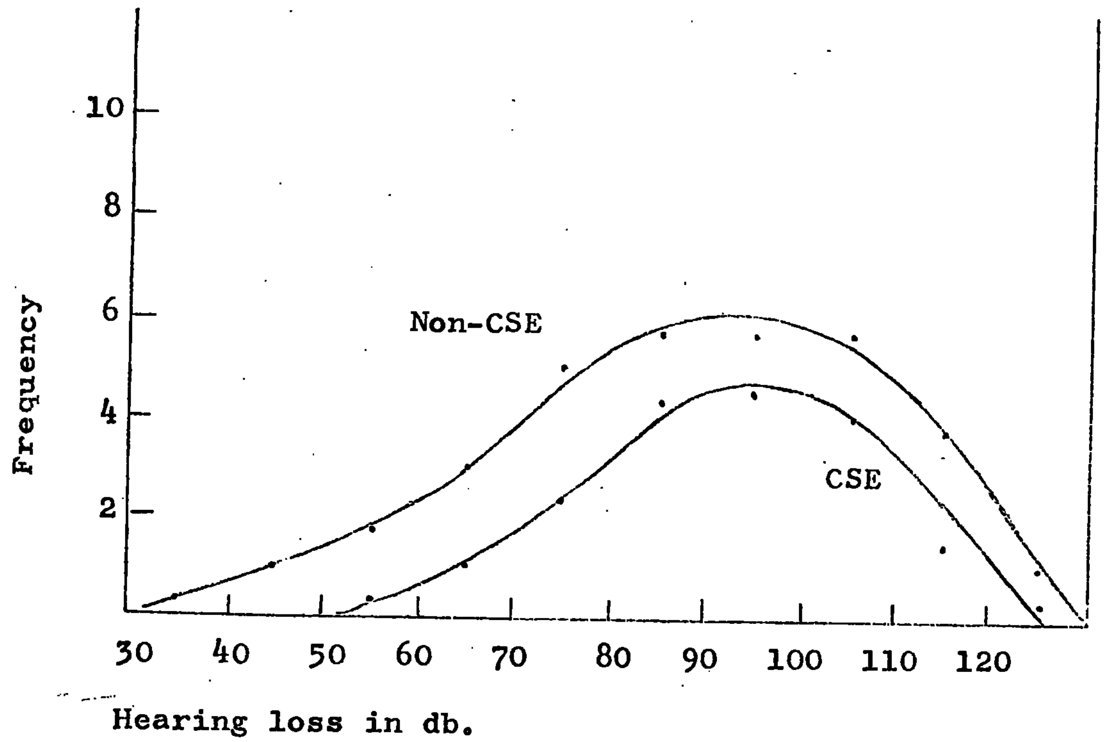


FIG. 8.1 Smoothed frequency distribution curves of average hearing losses for CSE and Non-CSE groups. (N = 52)

Knowledge of hearing loss does not contribute to the prediction of success in the Certificate of Secondary Education.

WISC (Perf.) results

The distribution of WISC (Perf.) IQ is shown in Table 8.4

TABLE 8.4

Percentage frequency distributions of WISC (Perf.) IQs

Age range	N	IQ: below 75	75-89	90-109	110-124	125 over
5-12	125	15	24	39	17	5
9-12	57	12	23	40	21	4
5- 8	68	18	25	38	13	6
Expected distribution = (according to norms)		5	20	50	20	5

There was a positive skewing of the distribution, when compared to the norms for hearing children. This skewing was slightly greater for the younger group of subjects. This is brought out further in Table 8.5, which reveals that for the older age levels the means were close to normal. The youngest children (age 5-6 years) had a mean 10 points below normal, and this influenced the mean for the sample as a whole.

TABLE 8·5

Mean IQs and standard deviations for WISC (Perf.)

Age range	N	Mean IQ	S.D.
5-12	125	94·8	17·74
11-12	36	97·8	14·32
9-10	31	95·5	17·37
7- 8	31	97·6	17·89
5- 6	37	89·6	18·87

These results might be explained in terms of the factors, previously mentioned, which might affect the level of intelligence of the population of a school for the deaf. In the description of the sample (Chapter 7), twelve subjects were identified as having aetiology of possible brain injury and four as dull borderline partially hearing children. When the IQs for this special group of 16 subjects were examined separately, the mean was 79·8, and the majority of the subjects were in the lower age group. When these subjects are excluded, the mean IQ of the other 109 children in the sample was 98·7.

TABLE 8.6

Reliability coefficients and standard errors of measurement for WISC (Perf.)

Age range	N	Split-half Correlation r_{tt}	Significance level p	SE_m
5-12	125	·96	<·01	3·55
11-12	26	·88	<·01	5·01
9-10	31	·91	<·01	5·21
7- 8	31	·95	<·01	3·94
5- 6	37	·94	<·01	4·53

For all age levels there was a satisfactorily high level of internal consistency reliability of the WISC (Perf.) results (Table 8·6). The Spearman-Brown coefficients were based on the results of four sub-tests only. The Coding sub-test, being a speed test, does not lend itself to the split-half method, and, following Wechsler's (1949) precedent in his original standardization, it was excluded for the purpose of computing the reliability correlation.

TABLE 8.7

Correlation between Hearing Loss and WISC (Perf.) IQ

Age range	5-12
N	125
Correlation Coefficient	$r_b = \cdot 09$
Significance level	$p > \cdot 05$

There was no significant correlation between hearing loss and WISC (Perf.) results (Table 8.7).

TABLE 8.8

Correlations between WISC (Perf.) IQ and placement in A or B stream

Age range	N	Correlation coefficient r_b	Significance level p
5-12	106	·78	$< \cdot 01$
11-12	22	·88	$< \cdot 01$
9-10	29	·69	$< \cdot 01$
7- 8	27	·77	$< \cdot 01$
5- 6	28	·80	$< \cdot 01$

Table 8.8 shows that when WISC (Perf.) results were correlated with A or B stream placement, there was high relationship between intelligence and this criterion of educational progress. This applied to all age levels.

TABLE 8.9

Relationship between WISC (Perf.) IQ and Certificate of Secondary Education results

N	52
Correlation coefficient	$r_b = \cdot 81$
Significance level	$p < \cdot 01$
Index of forecasting efficiency	E = 42 per cent

There was also a high level of validity for predicting CSE success (Table 8.9). From this degree of correlation, it can be calculated that WISC (Perf.) IQ accounts for over 65 per cent of the variance in CSE performance, a very high figure. The index of forecasting efficiency indicates that, with knowledge of WISC (Perf.) results, there is a substantial reduction in error of prediction of examination success than there would be without reference to WISC (Perf.) IQ.

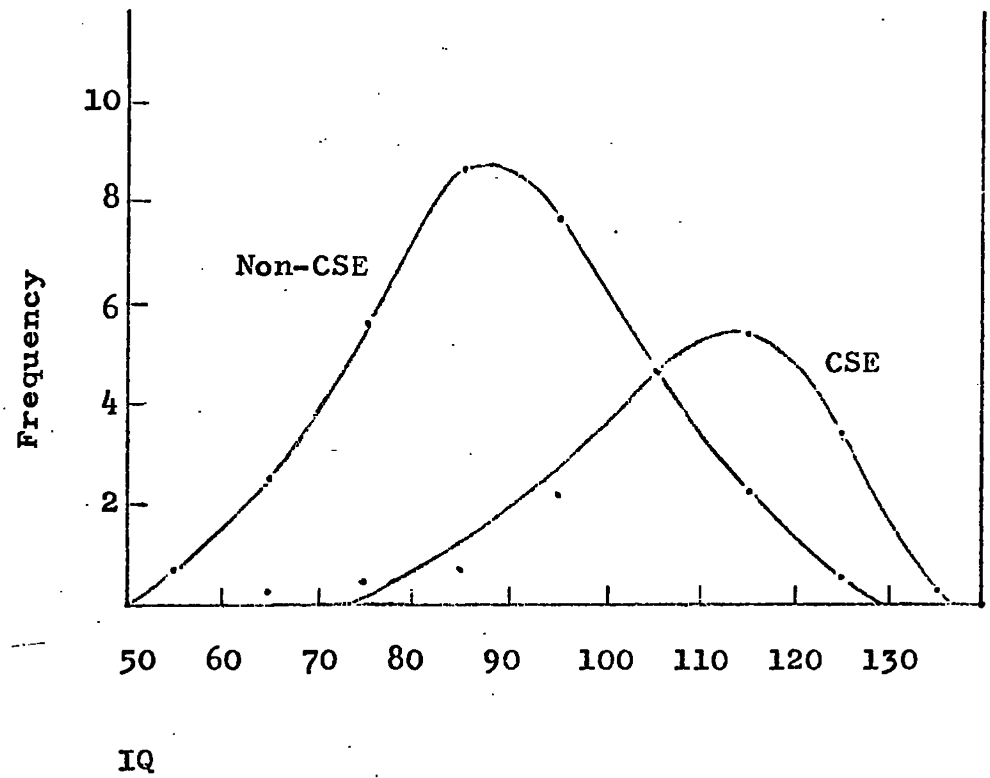


FIG. 8.2 Smoothed frequency distribution curves of WISC (Perf.) IQs for CSE and Non-CSE groups. (N = 52)

From Figure 8.2 it can be determined at what point on the scale of IQ measurement the two distribution curves for CSE and Non-CSE groups intersect. This gives the critical point for maximum accuracy of prediction of CSE performance from WISC (Perf.) IQ. It can be predicted that subjects with IQs higher than 105 succeed in CSE, whereas subjects with IQs lower than 105 are in the Non-CSE group.

Coloured Progressive Matrices results

TABLE 8.10

Percentage frequency distribution of Coloured Progressive Matrices results, in Grades *

Age range	N	Grade: V	IV	III	II	I
5-12	125	23	25	33	17	2
9-12	57	14	23	46	16	2
5- 8	68	31	26	22	18	3
Expected distribution = (According to norms)		5	20	50	20	5

The distribution of CPM results (Table 8.10) for the sample is skewed in the positive direction, with 44 per cent of cases scoring below normal (i.e. in grades IV or V). Examination of the results by age group shows, however, that the scores for the younger age group account for this skewing.

The abnormal distribution for the younger subjects is markedly skewed, with the mode occurring in the lowest grade. This is brought out in Figure 8.3.

* CPM Scores are expressed in five Grades, with the following values:-

Grade	percentile distribution	(equivalent WISC IQ)
I	5	125+
II	20	110-124
III	50	90-109
IV	20	75-89
V	5	<75

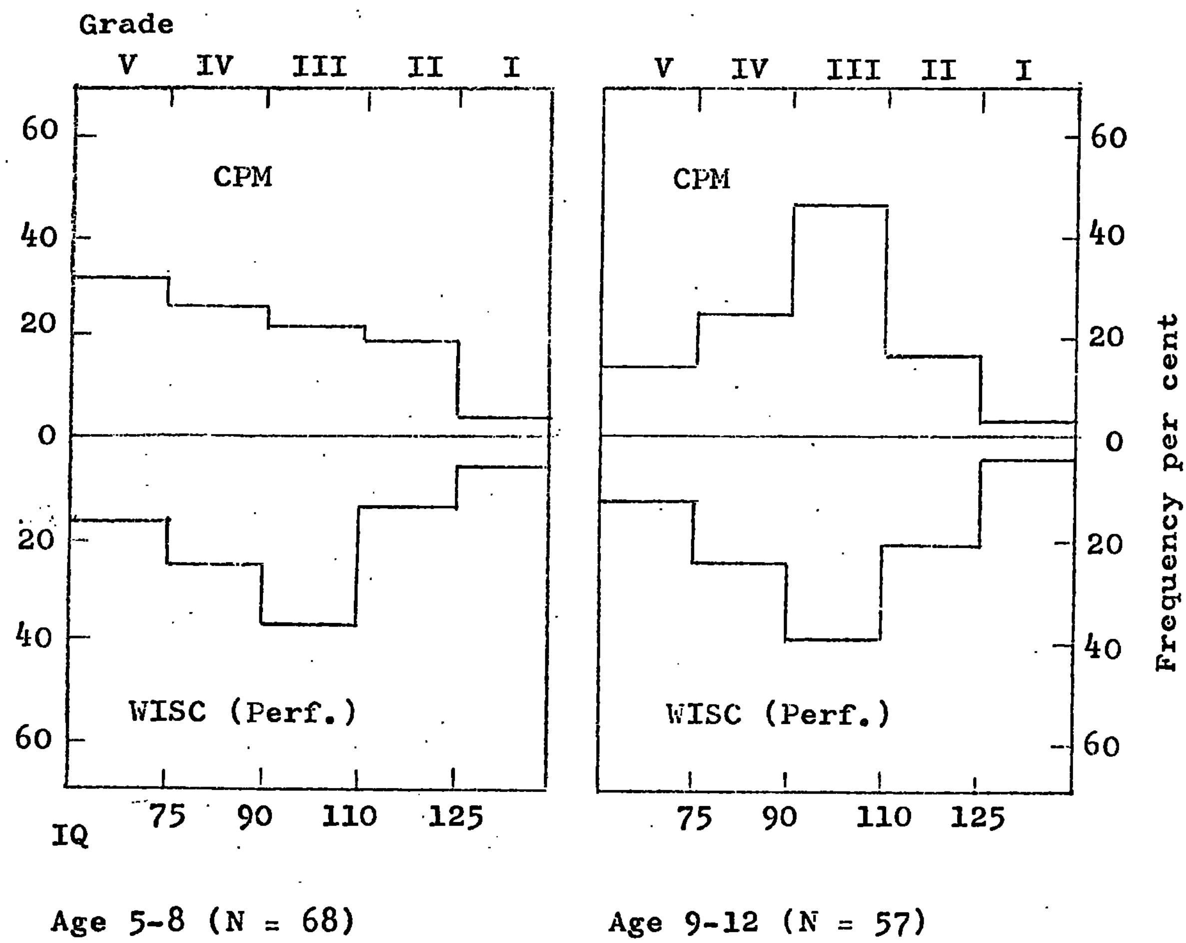


FIGURE 8.3 Histograms showing distributions of Coloured Progressive Matrices and WISC (Perf.) results for the two age groups.

It is clear (Figure 8.3) that the older subjects had CPM scores closely comparable to their WISC (Perf.) results.

For the younger children, however, there was relatively greater inferiority in the CPM Test.

TABLE 8.11

Reliability coefficients for Coloured Progressive Matrices

Age range	N	Split-half Correlation r_{tt}	Significance level p
5-12	125	·92	$<$·01
11-12	26	·92	$<$·01
9-10	31	·81	$<$·01
7- 8	31	·87	$<$·01
5- 6	37	·73	$<$·01

Table 8.11 shows that internal consistency reliability estimate for the whole sample reached a satisfactory level. When examined by age group, reliability was good for the older subjects, but less satisfactory for the younger subjects.

TABLE 8.12

Correlation between Hearing Loss and Coloured Progressive Matrices

Age range	5-12
N	125
Correlation coefficient r_{cos-pi} =	-0·04
Significance level	p $>$·05

There was no significant relationship found between hearing less and scores in the Coloured Progressive Matrices Test.

TABLE 8.13

Correlations between Coloured Progressive Matrices and WISC (Perf.)

Age range	N	Correlation Coefficient r_{pbi}	Significance level p
5-12	125	·60	< ·01
11-12	26	·83	< ·01
9-10	31	·65	< ·01
7- 8	31	·56	< ·01
5- 6	37	·56	< ·01

Table 8.13 shows the degree of relationship between CPM scores and WISC (Perf.) IQ. It can be seen that the correlations increase with age.

TABLE 8.14

Correlations between Coloured Progressive Matrices and placement in A or B stream

Age range	N	Correlation Coefficient r_{cos-pi}	Significance level p
5-12	106	·51	<·01
11-12	22	·55	<·01
9-10	29	·66	<·01
7- 8	27	·67	<·01
5- 6	28	·35	>·05

The correlations between CPM and educational progress as determined by A or B class placement are given in Table 8·14. Again, there was an age difference. For the older groups of subjects, aged 7 upwards, the correlations might be interpreted as indicating moderate to high predictive validity. The correlation for the youngest group of subjects, aged 5 - 6 years, failed to reach a statistically significant level.

TABLE 8.15

Relationship between Coloured Progressive Matrices and Certificate of Secondary Education results

N	52
Correlation coefficient	$r_{cos-pi} = \cdot 70$
Significance level	$p < \cdot 01$
Index of forecasting efficiency	E =29 per cent

There was a high correlation between Coloured Progressive Matrices results and performance in the Certificate of Secondary Education. These subjects were, of course, in the older group at the time of original testing. This finding is therefore consistent with the other results of the CPM, which are, generally, more satisfactory for the older children.

From the correlation in Table 8.15 it can be determined that CPM results account for almost 50 per cent of the variance in CSE performance.

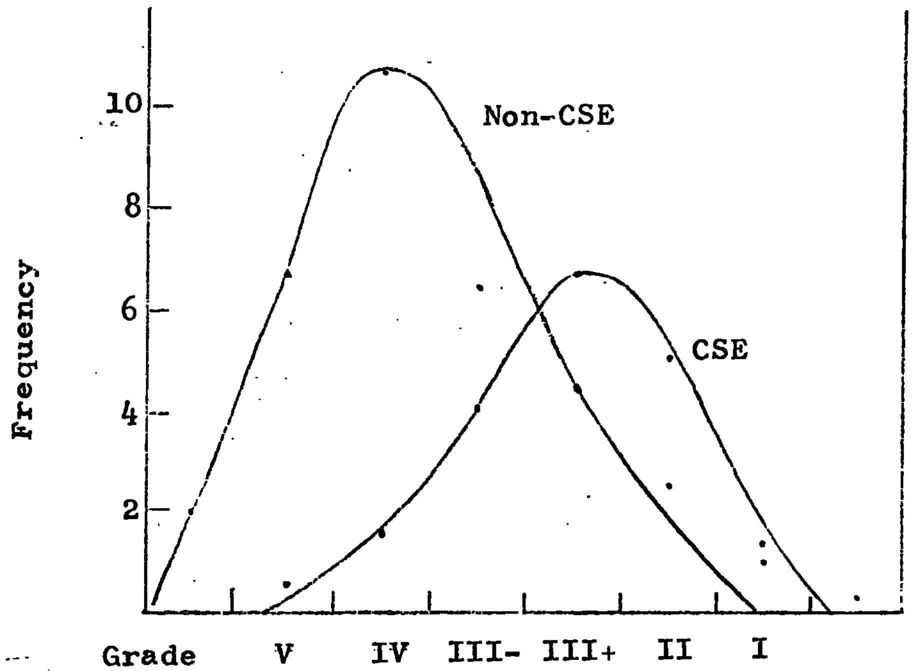


FIG. 8.4 Smoothed frequency distribution curves of Coloured Progressive Matrices results for CSE and Non-CSE groups. (N = 52)

The critical point for predicting CSE performance from CPM results occurs (in Figure 8.4) between Grades III and III+. Although only a minority of the subjects of the total sample scored in Grade III+ or above, those who did were likely to be in the CSE group. It is clear that subjects scoring in Grades IV or V were almost certain not to attain success in CSE.

Columbia Mental Maturity Scale results

There was a very abnormal distribution of Columbia Mental Maturity Scale IQs (Table 8.16). More than half the subjects in the total sample had IQs below 75. The older subjects were particularly poor in this test (in contrast with the results for the Coloured Progressive Matrices, in which the older subjects had higher scores than the younger children). A possible explanation for the relatively greater inferiority of the older subjects lies in the fact that most of the children, irrespective of age, met early failure in understanding the problems after the first easy items.

TABLE 8.16

Percentage frequency distributions of Columbia Mental Maturity Scale IQs

Age range	N	IQ: below 75	75-89	90-109	110-124	125 over
5-12	125	53	26	19	2	0
9-12	57	75	12	12	0	0
5- 8	68	34	37	25	4	0
Expected distribution = (according to norms)		5	20	50	20	5

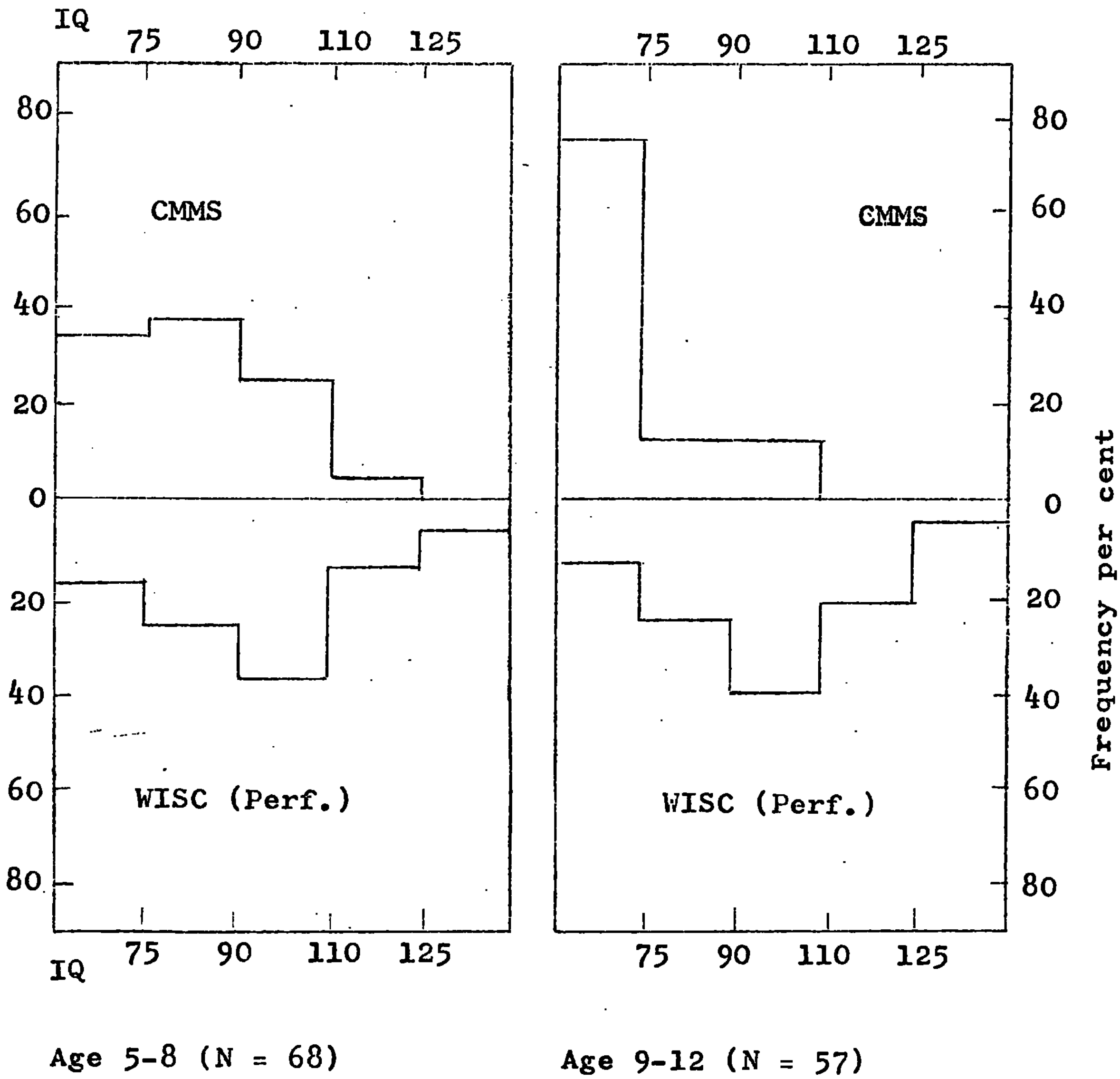


FIGURE 8.5 Histograms showing distributions of Columbia Mental Maturity Scale and WISC (Perf.) results for the two age groups.

It is clear, from Figure 8.5, that the CMMS distributions were highly skewed and lacked comparability with WISC (Perf.) distributions.

TABLE 8.17

Mean IQs and standard deviations for Columbia Mental Maturity Scale

Age range	N	Mean IQ	SD
5-12	125	75·4	15·95
11-12	26	68·0	17·65
9-10	31	67·3	10·15
7- 8	31	79·7	14·85
5- 6	37	83·6	13·56

The extent of the inferiority of the subjects when measured by the CMMS is shown in Table 8.17. The means at the various age levels were substantially lower than the corresponding WISC (Perf.) means, all differences being highly significant. It can be seen that the mean CMMS IQ for the 9 to 12 year old children was 30 points lower than their mean WISC (Perf.) IQ. (see Table 8.5).

TABLE 8.18

Reliability coefficients and standard errors of measurement for Columbia Mental Maturity Scale

Age range	N	Split-half correlation r_{tt}	Significance level p	SE_m
5-12	125	·97	$< \cdot 01$	2·71
11-12	26	·90	$< \cdot 01$	5·65
9-10	31	·93	$< \cdot 01$	2·64
7- 8	31	·96	$< \cdot 01$	2·97
5- 6	37	·98	$< \cdot 01$	4·75

Although abnormally distributed, the CMMS results were highly reliable (Table 8.18). There was no significant relationship with hearing loss (Table 8.19).

TABLE 8.19

Correlation between Hearing Loss and Columbia Mental Maturity Scale IQ

Age range	5-12
N	125
Correlation coefficient	$r_b = \cdot 04$
Significance level	$p > \cdot 05$

TABLE 8.20

Correlations between Columbia Mental Maturity Scale and WISC (Perf.)

Age range	N	Correlation Coefficient r	Significance level p
5-12	125	.52	< .01
11-12	26	.61	< .01
9-10	31	.67	< .01
7- 8	31	.74	< .01
5- 6	37	.67	< .01

Although the CMMS IQ were very much lower than the WISC (Perf.) IQs, there was a moderately high relationship between the two tests (Table 8.20). The subjects who had high WISC (Perf.) IQ tended to have relatively high score in the CMMA.

The CMMS results also correlated moderately highly with both the criteria of educational progress (Tables 8.21, 8.22; Figure 8.6).

TABLE 8.21

Correlations between Columbia Mental Maturity Scale IQ and placement in A or B stream

Age range	N	Correlation Coefficient r_b	Significance level p
5-12	106	·55	$< \cdot 01$
11-12	22	·54	$< \cdot 01$
9-10	29	·65	$< \cdot 01$
7- 8	27	·58	$< \cdot 01$
5- 6	28	·55	$< \cdot 01$

TABLE 8.22

Relationship between Columbia Mental Maturity Scale IQ and Certificate of Secondary Education results

N	52
Correlation coefficient	$r_b = \cdot 59$
Significance level	$p < \cdot 01$
Index of forecasting efficiency	E = 19 per cent

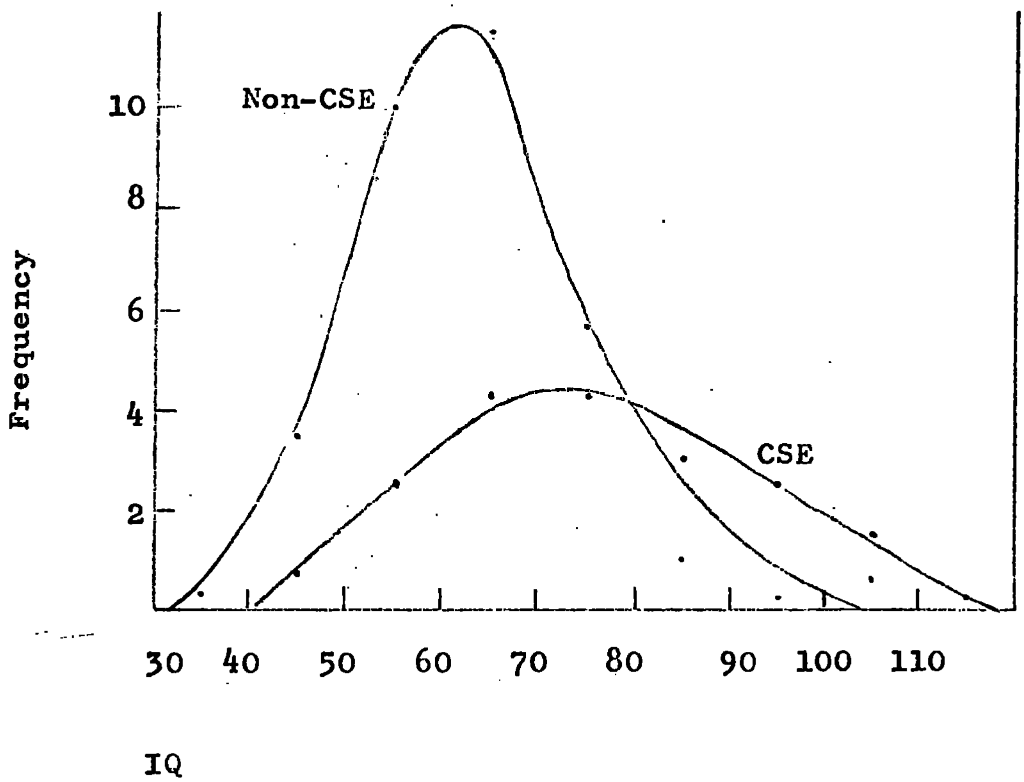


FIG. 8.6 Smoothed frequency distribution curves of Columbia Mental Maturity Scale IQs for CSE and Non-CSE groups. (N = 52)

Goodenough-Harris Drawing Test results

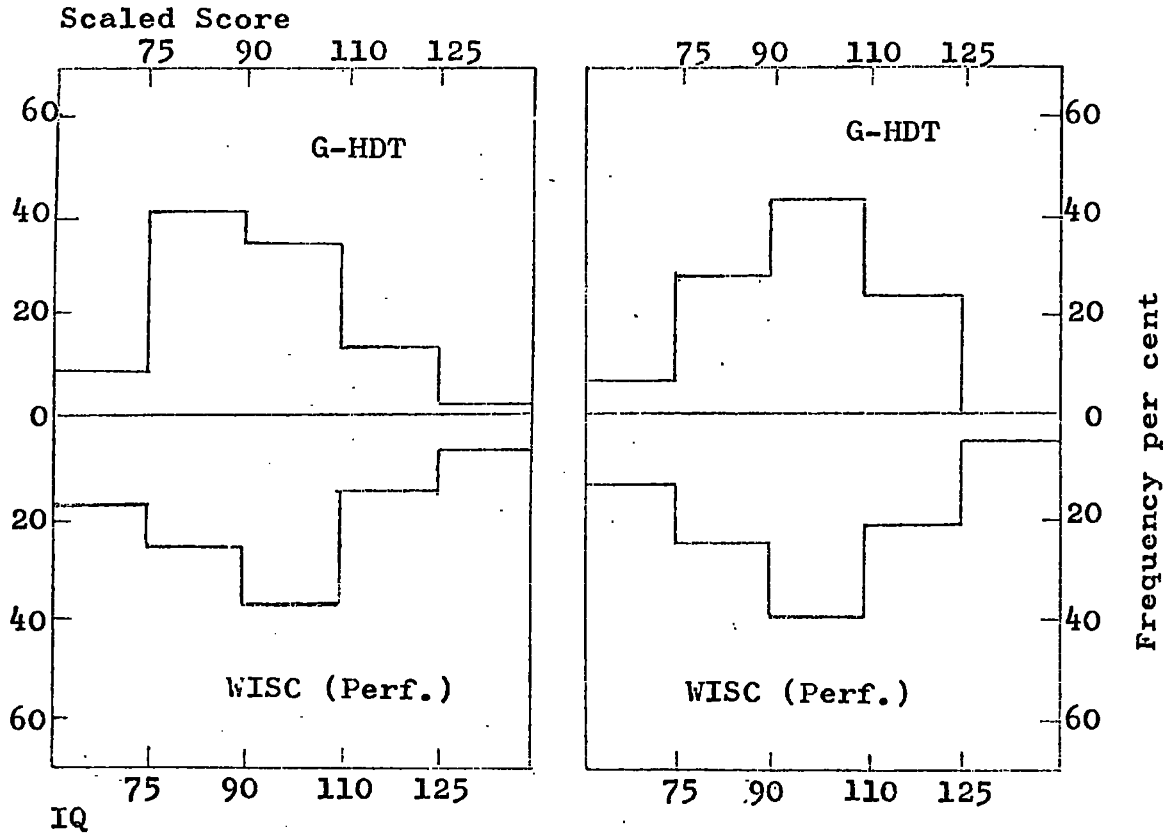
TABLE 8.23

Percentage frequency distributions of Goodenough-Harris Drawing Test results

Age range	N	Scaled Score:	below 75	75-89	90-109	110-124	125 over
5-12	125		8	35	38	18	1
9-12	57		7	28	42	23	0
5- 8	68		9	41	35	13	1
Expected distribution = (according to norms)			5	20	50	20	5

The distribution of G-HDT Standard Scores was reasonably closely comparable to the distribution of WISC (Perf.) IQs, although slightly less widely spread.

The distribution for the older subjects, aged 9-12 years, was particularly satisfactory in this respect. This is shown clearly in Figure 8.7.



Age 5-8 (N = 68)

Age 9-12 (N = 57)

FIGURE 8.7 Histograms showing distributions of Goodenough-Harris Drawing Test and WISC (Perf.) results for the two age groups.

TABLE 8.24

Mean standard scores and standard deviations for Goodenough-Harris Drawing Test

Age range	N	Mean	SD
5-12	125	93·7	15·06
11-12	26	97·2	15·16
9-10	31	94·7	14·12
7- 8	31	95·7	16·40
5- 6	37	88·8	13·21

At all age levels the mean G-HDT scores compared very closely with the corresponding WISC (Perf.) means. When tested statistically, none of the differences were significant.

The dispersion of scores was slightly less than was the case with WISC (Perf.), and the difference between the standard deviations reached significance at the 5 per cent level.

TABLE 8.25

Reliability coefficients and standard errors of measurement for Goodenough-Harris Drawing Test

Age range	N	Split-half Correlation r_{tt}	Significance level p	SE_m
5-12	125	·97	< ·01	2·56
11-12	26	·94	< ·01	3·64
9-10	31	·95	< ·01	3·12
7- 8	31	·95	< ·01	3·61
5- 6	37	·83	< ·01	5·42

There was satisfactorily high internal consistency reliability of G-HDT scores (Table 8.25). Hearing loss was not significantly related to G-HDT results (Table 8.26).

TABLE 8.26

Correlation between Hearing Loss and Goodenough-Harris Drawing Test

Age range	5-12
N	125
Correlation Coefficient	r_b = ·11
Significance level	$p > ·05$

TABLE 8.27

Correlations between Goodenough-Harris Drawing Test and WISC (Perf.)

Age range	N	Correlation Coefficient r	Significance level p
5-12	125	.73	$< .01$
11-12	26	.65	$< .01$
9-10	31	.69	$< .01$
7- 8	31	.79	$< .01$
5- 6	37	.71	$< .01$

It can be seen, from Table 8.27, that, in addition to the close comparability of level and distribution found between the G-HDT scores and WISC (Perf.) IQs, there was also a high correlation between the two tests. Subjects with high WISC (Perf.) IQs tended to have high G-HDT scores.

TABLE 8.28

Correlations between Goodenough-Harris Drawing Test and placement in A or B stream

Age range	N	Correlation co-efficient r_b	Significance level p
5-12	106	.68	$<.01$
11-12	22	.76	$<.01$
9-10	29	.77	$<.01$
7- 8	27	.66	$<.01$
5- 6	28	.81	$<.01$

The correlation between G-HDT score and A or B stream placement was high (Table 8.28). The test was a good predictor of educational progress according to this criterion.

It is noteworthy that the correlation in the case of the younger children, aged 5-6 years when originally tested, was particularly high.

TABLE 8.29

Relationship between Goodenough-Harris Drawing Test and Certificate of Secondary Education results

N	52
Correlation Coefficient	$r_b = \cdot 69$
Significance level	$p < \cdot 01$
Index of forecasting efficiency	E = 27 per cent

Table 8.29 indicates that the G-HDT also had high validity for predicting educational progress as determined by performance in the CSE Examination.

The level of correlation indicates that almost 50 per cent of the variance in CSE success is accounted for by G-HDT score.

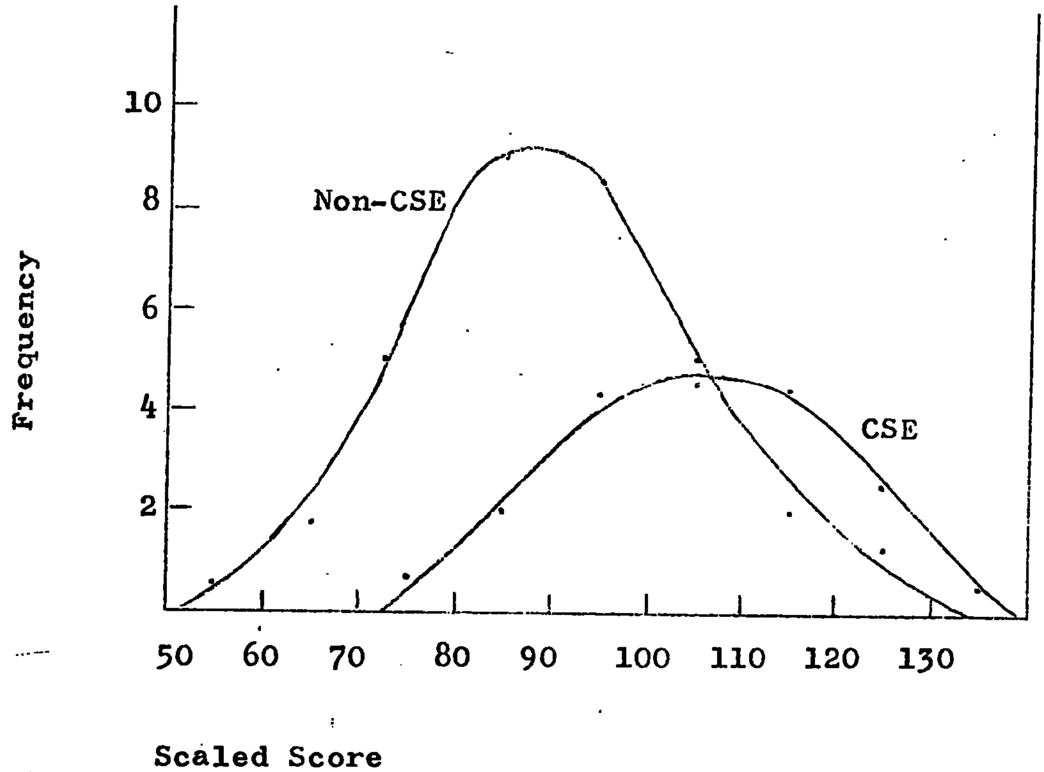


FIG. 8.8 Smoothed Frequency distribution curves of Goodenough-Harris Drawing Test scores for CSE and Non-CSE groups. (N = 52)

In Figure 8.8 the intersection of the distribution curves occurs at the same point as in the case of WISC (Perf.) This indicates that children with G-HDT scores above 105 are likely to be in the CSE group.

Multiple prediction of CSE performance

The results presented in Tables 8.1 to 8.29 provide information to answer the original specific aims, or questions, as set out in Chapter 7. These results include the correlations between the test and performance in the Certificate of Secondary Education examination. The correlations might be considered to be of a high order for predictive measures, ranging from ·59 to ·81, and this raises the additional question whether the predictive strength might be raised further by using combinations of two or more of the tests.

To answer this question a study was made of the multiple correlations with CSE performance. The multiple correlation represents the maximum association between the dependent variable and a combination of independent variables. The two main principles which determine the size of the multiple correlation are that (1) it increases as the size of correlations between independent and dependent variables increase and (2) it increases also as the size of intercorrelations of the independent variables decrease. A maximum multiple correlation will be obtained when independent variables are included which correlate highly with the dependent variable but have low intercorrelations.

In order to ascertain the likelihood that combinations of tests will yield multiple correlations, which improve the predictive strength, an examination of intercorrelations between tests is required. These are set out in Table 8.30. Hearing loss is also included as a predictive variable.

TABLE 8.30

Intercorrelations between tests and correlations with CSE results. N = 52

Variable		X_2	X_3	X_4	X_5	X_6	X_1
X_2	WISC	-	·72	·62	·78	·22	·81
X_3	CPM	·72	-	·54	·59	·22	·70
X_4	CMMS	·62	·54	-	·51	·04	·59
X_5	G-HDT	·78	·59	·51	-	·20	·69
X_6	Hg.Loss	·22	·22	·04	·20	-	·23
X_1	CSE	·81	·70	·59	·69	·23	-

Note: None of the correlations with hearing loss are significant ($p > \cdot 05$). All other correlations are significant ($p < \cdot 01$).

An examination of Table 8.30 shows that the test which has the highest correlation with CSE (viz, WISC, $r_b = \cdot 81$) also intercorrelates highly with the other tests. On the other hand, the test which has the lowest correlation with CSE (viz, CMMS, $r_b = \cdot 59$) tends to have lower intercorrelations with other tests. Hearing loss is not significantly intercorrelated with any of the tests, but it also lacks correlation with the criterion. This does not give rise to promise that the combination of tests will lead to improvement in the level of predictive strength.

Multiple correlations were calculated, but no combination of tests produced any significant improvement over the multiple correlations from reduced numbers of tests or the correlation with the WISC on its own. When all four tests and hearing loss were combined the multiple correlation showed a negligible increase of ·01 over the correlation for WISC alone. The F measure for this difference was ·176, which did not approach a level of significance.

Chapter 9

DISCUSSIONS AND CONCLUSIONS

Before commencing a discussion of the results of the investigation, it will be useful to recall the general aims. The research was carried out with deaf children, some of whom had additional handicaps. Their linguistic growth and progress in school subjects will be influenced by variables connected with the handicap. Level of intelligence is likely to be an important factor in their development, but the extent and nature of this influence might not necessarily be identical to the contribution that intelligence plays in the development of hearing children. There are special difficulties in the measurement of the intelligence of deaf children. Verbal tests are not strictly appropriate, but tests which can be administered readily and require a non-verbal response might yield results with deaf children different from those obtained with hearing children. It is therefore necessary to select tests that can be applied easily to the deaf and to assess their value when used with deaf children.

The tests selected for this investigation are evaluated on the basis of suitability for ease of non-verbal administration, reliability at the time of testing, and validity for predicting future educational development and success in school work. All the tests used were considered by the writer to be generally suitable for easy administration, particularly by a tester competent in communicating with deaf children. The only noticeable difficulties occurred with the timed items of the WISC (Perf.) for some children who had problems of motor-coordination, and with the Coding sub-test which was difficult for some of the very young children to understand.

The results of each of the tests are discussed before making a general comparison.

9.1 Hearing Loss

The pure-tone audiometric test divided the sample equally, half of the subjects having hearing losses up to 90 decibels and half having hearing losses of 95 decibels upwards. This distribution of hearing losses is similar to distributions reported in schools for the deaf at the time that some of the main studies using non-verbal intelligence were being carried out (Van der Meer, 1957; Dale, 1960; Ewing, 1962).

A hearing loss of about 90 decibels is considered by some authorities to be the limit of useful hearing for speech. Davis (1947) regards a loss of 90 decibels (for the frequency range 500 to 2000 Hz.) as constituting 'total impairment for everyday speech', and Hudgins (1960) also considered this to be the level of profound deafness. Van Uden (1962, p.9) states that this level of hearing loss over these frequencies 'is the real barrier of deafness'.

No significant correlations were found between degree of hearing loss and the results of any of the intelligence tests. This finding is in agreement with previous research. Hood (1949), using the Alexander Performance Scale, Kendall (1957), with the Merrill-Palmer test, and Zorska and Smolenska (1969), who used the Leiter International Scale, all reported lack of relationship between hearing loss and performance IQ. Glowatsky (1953), L.J. Murphy (1957), Pickles (1966) and De Marco (1970) all found that degree of hearing loss had no significant influence on WISC (Performance) results.

The present finding supports the statement by Ewing (1957, p.317) that

> 'there is no positive correlation between degree of deafness, as determined by pure-tone tests of auditory acuity and performance IQs'.

These findings, of course, apply to particular test results within groups of deaf children, and do not necessarily indicate lack of difference in intelligence between groups of deaf and hearing children or between different types of test. The mean scores found for the Coloured Progressive Matrices and the Columbia Mental Maturity Scale were below the normal for hearing children and lower than the other test means but within the sample there was no significant correlation with hearing loss. The implication is that is is 'deafness' (as a linguistic handicap) that influences some types of mental ability, rather than degree of hearing loss being correlated with the results of a particular intelligence test amongst a group of deaf children.

The relationship between hearing loss and WISC (Perf.) results was not statistically significant ($r_b = 0{\cdot}1$, $p > {\cdot}05$), but it is noteworthy that the slight correlation obtained was in the direction of higher intelligence going with more severe hearing loss. This is probably explained by the presence in the sample of a small number of children with moderate hearing losses who had been placed in the school for the deaf because of poor level of attainment, due probably in part to innate dullness. The twelve children with hearing losses less than 65 decibels had a mean WISC (Perf.) IQ of 88·9. This is a similar position to that reported by Gaskill (1957). He found, in a study of 180 children in schools for the deaf, that those children with hearing losses less than 60 decibels were below average in intelligence. Gaskill (p.211) considered that this was due to 'selective influences in enrolment', such as educational failure in ordinary schools.

The general conclusion to be drawn from the results of this investigation, which are in close agreement with previous studies, is that degree of hearing loss has no significant correlation with non-verbal intelligence amongst children within a school for the deaf. Hearing loss was also lacking in any significant correlation with progress and attainment in school work.

9.2 <u>WISC (Perf.)</u>

The positively skewed distribution of WISC (Perf.) results, with a mean IQ (for the whole sample) that was five points below normal for hearing children, raises the question of the accuracy of the norms (which were standardised on American hearing children, Wechsler, 1949) for use with British deaf children.

L.J. Murphy (1952) had concluded, on the basis of his investigation with a sample of deaf children, that it was not necessary to re-standardise the norms for use with the deaf. The subjects of Murphy's study were drawn from a total of thirteen schools for the deaf and units for the partially hearing and the sample was claimed to be a representative of children with impaired hearing.

The sample of this investigation, however, is not claimed to be strictly representative of all deaf children (including those in Partially Hearing Units) but is considered to be typical of the children found in schools for the deaf at the present time. A number of factors have been described (Chapter 2) that can have a lowering influence on the level of intelligence of a sample based on the population of a school for the deaf. All of these factors (viz. 1. The effects of brain injury, 2. the placement of borderline partially hearing children, 3. the transfer of children with good attainment) operated in the case of this sample.

There were twelve children in the sample who had conditions associated with brain injury and four children formally classified as partially hearing. The mean WISC (Perf.) IQ of this group of 16 subjects was below 80, whereas the mean IQ for all other subjects was 99. The majority of the brain-injured children were in the youngest age group, 5 to 6 years. The mean WISC (Perf.) IQ of this group was 89·6, in contrast to a mean of 97·8 for the oldest group.

The overall finding of a mean IQ below the normal for hearing children is consistent with that reported by Dale (1967), who used the WISC (Perf.) test with the pupils at a school for the deaf in New Zealand. He found a mean IQ of 90, and considered (p.24) that this

> 'would appear to be a reasonable figure since some of the conditions which cause deafness, e.g. German Measles in the mother during pregnancy, and cerebral palsy, sometimes also cause other handicaps which include mental retardation. In addition partially hearing children who are slow-learning often require full-time special educational treatment whilst bright ones can cope in ordinary schools'.

The distribution of WISC (Perf.) results is similar to that obtained in a recent survey carried out by the Department of Education and Science of fifteen year old children in schools for the deaf in England and Wales, in which 66 per cent of cases had IQs of 100 or below (Simpson, 1965). In the present study 63 per cent of the subjects had IQs of 100 or below.

The measures of reliability were satisfactorily high. The overall internal consistency coefficient and the standard error of measurement (r_{tt} = ·96; SE_m = 3·55) were as good as the estimates obtained in Wechsler's (1949, p.13) original standardisation (e.g. for ten year old children these were r = ·89, SE_m = 4·98).

The correlations between WISC (Perf.) results and later progress and attainment in school work, as measured by educational stream placement and attainment in the Certificate of Secondary Education examination (viz. $r_b = \cdot78$ and $r_b = \cdot81$, respectively), can be regarded as good levels of predictive validity. There is lack of previous information with which to make a direct comparison of forecasting effic iency although L.J. Murphy (1957) obtained teachers' subject ratings of academic ability, and found these to correlate $r = \cdot64$ with WISC (Perf.) results. Pickles (1966) found the WISC (Perf.) IQ of slow-learning deaf children to correlate $r = \cdot61$ with current classroom performance.

The findings with the WISC (Perf.) lead to the conclusion that it is, in general, a suitable test of intelligence for deaf children, giving reliable results which have useful validity for predicting educational progress. The test was not completely satisfactory for the five and six year old subjects and also for those children with physical handicaps who had some difficulty in carrying out items which require motor coordination. This emphasises the need to find a supporting test that yields comparable results, whilst still being specially suitable for use with the difficult cases.

As the three other tests are being examined in the light of their suitability as a supporting or alternative test to the WISC (Perf.), the results will be discussed in relation to the WISC (Perf.) results, rather than in strict comparison only with the norms for hearing children.

9.3 Coloured Progressive Matrices

In the case of the CPM results, there was a consistent age difference. The distribution of scores for the older subjects (9 - 12 years) was quite similar to their WISC (Perf.) distribution, with 37 per cent of cases scoring below normal, i.e. below equivalent IQ 90 (which is almost identical to the percentage scoring below normal in the WISC (Perf.) distribution). This distribution is closer to the norm for hearing children than the results of those investigations of the Standard Progressive Matrices with deaf children, which reported distributions with from 43 per cent to 63 per cent of cases scoring below normal (Ewing and Stanton, 1943; Oléron, 1950; Gaskill, 1952; Denmark, 1952; Evans, 1966).

The results for the younger subjects (5 - 8 years) were, however, less satisfactory, having a skewed distribution in which 57 per cent of subjects scored below normal (compared with 43 per cent in the WISC (Perf.) Test).

The level of reliability was also higher for the older subjects.

A high relationship was found between CPM scores and WISC (Perf.) IQ for the oldest age group (11 - 12 years). This was exactly the correlation that Gaskill (1957) reported between these two tests for children in a school for the deaf. The correlation for the younger age groups (aged 5 - 8 years) was, however, lower.

The measure of predictive validity, based on educational streaming, was acceptably high for the oldest children, but for the youngest subjects the correlation failed to reach significance at the ·05 level. A high validity coefficient with Certificate of Secondary Education attainment (r_{cos-pi} = ·70) was a consistent finding, as this measure involved only the older age group.

The age differences in CPM results are illustrated in Table 9.1.

TABLE 9.1

Comparison of measures of reliability, relationship with WISC (Perf.), and predictive validity (with educational streaming) of the Coloured Progressive Matrices results for the oldest and youngest age groups.

Age range		11 - 12 years		5 - 6 years		
		correlation	p	correlation	p	
Reliability	r_{tt}	·92	<·01	·73	<·01	
Relationship with WISC (Perf.)	r_{pbi}	·83	<·01	·56	<·01	
Validity	r_{cos-pi}	·55	<·01	·35	>·05	NS

Gaskill (1957), who had found deaf children to be retarded in the Standard Progressive Matrices, obtained more satisfactory results with the Coloured Progressive Matrices and concluded (p.193) that

> 'this version...... appears to have more promise for use with deaf children'.

The results of this investigation tend to support this statement, as far as the results for the older subjects were concerned. From the correlations in Table 9.1, together with the distributions of results (Table 8.10 and Figure 8.3), a pattern emerges that leads to the conclusion that the Coloured Progressive Matrices Test is a suitable test when used with deaf children in the age range 9 - 12 years, but is not satisfactory for use with younger children.

9.4 Columbia Mental Maturity Scale

The CMMS results had good reliability, and were also moderately highly correlated with educational progress.

There was, however, a very abnormal distribution of results. The mean IQ was very much lower than the mean WISC (Perf.) IQ. This discrepancy varied with age, the greatest retardation occurring in the older age levels (this being the reverse position to the CPM results, in which the younger subjects scored low in comparison with WISC (Perf.) results). Over 75 per cent of the children in the 9 - 12 year range had CMMS IQs below 75. According to the norms for hearing children five per cent of cases should be expected to score as low as this (Burgemeister, Blum and Lorge, 1954). The test offered virtually no discrimination between the individual abilities of this large proportion of subjects. It was observed, in the administration of this test, that after a successful start on the initial items, a 'ceiling' was reached rather abruptly, above which the subjects experienced failure, and this point was, in general, the same for all subjects irrespective of age. This accounts for the relatively greater retardation in the older subjects.

On this evidence of those results, this test can not be considered to be a suitable measure of the general intelligence of deaf children.

9.5 Goodenough-Harris Drawing Test

The G-HDT results were satisfactory in respect of all the criteria of suitability applied, and for all age groups.

The level of scoring was closely comparable to the WISC (Perf.), the distributions being similar, and there was no significant differences between means.

There was close relationship with the WISC (Perf.) results (approximately r = ·7 for all ages). This correlation was higher than that found between G-HDT and some of the WISC sub-tests in a study carried out with hearing children in Britain (Yule, Lockyer and Noone, 1967).

The predictive validity was high, and it is important to note that this applied particularly for the youngest group of subjects. The 'critical point' of maximum accuracy for forecasting attainment in the CSE examinations is approximately the same for both the G-HDT and the WISC (Perf.) tests (see Figures 8.2 and 8.8). Children with WISC (Perf.) IQs or G-HDT scores above 105 are likely to succeed in CSE.

These findings indicate that the G-HDT yields comparable results to the WISC (Perf.). As a testing technique it was admirably suitable for administering to deaf children, and proved to have the following features in its favour:

1. The idea of drawing a man was easily conveyed, and readily understood by the children.
2. The drawing task was carried out with enjoyment and enthusiasm by the children.
3. No verbal response was required.
4. The test usually took just a few minutes to complete.
5. There was no evidence of fatigue.
6. The children were under no pressure of working at speed.
7. Motor-coordination played no crucial part in the test.

There is a further feature of the drawing technique of special interest. Young children might be expected to produce drawings of a man from time to time, either quite spontaneously, or with some lead from the class teacher. If for some reason a child will not make a drawing when required in a 'test' situation, there is the possibility that a drawing made at some other time might be preserved for formal scoring.

One point is of particular importance. A number of the very young children, including some with additional physical handicaps, had been observed to have apparent difficulties when tested in some of the WISC (Perf.) items, and their resultant IQs were therefore slightly under-estimates of their true ability. These children had no special difficulty in carrying out the drawing test. Their G-HDT scores were higher than their WISC (Perf.) IQs, and were possibly more accurate estimates of intelligence.

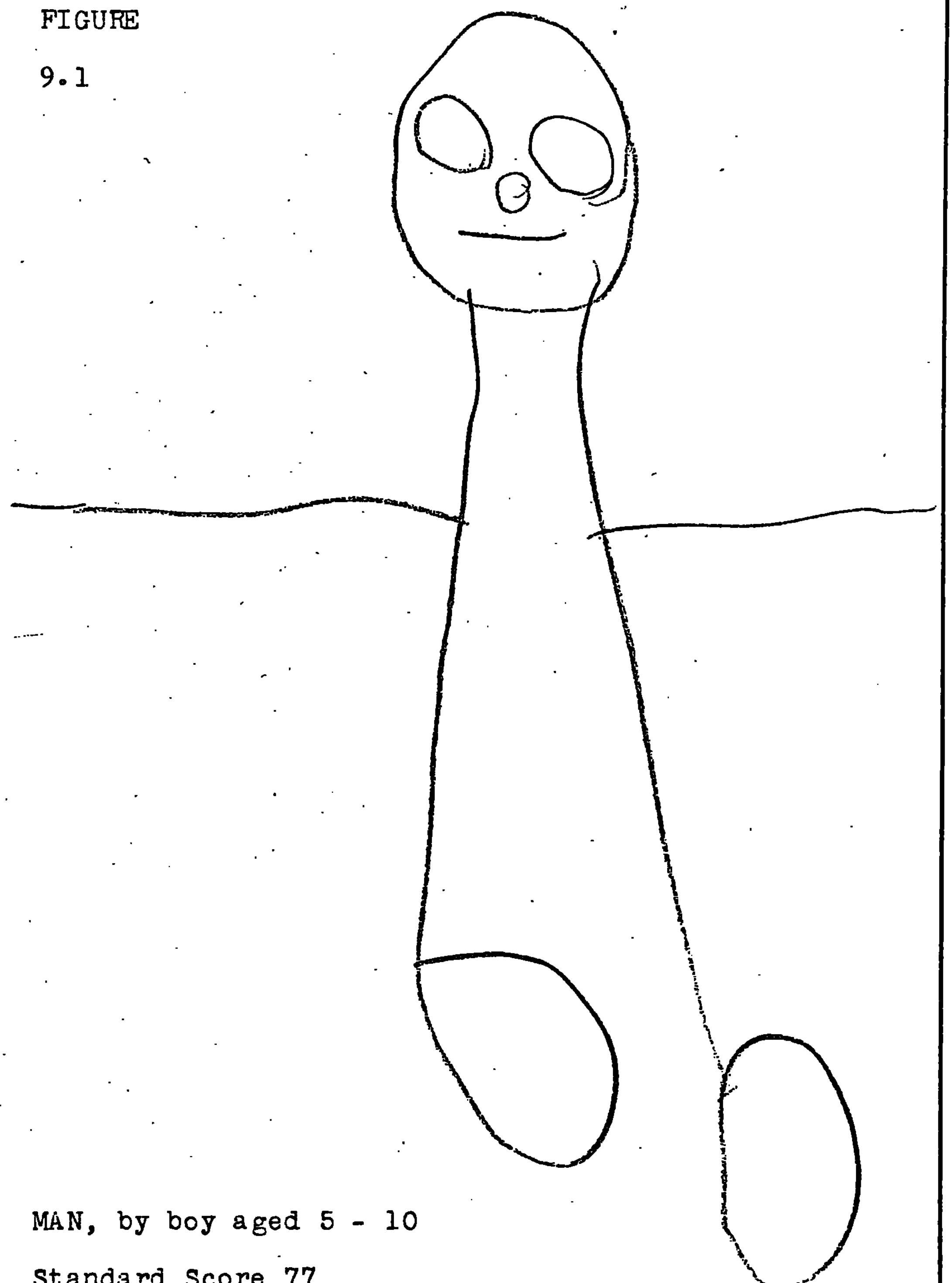
A test as simple and brief as the drawing technique can not be regarded as a full substitute for the WISC (Perf.) with its wealth of materials to sample a range of abilities, but the findings of this investigation suggest that the G-HDT offers promise as a suitable comparable test for use as an alternative when the WISC (Perf.) can not be applied, or as a supporting test.

Of the three tests evaluated with the WISC (Perf.), the G-HDT is considered to be the most suitable. There is evidence that this test is already becoming quite widely used in schools for the deaf in the United States. A survey of psychological tests currently used in 76 schools for the deaf (Levine, 1974) revealed that the WISC (Perf.) was the most widely used intelligence test (57 schools). The G-HDT ranked fourth in order of frequency (after the Leiter International Scale and the Hiskey-Nebraska Test of Learning Aptitude), being used in 25 schools.

The progression of the drawings with age and intelligence is illustrated in a series of examples which follow (Figures 9.1 to 9.16). Two drawings are included at each age level from five years to twelve years, one by a child below average in intelligence as measured by the G-HDT and one above average. The WISC (Perf.) IQs are also given, to indicate the agreement with the G-HDT scores.

FIGURE

9.1

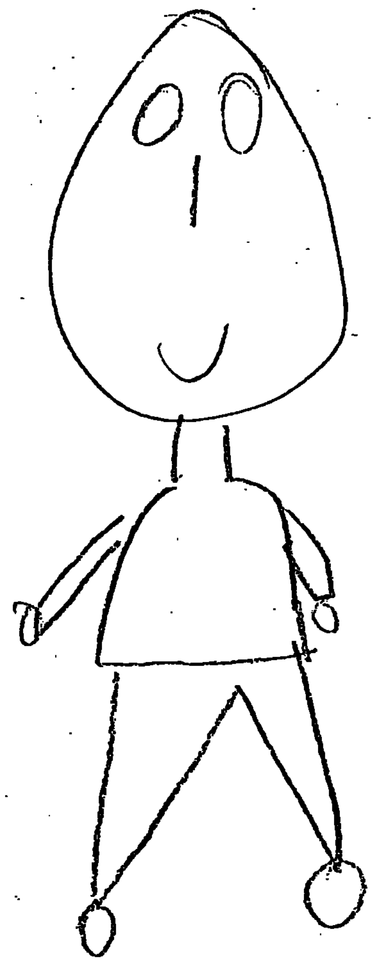


MAN, by boy aged 5 - 10

Standard Score 77
WISC (Perf.)IQ 76

FIGURE

9.2



MAN, by boy aged 5 - 6

Scaled Score 107
WISC (Perf.) IQ 113

FIGURE

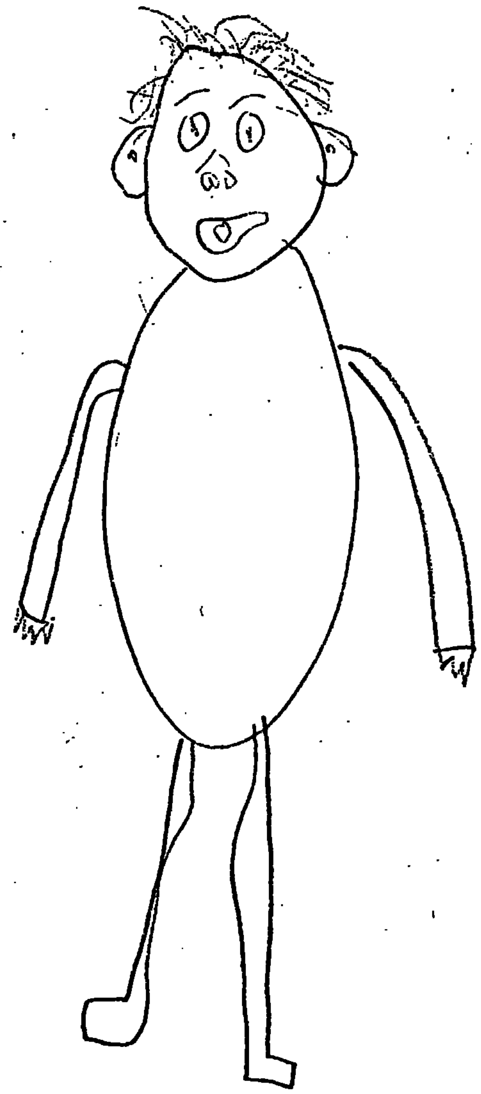
9.3

MAN, by girl aged 6 - 8

Scaled Score 77
WISC (Perf.) IQ 76

FIGURE

9.4

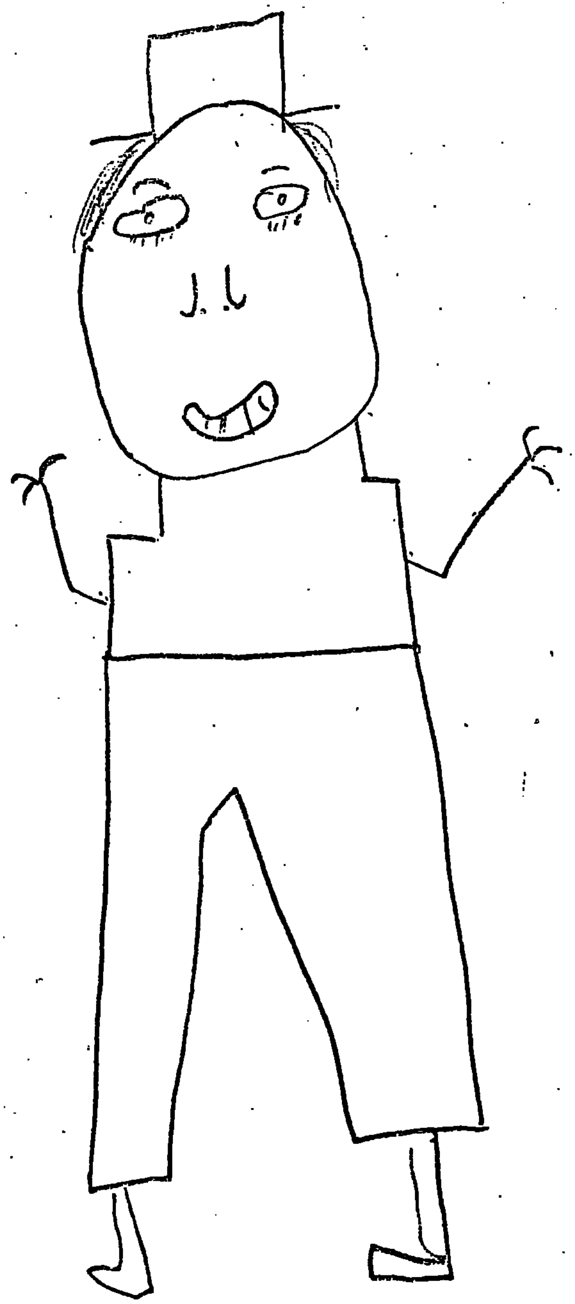


MAN, by boy aged 6 - 0

Scaled Score 115
WISC (Perf.) IQ 122

FIGURE

9.5

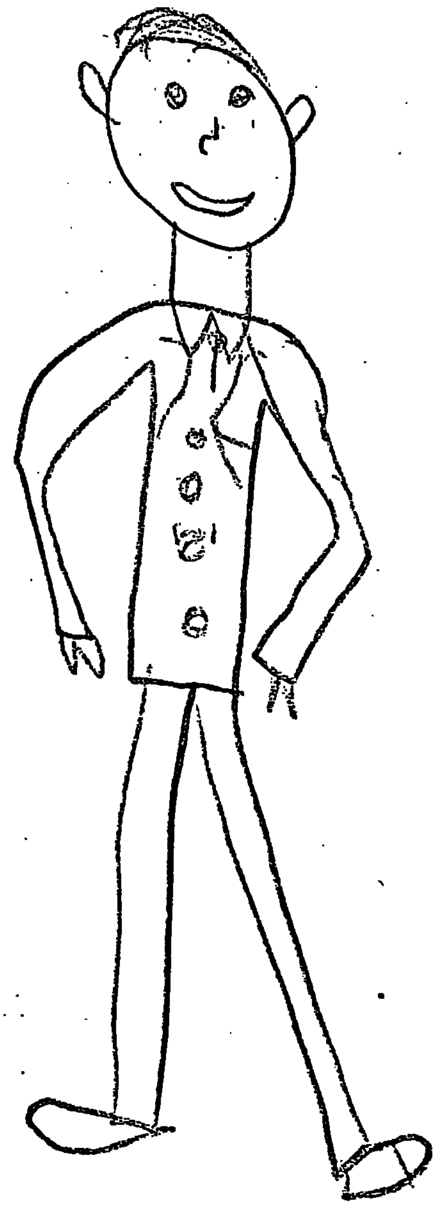


MAN, by girl aged 7 - 9

Scaled Score 101
WISC (Perf.) IQ 97

FIGURE

9.6

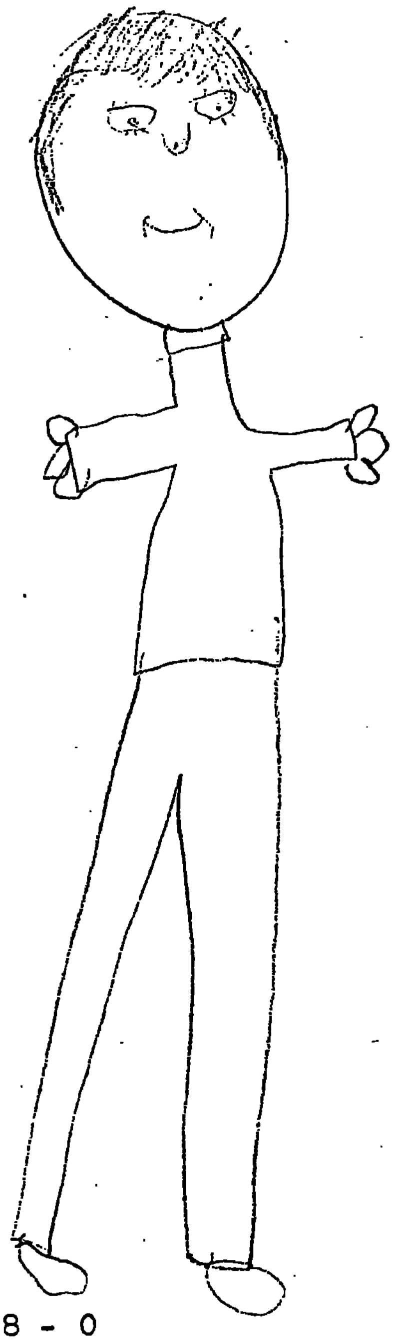


MAN, by girl aged 7 - 11

Standard Score 110
WISC (Perf.) IQ 107

FIGURE

9.7

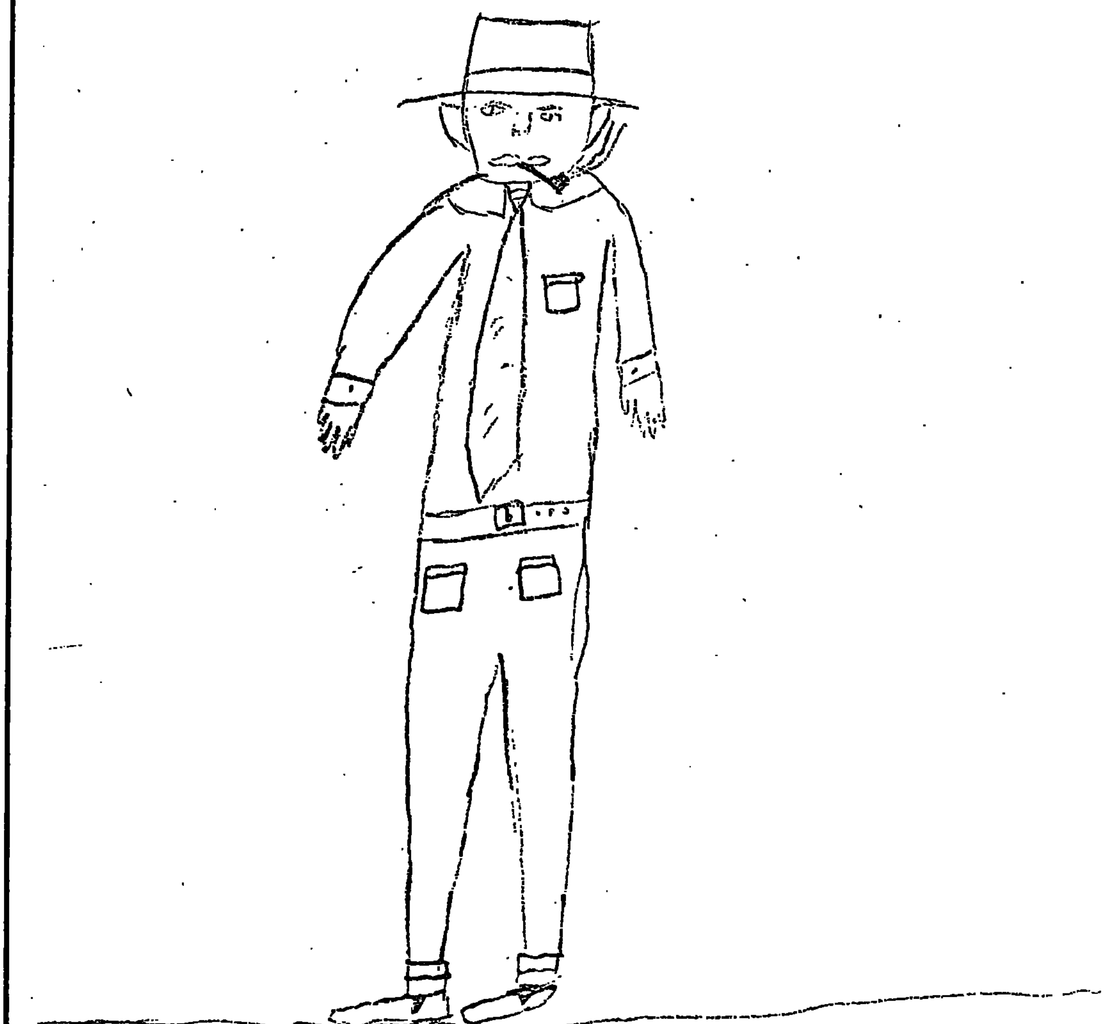


MAN, by girl aged 8 - 0

Scaled Score 99
WISC (Perf.) IQ 100

FIGURE

9.8

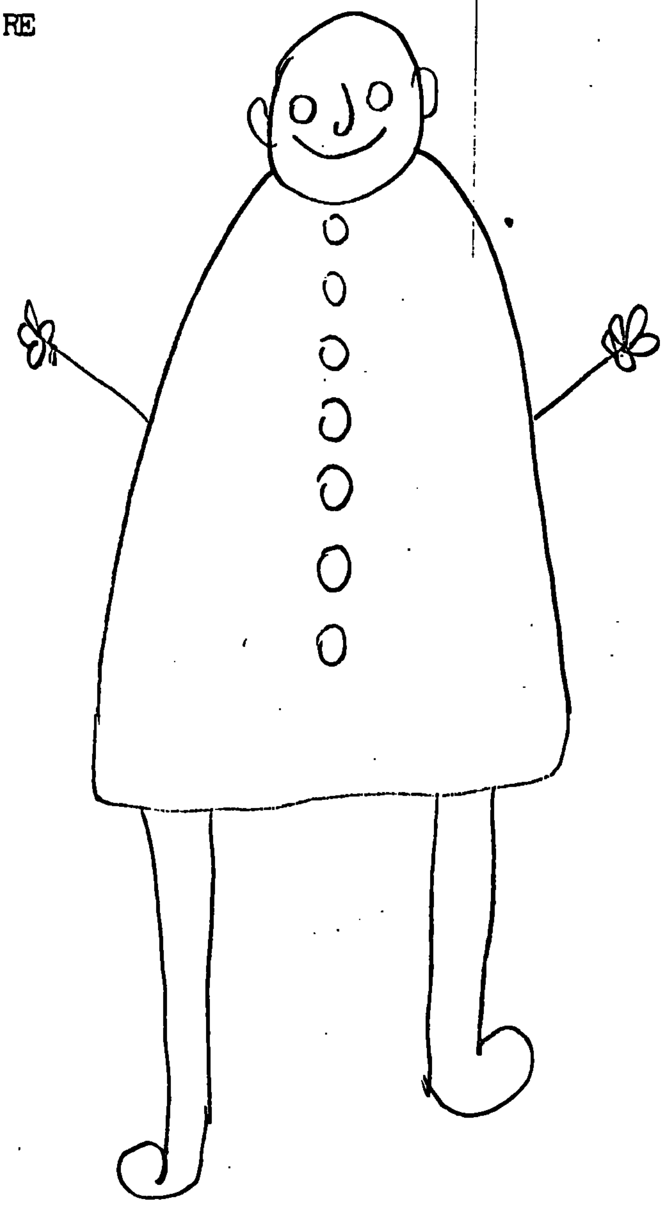


MAN, by boy aged 8 - 9

Scaled Score 127
WISC (Perf.) IQ 122

FIGURE

9.9

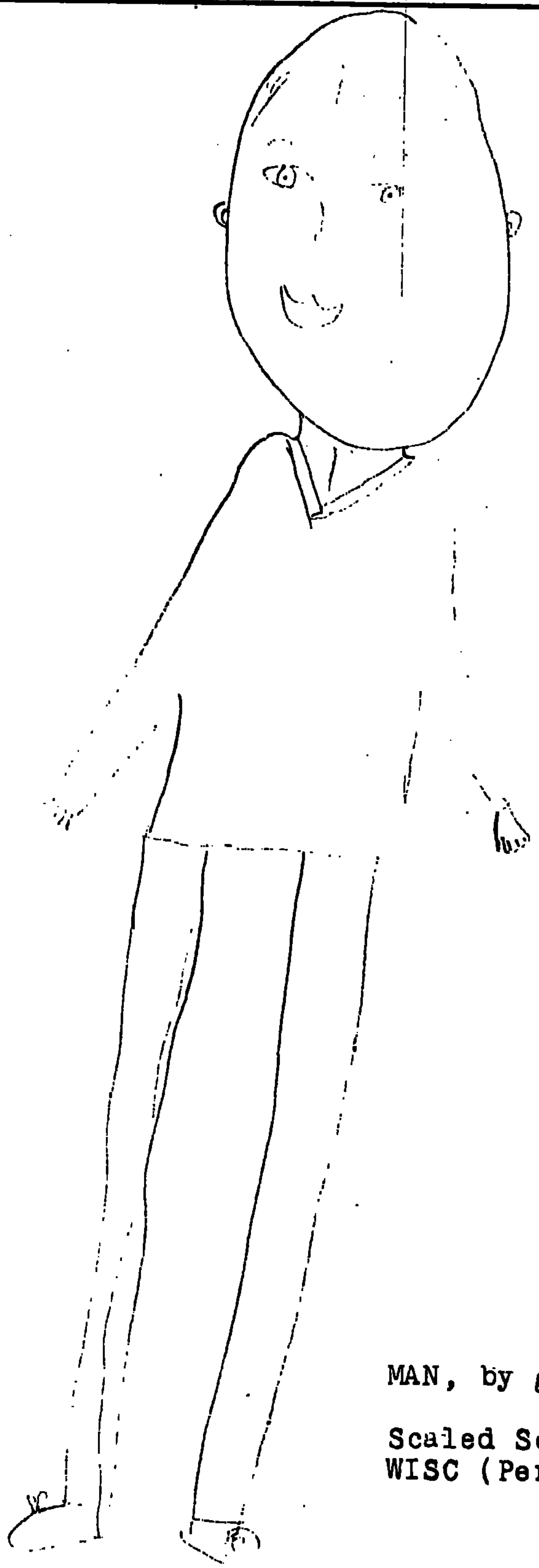


MAN, by boy aged 9 - 10

Scaled Score 82
WISC (Perf.) IQ 71

FIGURE

9.10

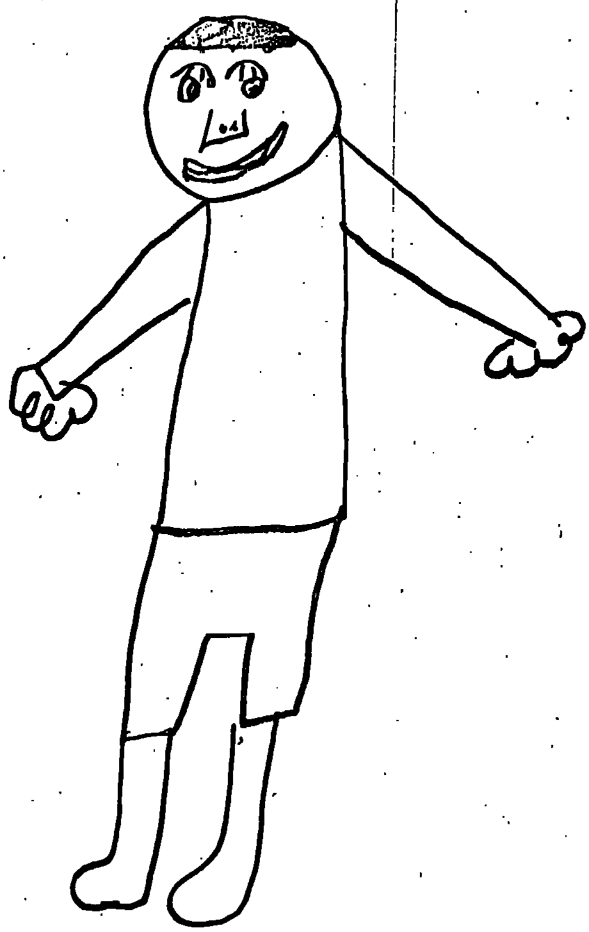


MAN, by girl aged 9 - 3

Scaled Score 100
WISC (Perf.) IQ 103

FIGURE

9.11

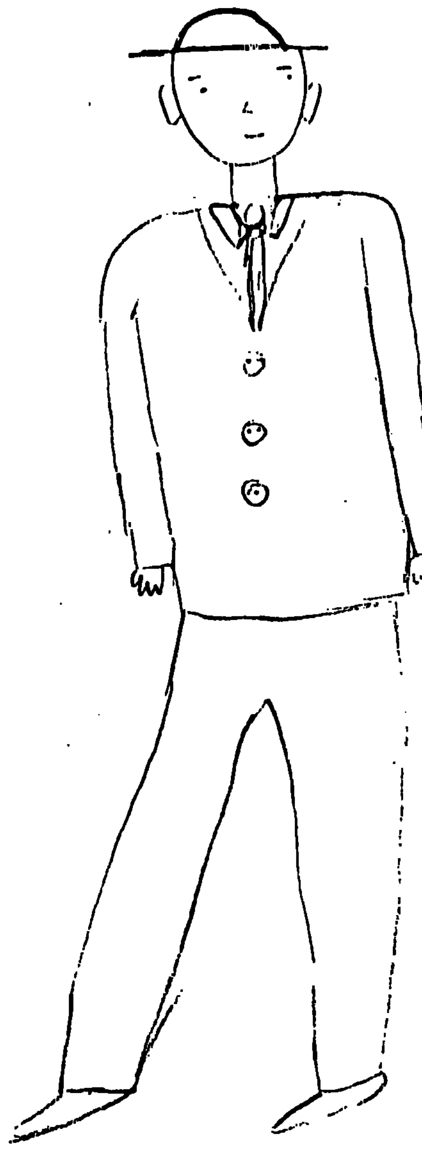


MAN, by girl aged 10 - 1

Scaled Score 74
WISC (Perf.) IQ 68

FIGURE

9.12

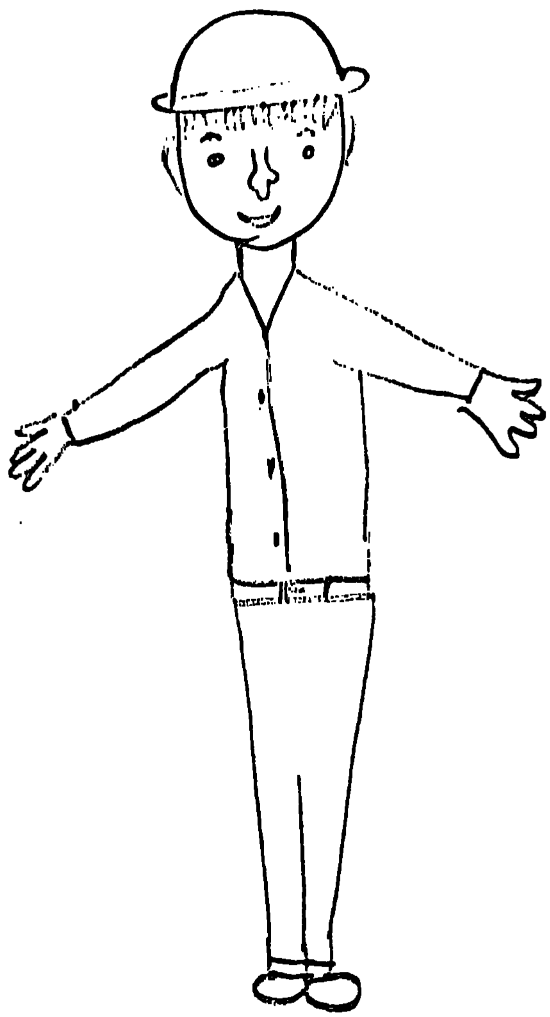


MAN, by girl aged 10 - 9

Scaled Score 91
WISC (Perf.) IQ 96

FIGURE

9.13

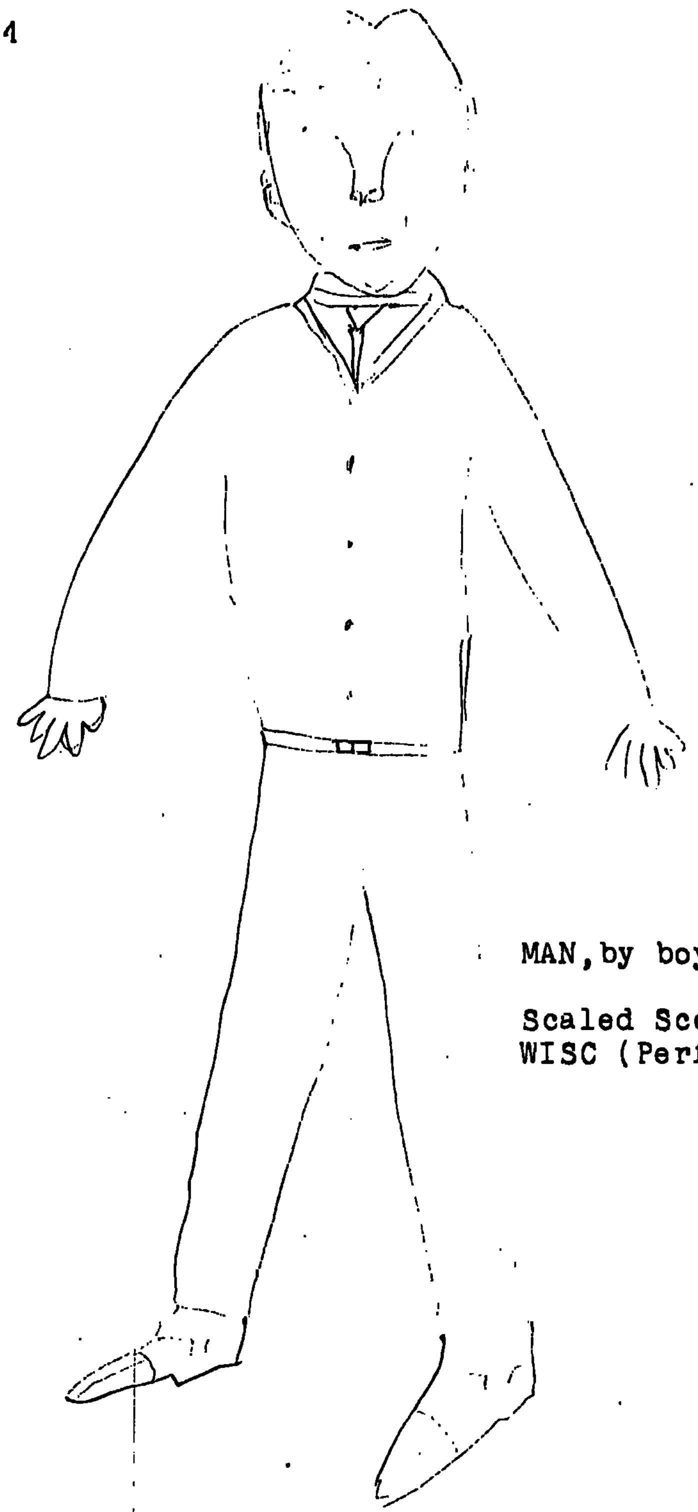


MAN, by boy aged 11 - 0

Scaled Score 101
WISC (Perf.) IQ 101

FIGURE

9.14

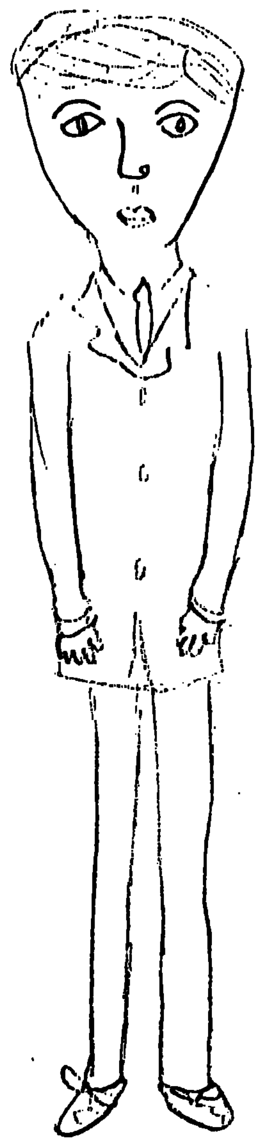


MAN, by boy aged 11-10

Scaled Score 116
WISC (Perf.) IQ 121

FIGURE

9.15

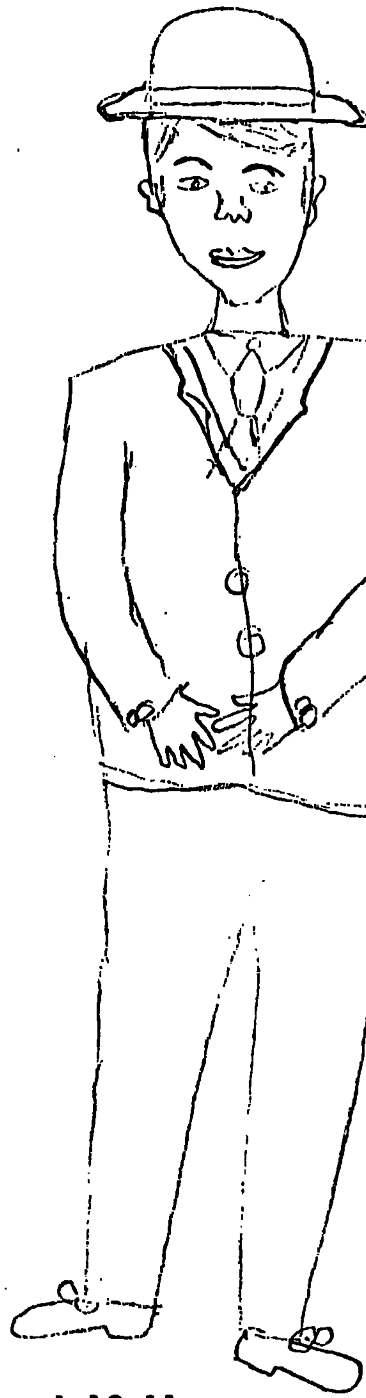


MAN, by girl aged 12-10

Scaled Score 100
WISC (Perf.) IQ 100

FIGURE

9.16



MAN, by girl aged 12-11

Scaled Score 113
WISC (Perf.) IQ 110

9.6 Comparison of the abilities measured by the tests

In the review of previous studies (Chapter 3), the comparison was brought out between tests in which deaf children score within normal limits and tests in which they score below normal. The point was made that the explanations of the discrepancies in test performances, in terms of the nature of the abilities measured, were based mainly upon the composite findings of various different studies. The one direct comparative study quoted was limited to two tests. The present investigation does, in fact, constitute a basis for directly comparing the abilities measured in four different tests.

The two tests in which the subjects of this study scored highest were the WISC (Perf.), which is widely regarded as an appropriate test of general ability in deaf children, and the G-HDT, which is claimed to correlate closely with individual performance tests (Harris, 1963). The mean IQs for these two tests were 95 and 94, respectively, but the explanation has been given of the special factors operating in the sample to 'depress' the general level of intelligence. When allowance is made for this, the results might be regarded as being consistent with the findings of previous researches which have indicated the normality of the population of deaf children as a whole when measured by performance type tests (Drever and Collins, 1928; Peterson and Williams, 1930; Heider and Heider, 1940; Ewing and Stanton, 1943; Myklebust and Burchard, 1945; Hood, 1949; Templin, 1950; Gaskill, 1952; L.J. Murphy, 1952; Glowatsky, 1953; Birch and Birch, 1956; Myklebust, 1953, 1958;

K.P. Murphy, 1956; Goetzinger and Rousey, 1957; Simpson-Smith, 1962; Brill, 1962; Evans, 1966; Hine, 1969).

The older subjects had Coloured Progressive Matrices results which were closely comparable to their WISC (Perf.) and G-HDT scores but the younger subjects, below the age of nine years, were retarded in the test. This suggests that a minimal amount of linguistic competence is required for the solution of these problems, which is delayed in deaf children. Raven (1960, p.1) states that the Coloured Progressive Matrices Test was designed to measure the level of ability before the capacity to reason by analogy has developed. It would seem that verbal symbolisation is involved at this level of reasoning, and the CPM Test should be regarded as 'non-verbal' only from the point of view of its administration and response.

The greatest degree of abnormality was found in the results of the CMMS. There was very severe retardation in the ability measured by this test. The authors of the test (Burgemeister, Blum and Lorge, 1954) describe it as involving a 'classification' type of activity. Previous research has pointed out the inferiority of deaf children in classification problems (Oléron, 1952, 1957; Vincent, 1957; Blair, 1957).

Reference has been made (in Chaper 3) to the inter-test variability on the five sub-tests of the WISC (Perf.). In the present investigation the highest performance was in the Block Design sub-test, with a mean score (expressed as equivalent IQ) of 103. The poorest performance was in Picture

Arrangement, with a mean IQ of 87. The discrepancy of 16 IQ points between these two sub-tests is similar to the differences recorded in the two studies of inter-test variability previously reported (L.J. Murphy, 1952; Evans, 1966) and also a study with educationally sub-normal deaf children (Pickles, 1966). The differences between Block Design and Picture Arrangement scores in the four studies ranged from 13 to 18 IQ points. The weak scoring in Picture Arrangement, which agrees with previous findings (Bindon, 1957; Myklebust, 1960; Luszki, 1965), reflects the difficulty deaf children experience in understanding temporal sequential relationships. The assumption has been made that the results for this sample underestimate the true level of WISC (Perf.) IQ for the total population of deaf children. If the mean Performance IQ for the sample of 95 is adjusted to the level recorded for the older age groups (which were comparatively free of the special factors), i.e. to IQ98, then the corresponding Block Design Score would be 106, which is the same as the previous findings for sample which were considered to be representative of the total deaf child population (L.J. Murphy, 1952; Evans, 1966).

Ewing (1957, p.321) who reported that deaf children do well in Block Design and similar tasks, has proposed that they succeed

> 'through having found a way of learning that deviates from normal'

and considers that this

> 'may be an instance of the capacity of human intelligence to make special use of residual resources, when deprived of the full range of ordinary ones'.

Pickles (1966, p.382) also suggests that

> 'loss of hearing may lead to a compensatory dependence on vision and enhance the development of some visual skills'.
>
> (An example exists, in the area of linguistic communication, of how deaf children are able to compensate for restricted capacity for normal communication, through hearing and speech, by developing skills in lipreading, fingerspelling or signing).

Although Furth, on the basis of experiment (1964b) and the review of research in this field (1971) held the view that language had no direct general influence on intellectual development, he has more recently agreed that linguistic deficiency in deaf children, whilst having a neutral effect on many aspects of mental development, can have a negative influence on some cognitive activities (Furth, 1974).

The findings of inter-test (or sub-test) variability in the present study, if accepted as evidence of differential cognitive development in deaf children, suggest that linguistic deficiency might have negative, neutral, and positive effects, and as such support the hypothesis (put forward in Chapter 3) that restricted language of deaf children can retard or accelerate intellectual growth. The corollary of this is that language competence in hearing children, whilst normally promoting cognitive ability (of the type in which deaf children are retarded) can also impede the extension of some abilities (of the type which are accelerated in deaf children) beyond the normal ceiling.

Lewis (1963, p.179), whilst emphasising the large part that verbalisation must play in the development of thinking, considers that it can also have an adverse effect. (Lewis is here using the term 'thinking' to describe the level of cognitive activity corresponding, in Piagetian terms, to 'internalized actions'). He summarizes his view of the effects of language on mental growth (of hearing children) by stating (Lewis, 1960, p.44-45) that

> 'cognitive activities may go on without the aid of linguistic symbols. Often language may promote the efficiency of cognitive processes. Sometimes language may hinder their development'.

It has long been suggested (Bartlett, 1916) that language may interfere with perception and recall. The recognition that language competence might hinder some learning processes has more recently seen practical application in the introduction, by mathematical educators such as Cuisenaire, Dienes and Stern, of manipulative apparatus to assist the acquisition of number concepts.

The relationship between language level and non-verbal cognitive development might be expected to be reversed in deaf children. They should be retarded in abilities which require a sub-structure of verbalisation, but advanced in those abilities in which language competence intervenes. The findings with deaf children therefore provide indirect evidence of the role of language in mental development of hearing children.

The research with deaf children has shown that language deficiency retards or delays the development of the ability measured in the Progressive Matrices tests. The converse inference of this is that language competence promotes this type of ability, and this is supported by evidence from factorial analysis with hearing children. Emmett (1949) has shown that there is a verbal factor in the solution of diagramatic tests which can be presented non-verbally. Smith (1964) in his study of spacial ability, found a verbal loading in the Progressive Matrices. Oleron (1950) found that adventitiously deaf children, who had normal hearing and spoken language development up to the age of five years, were less retarded in their performance in the Progressive Matrices than congenitally deaf children.

In the case of the Wechsler scales, also, factorial studies (Wechsler, 1958; Maxwell, 1959; Jackson, 1960; Burt, 1960) have indicated an overlap of factor loadings into the verbal and performance sub-scales. Pickles (1961), in his study of the WISC (Perf.) with educationally sub-normal deaf children, found that poor scoring in one of the performance sub-tests, Picture Arrangement, in contrast to good scoring in Block Design, was significantly related to spoken language competence. In a study of psychotic children, Rutter (1965) found a similar consistent pattern of variability in WISC (Perf.) sub-tests for children lacking verbal communication.

Whereas the low level of performance of deaf children in the Picture Arrangement sub-test indicates the adverse effect of deafness on cognitive growth, the tendency for deaf children to do well in Block Design suggests a 'positive' effect of restricted language. The comparatively high level of functioning in this test by the subjects of this study supports the view put forward by Raven (1966) that language deprivation in deaf children accelerates the development of the ability involved in 'form manipulation' as in the Block Design Test.

Given that deaf children are more advanced in some tests than others, in comparison with normal, it is important to understand the nature of the abilities measured in the tests. Psychologists with entensive experience of working with deaf children have attributed the uneveness of test profiles to the 'concrete' or 'abstract' quality of the abilities involved. Oléron (1950), on the basis of experimental work, proposed that deaf children do well in tests of concrete ability, which he defines as behaviour largely restricted to the efficient handling of the immediately perceived stimulus, but that they are inferior in tests demanding abstract operations away from the perceived stimulus. ('Concrete' ability in this sense does not describe the Piagetian developmental stage of 'concrete operations' using symbols as a means of relating new situations to past situations).

Myklebust (1960) examined a range of tests in this light, and discovered that the results for deaf children were consistent with Oléron's findings. Lewis (1963) made a survey of work in this field and came to a similar conclusion.

He says (p.115) that

> 'deaf children in general do as well as children with normal hearing, if not better, when given performance tests'.

but (p.197)

> 'as soon as a deaf child moves from a concrete situation, of which he can be immediately aware, to such symbolisations as pictures and diagrams, deficiencies of language begin to affect his success. So, too, when the situation becomes at all abstract.'

Borelli (1951), in comparing the performances of deaf children in different tests, discovered that they experience special difficulty as soon as the tasks become abstract. Templin (1950) has also shown that deafness has an adverse effect on non-verbal abstraction.

If deaf children are better in some abilities than in others, what are the implications for planning their learning strategies? Special emphasis might be placed upon a concrete approach, such as the use of manipulative apparatus to help in the development of quantitive thinking. The crucial question is whether we should actually minimize the use of abstract situations. Although deaf children tend to be inferior in abstract ability, this might still be of special importance to their development. This is, in fact, what Pickles (1966 discovered. He found that the test in which deaf children scored best, Block Design, correlated only r = .40 with teachers' ratings of progress in school work, whereas the test in which they scored lowest, Picture Arrangement, had a higher correlation of r = ·62. Rather than ignoring the abstract reasoning of deaf children, because of their retardation, the indications are that we should attempt to find means to promote this area of development, such as the use of materials to help the understanding of concepts of sequence in relation to time and actions.

The variability of WISC (Perf.) sub-tests and the inferiority in tests such as the Progressive Matrices does not necessarily lessen their value, but might well change their diagnostic meaning in the educational assessment of deaf children. This would seem to be an area warranting further study.

9.7 Summary of the conclusions

1. The WISC (Perf.) results confirmed the reliability of this test, and indicated its suitability as a measure of the general ability of deaf children from the age of seven years up to twelve years. There was good predictive validity for forecasting educational progress and attainment. The test was not quite as satisfactory for the five and six year old children, or those with some degree of physical handicap effecting motor-coordination.

2. The CPM Test was consistently suitable for children aged nine to twelve years, but was not satisfactory for younger children.

3. The CMMS proved to be unsatisfactory as a measure of general intelligence.

4. The G-HDT results were highly reliable, compared closely with WISC (Perf.) results, and had good predictive validity. This test was specially satisfactory with the five and six year old children.

9.8 Implications of the findings

The WISC (Perf.) can be used as a test of general intelligence with deaf children aged seven to twelve years, and with five and six year old children who do not have difficulty in understanding the Coding Sub-test.

The G-HDT can be used as a supporting test in a 'short battery' with the WISC (Perf.), or, if necessary, as an alternative test when the WISC (Perf.) can not be applied. The test should not, however, be regarded as a complete substitute for the WISC (Perf.)

9.9 Indications for further research

The correlations found between the WISC (Perf.) and the G-HDT tests and the two criteria of educational progress show a good level of relationship. This was, however, an initial study of medium to long-term forecasting for deaf children, and the findings should be regarded as tentative evidence. Further study should be made of the validity of intelligence tests for predicting educational development.

The inferiority of deaf children in some tests might be explained in terms of the adverse effects of linguistic deprivation. The superiority of deaf children in other tests, however, suggests that there can also be 'positive' effects. The relationship between restricted language and differential cognitive development has important implications for the education of deaf children and this requires further exploration. In particular, it would be of value to study the influence of different cognitive abilities on the acquisition of the special linguistic communication skills of lipreading and fingerspelling.

Appendix A

LIST OF SCORES IN THE PILOT TRIAL OF THE GOODENOUGH-HARRIS DRAWING TEST

	G-HDT Score		WISC (Perf.)
	1st Test	Retest(after 1 wk.)	IQ
A	128	128	106
B	126	118	115
C	115	111	110
D	108	105	96
E	101	101	115
F	101	96	103
G	96	96	93
H	95	95	103
I	94	91	85
J	87	103	113
K	83	81	68
L	80	85	74

Appendix B

LIST OF RAW DATA

Subject	Age	Hearing Loss	WISC (Perf.)	CPM	CMMS	G-HDT	Stream	CSE
001	5.0	NR	87	IV	102	83	(L)	-
002	5.0	88	101	IV	103	87	A	-
003	5.1	63	79	IV	79	82	A	-
004	5.2	75	85	IV	79	77	B	-
005	5.2	97	61	V	65	85	B	-
006	5.2	NR	54	V	65	53	(L)	-
007	5.4	103	80	V	100	79	(L)	-
008	5.4	98	78	V	95	86	B	-
009	5.4	63	108	IV	102	90	(L)	-
010	5.4	105	99	III-	81	98	A	-
011	5.5	107	111	III+	98	80	(L)	-
012	5.6	78	113	III-	85	107	A	-
013	5.6	NR	85	IV-	73	89	B	-
014	5.7	NR	65	V	60	80	B	-
015	5.7	83	83	IV	82	85	B	-
016	5.8	67	78	IV-	71	83	A	-
017	5.9	88	92	V	78	86	A	-
018	5.9	102	135	IV-	96	113	A	-
019	5.10	108	125	I	117	104	A	-
020	5.10	NR	83	IV-	84	90	B	-
021	5.10	NR	74	V	64	82	(L)	-
022	5.10	NR	76	IV	84	77	B	-
023	6.0	88	65	V	78	68	B	-
024	6.0	80	99	V	89	83	A	-
025	6.0	92	122	II+	99	115	A	-

(L) = Left the school

LIST OF RAW DATA (continued)

Subject	Age	Hearing Loss	WISC (Perf.)	CPM	CMMS	G-HDT	Stream	CSE
026	6.1	110	86	V	81	70	B	-
027	6.1	85	72	IV-	86	85	B	-
028	6.1	97	90	V	95	100	A	-
029	6.3	100	110	III+	91	110	(L)	-
030	6.4	93	82	IV-	70	98	A	-
031	6.5	55	83	IV-	91	90	A	-
032	6.6	63	107	II	95	83	A	-
033	6.8	97	76	III+	68	77	B	-
034	6.8	NR	97	IV	69	104	(L)	-
035	6.8	NR	107	IV	86	104	A	-
036	6.10	NR	62	V	55	85	(L)	-
037	6.11	108	99	V	70	107	A	-
038	7.0	103	94	II	82	88	A	-
039	7.1	NR	120	II	99	99	A	-
040	7.3	110	86	III+	86	79	A	-
041	7.4	98	107	II	81	82	A	-
042	7.4	90	94	III+	88	99	B	-
043	7.4	85	69	V	70	73	(L)	-
044	7.5	110	100	III+	78	112	A	-
045	7.7	63	55	V	54	59	(L)	-
046	7.8	105	104	II	87	118	(L)	-
047	7.8	67	99	II+	91	118	A	-
048	7.9	108	97	III-	78	101	A	-
049	7.9	97	92	V	71	75	B	-
050	7.10	72	97	V	71	97	A	-

LIST OF RAW DATA (continued)

Subject	Age	Hearing Loss	WISC(Perf.)	CPM	CMMS	G-HDT	Stream	CSE
051	7.11	105	107	IV-	89	110	B	-
052	7.11	103	117	III+	111	108	A	-
053	7.11	77	94	III+	73	94	B	-
054.	8.0	93	83	III-	72	81	B	-
055	8.0	93	100	V	81	99	B	-
056	8.1	93	127	II	95	106	A	-
057	8.1	77	103	II+	75	94	A	-
058	8.3	102	97	V	77	106	A	-
059	8.6	77	72	V	61	76	B	Non-CSE
060	8.6	80	74	V	64	74	B	-
061	8.6	58	92	III-	69	87	B	-
062	8.7	83	131	II+	76	116	A	CSE
063	8.7	102	87	III+	65	94	B	-
064	8.8	107	110	II	68	99	A	Non-CSE
065	8.8	77	72	IV	54	86	(L)	-
066	8.8	75	120	II	96	123	A	CSE
067	8.9	93	122	I	119	127	A	-
068	8.10	105	106	III-	92	100	A	-
069	9.0	107	83	IV	60	82	B	Non-CSE
070	9.0	100	82	V	76	80	B	Non-CSE
071	9.2	73	87	III-	68	89	B	Non-CSE
072	9.3	97	103	IV	72	100	A	CSE
073	9.5	103	133	II	78	119	A	(L)
074	9.5	107	108	III-	78	118	A	(L)
075	9.5	40	65	V	56	85	B	Non-CSE

LIST OF RAW DATA (continued)

Subject	Age	Hearing Loss	WISC (Perf.)	CPM	CMMS	G-HDT	Stream	CSE
076	9.6	88	104	III+	74	116	A	CSE
077	9.6	87	97	III-	68	93	B	Non-CSE
078	9.7	75	64	V	55	66	B	Non-CSE
079	9.7	92	118	III+	91	92	A	(L)
080	9.7	63	117	III+	73	87	A	CSE
081	9.8	98	99	III+	72	92	B	Non-CSE
082	9.9	93	114	III+	75	109	A	CSE
083	9.9	103	122	III+	93	105	(L)	(L)
084	9.10	102	114	I	69	122	A	Non-CSE
085	9.10	107	71	IV-	45	82	B	Non-CSE
086	9.10	78	83	V	66	100	A	Non-CSE
087	10.0	110	93	IV	65	98	B	Non-CSE
088	10.0	62	96	III+	62	88	B	Non-CSE
089	10.0	62	100	III+	64	85	B	Non-CSE
090	10.1	77	67	V	59	75	B	Non-CSE
091	10.1	NR	68	V	53	74	(L)	(L)
092	10.1	92	104	IV-	62	110	B	Non-CSE
093	10.3	83	78	III+	65	90	A	CSE
094	10.3	95	106	III+	67	90	A	CSE
095	10.3	88	101	III+	75	93	B	Non-CSE
096	10.9	80	111	III+	63	122	A	CSE
097	10.9	95	96	III+	57	91	A	CSE
098	10.11	78	97	III+	55	82	B	(L)
099	10.11	57	93	IV-	67	97	B	Non-CSE
100	11.0	93	97	II+	56	124	A	(L)

LIST OF RAW DATA (continued)

Subject	Age	Hearing Loss	WISC (Perf.)	CPM	CMMS	G-HDT	Stream	CSE
101	11.0	95	101	IV	68	101	B	Non-CSE
102	11.0	98	89	IV	61	106	A	Non-CSE
103	11.0	87	85	III-	58	83	B	Non-CSE
104	11.0	82	85	IV	58	84	B	Non-CSE
105	11.1	88	89	II	107	91	B	Non-CSE
106	11.2	NR	90	II	55	97	B	Non-CSE
107	11.2	102	99	IV-	72	98	A	CSE
108	11.2	93	111	II	96	103	A	CSE
109	11.3	100	99	III+	65	121	B	Non-CSE
110	11.3	77	113	II+	99	113	A	CSE
III	11.3	110	111	II	67	114	A	(L)
112	11.5	110	86	V	51	88	B	Non-CSE
113	11.8	93	107	II	63	84	(L)	(L)
114	11.8	57	72	IV-	54	74	B	Non-CSE
115	11.8	78	72	V	51	81	B	Non-CSE
116	11.9	90	82	III-	53	92	B	Non-CSE
117	11.10	100	121	II+	107	116	A	CSE
118	11.10	102	101	III-	59	92	A	CSE
119	12.3	107	80	IV-	52	62	B	Non-CSE
120	12.4	103	115	III+	81	94	A	CSE
121	12.7	90	127	III+	94	117	A	CSE
122	12.8	NR	103	III-	79	104	(L)	Non-CSE
123	12.9	80	86	IV-	53	87	(L)	Non-CSE
124	12.10	110	100	III-	62	100	A	CSE
125	12.11	98	110	III+	54	113	(L)	CSE

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