JYVÄSKYLÄ STUDIES IN EDUCATION, PSYCHOLOGY AND SOCIAL RESEARCH 4

ON THE ABILITY STRUCTURE OF THE DEAF

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JYRKI JUURMAA

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Kustantajat / Publishers: Jyväskylän Yliopistoyhdistys; Jyväskylän kasvatusopillinen korkeakoulu

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JYVÄSKYLÄ 1963

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PREFACE

The nature of psychological research has changed markedly during the last decades and, in particular, the last few years. Especially in differential psychology the development of modern research institutes and continued mechanization of the mathematical treatment of research results has made it possible to attack problems which previously could only be referred to. It goes without saying that an individual investigator responsible for research work of this kind remains in a debt of gratitude to many institutions and to many persons. The present monograph reports a part of a more comprehensive project concerning the sensorially deprived.

The study was carried out at the Institute of Occupational Health (Head: Professor Leo Noro) and financed by a grand awarded by the Public Health Service, U.S.A. A number of my colleagues at the Institute have advanced support to my work in various ways. Mr. Aarne Sipponen has participated in the treatment of the results and given useful advice to me continually. I have also profited a great deal from exchange of ideas with. Mr. Johan Weckroth, another collegue of mine acquainted with the psychology of deviate groups. Messrs. Martti Leskinen and Ismo Kammonen participated in the actual testing work and aided me in overcoming the difficulties concerning the test instructions.

Mr. Touko Markkanen generously gave me advice in matters dealing with mathematical statistics and was kind enough to permit me to utilize, as the first empirical research worker, the improved rotation and transformation techniques elaborated by himself.

Professors Martti Takala and Tapio Nummenmaa have read my manuscript and suggested a number of changes.

It is impossible here to mention all the persons who have given me assistance in my work. I should like, however, to acknowledge the understanding and helpful attitude of the Headmasters of the Schools for the Deaf in Turku and Oulu, Mrs. Sylvi Pikkola and Mrs. Helvi Rasi. Messrs. Heikki Hyvärinen and Lauri Paunu, as well as Mrs. Tora Vehanen, aided me as interpreters and gave me advice concerning the technique of test instructions. All of them unselfishly devoted a great deal of time to the study.

The work was translated into English by Mr. Jaakko Railo. The stimulating discussions with him have also influenced the contents of this monograph. The translation was checked by Mr. Herbert Lomas.

My best thanks are due to all the persons mentioned, as well as to all those, not mentioned here, from whom I have received assistance in my work on this study.

Helsinki, June 21st, 1963

Jyrki Juurmaa

INTRODUCTION

The problem of the extent to which mental activities depend upon the different senses and sensations is an ancient one. Innumerable theories, philosophical as well as psychological, have been advanced. Even today it is hard to indicate the paths clearly promising to lead to a total picture. The situation is extremely confused both with regard to the concepts applied and the ways in which the problems are posed. It is amazing that only few philosophers and, relatively, still fewer psychologists have devoted attention to the information offered by the systematic study of the persons in whom some particular sense is entirely non-functional: those with sensory defects. To be sure, some researchers have given attention to these matters — Eino Kaila (1944), for example, referred to the gifted deaf-blind as evidence in support of the view that sensori-motor functions form no necessary condition for the higher mental processes. Hebb (1949), who based his theories partly upon the study of the sensorially deprived, should also be mentioned in this context.

The study reported here concerns analysis of the ability traits of the deaf. There are even *a priori* grounds for assuming that marked structural differences exist between both the functional and experiential worlds of the deaf and the normal persons. But what kind of differences? The most interesting question related to the study of the blind may be asserted to be this: How is it possible to recognize shapes or, more generally, to operate with spatial relationships without the sense of vision? Correspondingly, the crucial and most interesting problem in the study of the deaf is: How it is possible to learn language and to acquire a body of concepts without the sense of hearing? Consequently, to bring the matter to a head, the crux of the problem with the blind relates to technical control, and in the case of the deaf to theoretical mastery of the world. The degree of blindness, its duration and age of onset are factors of the utmost significance from the point of view of the problems referred to above. It goes without saying that similar factors are important, in one way or another, in the study of the deaf as well. Psychologically, however, the most decisive point is whether the child learns mastery of speech with or without the aid of hearing. As soon as the person has achieved something like complete mastery of language, the problems associated with mental abilities ot the deaf are often rendered to a large extent trivial. After the stage when the person is already in possesion of a vocabulary, the centre of emphasis of the psychological problems related to the deaf lies principally in the characterological sphere.

A practical object often furnishes the initial impulse for theoretical research. This was also the case with the present study. In framing plans for vocational guidance of the sensorially defective and for the enlargement of the range of occupations open to them, the Institute of Occupational Health found two things necessary: to secure factual information about the aptitudes of the deaf; and to evolve truly useful methods for the purposes of guidance. A practical goal of this kind never fails to entail certain limitations in the theoretical respect. Nevertheless, the principal problem was considered to be the degree of verbal retardation in the deaf and the relation of their other mental abilities to those of normal people. It was felt that, in this inital stage, an exploration of the manipulative functions or the motor functions in general was less imperative than, for instance, on the case of the blind.

The present study falls primarily within the scope of differential psychology — provided one wants to adhere to the somewhat artificial distinction between differential and general psychology. As already pointed out, however, the problems related to a group such as that of the deaf serve to bring to the fore interesting and pivotal questions of, for instance, the psychology of thinking. It seems to me that the study of the sensorially deprived very clearly bears out the view that the methods of differential psychology, starting from a different standpoint than those of experimental research of the traditional type, are able to produce general psychological knowledge. The Discussion chapter of this monograph is consequently more extensive than usual. As is natural, the empirical part of the study is principally concerned with comparisons between the deaf and the hearing. A comparative analysis of the factor structures of the two groups furnishes the most differentiated kind of information concerning the relationship of various abilities of the deaf and the hearing. A variety of mathematical techniques of factorial rotation have been elaborated, and many of these are in current use. Different rotations suggest slightly different interpretations. On the other hand, there are few instances where a comparison of different factor structures is so useful and where it is likely, at least in principle, to yield such interesting information as here, where the deaf — so important and so homogeneous a group in respect of the injury — are compared to normal people. For this study to provide such a source of information, several rotational solutions are presented in many instances. The chapter dealing with previous studies may be able to give the representatives of this field some clues concerning the present state of the study of the deaf and, at the same time, provide them with a kind of overall picture. It is likely to show, also, how little interest has so far been devoted to strictly scientific research concerning a group so highly important in the theoretical respect as the deaf.

The present study may be regarded as a relatively extensive total construction of a kind to which more detailed results can be related later on. It is to be hoped that, while helping to elucidate the problems at hand, the study will also raise new and interesting psychological problems either related to the deaf or capable of being elucidated through the study of the deaf.

PROBLEMS

The problems of the study concerned analysis of the ability structure of the deaf and comparison of the abilities of the deaf with those of the hearing.

The study dealt with the following hypothetical ability factors:

(1) verbal ability
(2) reasoning
(3) numerical ability
(4) visual (spatial) ability
(5) visual memory
(6) perceptual speed and accuracy.

(Two or three tests, with 18 variables in total, were used to measure each of these factors.)

Specific attention was devoted to the following points.

(1) What is the relationship between the performances of the deaf and the hearing on the different test variables? In other words: In which traits do possible retardation or compensation make their appearance? (Boys, girls and the total groups of deaf and hearing subjects were studied separately.)

(2) How is the ability structure of the deaf differentiated with respect to the above factors? (The analysis was separate for the boys, the girls and the total group.)

(3) How are the ability structures of the control groups differentiated with respect to the same factors? (The analysis was separate for the boys, the girls and the total groups.) A further related problem concerned the test battery designed for this study: How great was its discriminative power when used with adults?

(4) How are the factorial structures of the deaf and the hearing related to each other? In other words: To what extent do the deaf employ the same abilities as the hearing in performing the tasks involved in the tests?

I Background of the Study

A. DEFINITIONS OF DEAFNESS

'Deafness' is not a scientific concept. The consequences of a loss of hearing vary from one person to another and from environment to environment. Different definitions are applied depending on the purpose at hand. Educational, social, psychological and medical points of view are considerably at variance with one another.

The following terms have been commonly used, though with somewhat different meanings in different contexts: deaf-mute, deaf, adventitiously (in contrast to congenitally) deaf and hard of hearing.

The measures of hearing that have been long used include the ability to distinguish whispering or speech at a specified distance, the limits most commonly applied being half a metre, two and six metres. To attain a higher degree of accuracy, use has been made of audiometric apparatus. The measure of the intensity of sound, the decibel (dB), is used as the unit of measurement. The normal scale in use is as follows.

mild impairment — 0 to 30 dB
considerable impairment — 30 to 60 dB
serious impairment — 60 to 90 dB
deafness — 90 dB or over.

In practice and in studies of human behaviour precise dB-values have a merely relative significance. The factor underlying the definitions has been the bearing upon the behaviour of the person with the hearing loss. The definition adopted by the Conference of Executives of American Schools for the Deaf was simply as follows.

The Deaf: — Those in whom the sense of hearing is nonfunctional for the ordinary purposes of life. This general group is made up of two distinct classes based entirely on the time of the loss of hearing:

(a) The congenitally deaf: — Those who were born deaf.

(b) The adventitiously deaf: — Those who were born with normal hearing but in whom the sense of hearing became nonfunctional later through illness or accident.

In Finland the 1958 report of the Committee for the Rehabilitation of the Hard of Hearing defined the deaf as those who had been born without hearing or had lost it so early in childhood that learning of speech had not taken place primarily on the basis of hearing. The deaf-mute is correspondingly a deaf person who is unable to speak, in contradistinction to the deaf who have learned to speak. If a person has learned to speak prior to the hearing loss, he is referred to as adventitiously deaf.

Definitions of this kind are also very rough. For precision a definition should state how and in regard to what the person is deaf. The social, educational and psychological aspects are the most essential in considering the respects in which a person is deaf.

Myklebust (1960), in turn, gives this sort of summary of the factors that should be taken into account in defining and classifying deafness.

a. *Degree of deafness,* the basis of the classifications deaf and hard of hearing.

b. *The factor of time,* referred to as the age of onset; the basis of the classifications congenital and acquired.

c. *The causal factor,* the basis of the classifications exogenous and endogenous.

d. *The physical origin* of the impairment, referred to as the site of the lesion; the basis of the classifications sensory-neural, conductive, and central deafness.

Educationally, the most important criterion is whether or not the person has learned speech with the aid of hearing. In this respect the age of onset of deafness is important. On the other hand, the degree of deafness is essentially related to the extent to which audition is of aid in learning articulation.

Several psychological aspects are distinguishable. Even here the crucial point is whether or not the person has learned to speak prior to the hearing loss or after it. The disability of the deaf is, above all, a verbal disability. Accordingly, the term 'deaf' should refer to those in whom the lack of hearing prevents the actualization of certain particular abilities or in whom it prevents these abilities from reaching some specified level, and so on. Another important principle of classification is clinical. On the basis of hearing loss, people could be classified according to the degree of social adjustment, the degree of mental disturbance, and so on.

In the present study we simply use the term 'deaf' to refer to any person who is unable to learn words through hearing. From the point of view of the problems to be dealt with here, a detailed analysis of residual hearing has not proved appropriate. (It is difficult to specify to what extent residual hearing helps articulation; how much articulation, in turn, assits language learning; and the degree to whitch groups that are homogeneous in these respects occur.) In other words, in the terminology of this study the deaf are the persons who are unable to understand language or spoken words with the help of audition. This condition is generally met by the pupils at schools for the deaf. In Finland a Decree expressly stipulates that, for a child to qualify for admission to schools for the deaf, he must be unable to utilize audition in language learning. Many of the pupils are in possesion of residual hearing of some kind. In principle, homogeneous groups could be formed using residual hearing as the criterion of classification, but these groups would be too small to be significant from the point of view of the problems of an extensive differential psychological study of the present kind. Consequently, 'deafness' is not even here any absolute concept. From the point of view of the problems at hand, however, the difference between the group of the deaf and the control group is clear. (The impact of residual hearing upon educational achievement, upon various psychological functions and so forth would constitute a research problem on its own.)

B. PREVIOUS STUDIES AND HYPOTHESES

Early Problems and the First Experiments

Concerning the deaf, problems related to philosophical and educational questions were the first to attract attention. Diderot, for example, was primarily interested in philosophical speculations on the relationship of the senses and sensations to knowledge and thinking. During the nineteenth century several investigations were conducted with the deaf to discover what kinds of *a priori* conceptions man had about God, the essence of natural phenomena, and so on. The point of departure for such studies was the view that when the deaf acquired an ability to express themselves later in their lives, they would be able to relate the opinions they held of these things before they were told anything about such matters. Nevertheless, here we shall only refer to these questions, not giving them any further attention.

Simultancously with such interests the vehement dispute began concerning the methods of instruction most adequate for the deaf. This continues even today. Should instruction for the deaf be based on speechreading, sign language or a combination of both? This educational aspect also falls outside the scope of the present study. It should merely be mentioned that, in the absence of systematic research, there has been plenty of space for dispute.

One of the first experimental studies of the deaf was carried out by Greenberger in 1889. He paid attention to the fact that some deaf pupils are unable to learn regardless of the method applied, advancing the view that feeble-mindedness rather than deafness might be responsible for this phenomenon. One of his tests simply consisted of giving attractive picture books to the deaf children serving as his subjects. He also devised a simple number test, for he held that an entire lack of numerical ability was a sign of deepest-level feeble-mindedness. Likewise, he gave the children colours, building blocks, and so forth, watching what they did with these No standardization of the tests was undertaken by him, so that subsequent investigators have not been able to make use of his results. It should be noted, however, that the test materials employed by Greenberger, namely, colours, blocks, pictures, and the like were essentially the same as those used today.

Around the turn of the century, the relationship between deafness and intelligence began to attract more detailed attention. Does deafness cause mental retardation and — provided such retardation does occur — is it a direct result of the deafness? Or are deafness and retardation both attributable to one and the same underlying factor? The last view has been advanced by numerous researchers. They maintain that, due to the factor making for deafness, deafness and mental retardation are met more frequently in one and the same person than would be expected by chance. Meningitis, for example, may be the cause of both.

It is, of course, quite senseless to ask: Which are the more intelligent, the deaf or the hearing? Nevertheless, the questions underlying dispute, and research work too, in this field have to a large extent been fundamentally of this sort. It is an obvious fact, confirmed by the results of all the later investigations, that lack of audition decisively affects verbal development. Taking this as a point of departure, the question assumes a quite different form: What traits depend on verbal development and what are wholly independent of it? Modern research is able to settle the question of the impact of deafness upon mental development, because an accurate and thorough analysis of the interrelations of various traits can be made. But such a possibility did not exist at the turn of the century, when only a theory of general intelligence was available. It is peculiar, however, that until very recently most studies rested exclusively upon foundation of this sort. For example, in 1909 Jones advanced the guess that 20 per cent of the pupils at schools for the deaf in the United States were feeble-minded (Pintner 1941); and I venture to maintain that the proportion is overestimated in Finland, for instance, even today.

In the earliest studies the sampling errors were likely to be truly considerable. The subjects were selected largely according to the kinds of results expected or desired to emerge. The first study with the aid of standardized tests was carried out by MacMillan and Bruner (1906). They examined a group of 184 deaf pupils whom the teachers considered to represent a high enough mental level to warrant the application of special methods of instruction. In this sense the group was thus relatively highly selected. Use was made of tests measuring both physical and mental traits. The same tests were administered to a control group of hearing subjects. The results are interesting in several respects. The authors' conclusions included the following, about which opinions diverge to a large extent even today: "This inferiority of the deaf on the mental side perhaps means no more than that the child is from three to four years less mature than the hearing child of his own age, and that his date of maturing will be correspondingly delayed. . . . . Indeed this mental retardation may be due to conditions in training, and were the deaf child's instruction begun in infancy instead of at six years, the difference might be reduced or even eliminated." Thus, three assertions were made by the authors: first, that during childhood and adolescence the deaf are 3 to 4 years retarded, on the average; second, that, in adulthood, they perhaps catch up with the hearing; and, third, that efficient instruction of the deaf should already be commenced in infancy. The first assertion finds support to at least some extent in a great many later studies. It goes without saying, however, that the question must be formulated separately for each particular trait. Deaf adults have, of course, been studied much less than deaf children. Hence, it has not been possible to establish for certain whether the deaf catch up with the hearing later in life. Many researchers are quite skeptical on this point. As for the requirement that instruction of the deaf should be commenced in infancy, numerous reformers share this opinion even today. Thus, in the study of the deaf the fundamental lines of approach and the basic problems began to take shape even several decades ago.

The Initial Stage of Systematic Research

Rudolf Pintner must be regarded as the pioneer of the systematic study of the deaf. The principal instrument employed by him was a group-test elaborated by himself, namely, the Pintner Non-Language Mental Test. In 1921, Reamer published a comprehensive study which he had carried out with this test battery to explore the intelligence level and educational achievement of 2,172 pupils of 26 schools for the deaf throughout the United States. Here there is no need to describe the technical properties of this test or the other tests to be mentioned in the following. Attention will exclusively be devoted to the results obtained.

Reamers' study served to enliven the dispute concerning the interrelations between deafness and intelligence. His conclusions crystallized into the statement that, in intelligence, deaf children are two years retarded and, in educational achievement, five years. The age range of his subjects was from 8 to 21 years. No statistically significant differences in intelligence between the congenitally and adventitiously deaf children were found. Reamer divided his subjects into three categories according to the methods of instruction: oral, manual and combined pupils. The group of combined pupils did best on the test; that of oral pupils was the second best; and the group of manual pupils, was the poorest. Nevertheless, since the intellectually weakest pupils are placed in manual classes, the result may be of a merely technical nature.

Eight years later, a very extensive study with the same test, undertaken at the initiative of the National Research Council, was published by Day, Fussfeld and Pintner. A total of 4,432 pupils aged between 12 and 21 were examined. The results were in the same direction as those of Reamer's study; for example, no differences were found between the congenitally and adventitiously deaf subjects. Nevertheless, in this study the oral group was the best, the combined group the second best and the manual group the weakest. A minor source of error in this study was perhaps constituted by the failure to exclude the hard of hearing from the series of subjects. The fact that the Pintner Non-Language Mental Test yielded no significant differences between the congenitally and the adventitiously deaf serves to show that the test is relatively purely non-verbal.

A tendency to interpret Reamer's results as an outcome of the group-test situation appeared. Is was consequently necessary to devise an adequate method of individual testing. In 1923 Pintner and Paterson published a test battery, entitled the Pintner—Paterson Performance Scale. This test battery has been employed quite widely, and it has proved relatively useful. The use of spoken language in the instructions is entirely unnecessary. In 1930 G. Arthur published a performance test battery for the deaf; this is usually referred to as the Arthur Performance Scale, in brief. At about the same time a modified version of the Pintner—Paterson Performance Scale was published by Drever and Collins in Great Britain.

In 1933 MacKane carried out a comparative study of the deaf and the hearing using all three batteries mentioned, administering each of them to one and the same series of subjects. The group of deaf subjects comprised 130 children of 10 to 12. A hearing group matched to this in respect of age, sex, national background and economic status served as the controls. The Pintner—Paterson Performance Scale and the Arthur Performance Scale both indicated that the mental age of the deaf was 6 to 7 months lower, on the average, than that of the hearing. On the other hand, the Drever—Collins battery turned out to be poorly standardized. It is notable that this study showed, just as Pintner's own studies had done, that the deaf did worse on the non-verbal tests too. Against this background it seems obvious that the test instructions in Reamer's studies were marred by some technical shortcomings.

The other relatively comprehensive test batteries developed more or less simultaneously with those mentioned above include the Chicago Non-Verbal Examination Test, devised by Brown. This test has both verbal and pantomime instructions. The battery is standardized for the ages of 10 and over.

Zeckel and van der Kolk (1939) used the Porteus Maze Test to compare the deaf with the hearing. The deaf group consisted exclusively of congenitally deaf subjects. The deaf were significantly inferior to the hearing, and the deaf girls significantly inferior to the deaf boys. The interpretation that these authors gave to their results is particularly interesting. According to them, verbal retardation is reflected in all kinds of psychological processes, thus resulting in general mental retardation. They assumed, consequently, that the inferior performances of the deaf were directly caused by their deafness. In other words, they did not think, for instance, that deafness and mental retardation had a common underlying cause. Here they touched upon the most essential question in the study of the deaf, to which no unambiguous answer has been given hitherto.

Of the previous studies conducted with separate tests, Pintner's and Paterson's investigations in learning ability should be mentioned. They made use of the Digit-Symbol and Symbol-Digit tests, measuring the rapidity with which the subjects learn to associate a symbol with digit and *vice versa.* The series of subjects comprised 992 deaf children in the Digit-Symbol test and 1,049 children in the Symbol-Digit test. According to the norms for different ages, the deaf were from 2 to 3 years below the hearing. Even though the performances presupposed learning, the scores on the tests obviously depended upon the verbal factor. Myklebust assumes that tests of this kind are good predictors of symbolic, verbal learning.

A comparative study of the deaf and the hearing from many different aspects was performed by Lindner in Germany. This is one of the investigations of miscellaneous traits. The traits covered included motor ability, dexterity, spatial ability, ability in drawing, memory, suggestibility and the like. The principal results were as follows. In an easy block-building test, 29 per cent of the deaf were successful, while the corresponding figure for the hearing was 36.5 per cent. In a difficult block-building test the figures were 8 and 15 per cent respectively. In picture arrangement, suggestibility and purposeful manipulation (measured by a test resembling Köhler's tests for apes) the deaf did worse than the hearing. (In the case of suggestibility this signified that the deaf were more suggestible.) In the memory tests the groups did equally well, or the deaf were even slightly superior to the hearing. On the other hand, there were some drawing tests on which the deaf did definitely better than the hearing subjects. Nevertheless, Lindner's study is rather fragmentary, and no consistent conclusions can be drawn from it. In one respect, however, the study is significant: it has furnished impulses for further research. Lindner published his results in 1925.

Later Test Batteries of the I Q type

Some studies of the deaf conducted in the 1920s and 1930s were briefly described in the foregoing. Despite the relatively primitive methods applied, these furnished ideas and starting points utilized in later studies and test constructions. In the following we propose first to present a brief survey of some of the more recently developed, comprehensive test batteries for the deaf, and then to review the body of systematic knowledge accumulated about certain separate traits.

The different variants of the well-known Wechsler-Bellevue test battery (the Wechsler-Bellevue Scale, the Wechsler-Bellevue Intelligence Scale and the Wechsler-Bellevue Adult Intelligence Scale) have been used in extensive studies and standardizations with the deaf. The battery consists of a verbal part and a performance part, containing five sub-tests each. With the deaf, use has principally been made of the performance scale. As is evidenced by the following table, the deaf are definitely inferior to the hearing on verbal items, but on the performance items the two groups are equal.

Table 1. *Intelligence quotients for deaf children on the Wechsler-Bellevue Scale (according to Myklebust 1960)*

		Verbal		Performance	
Age	N	Mean	SD	Mean	SD
12	18	64.6	14.3	102.2	15.1
13	16	60.6	11.4	104.8	13.2
14	16	62.6	14.7	98.5	14.8
15	15	69.9	12.0	102.0	14.5
16	10	73.5	13.6	100.5	12.1
17	10	70.9	10.8	103.0	9.9
Total	85	66.5	13.7	101.8	14.5

The figures in the table are drawn from a study undertaken by Murphy in 1957. The deaf subjects had all been deaf from early life. On the verbal items the difference between the deaf and the hearing remains much the same from the age of 12 to the age of 17. Nevertheless, attention should be called to the small numbers of subjects in the different age groups. The breakdowns by sex and aetology resulted in no differences between the mean scores. Another analysis showed Information and Comprehension to be the items on which the difference between the deaf and the hearing declined most markedly with age. The decline was smallest on Digit Span and Similarities. As regards the use of the Wechsler-Bellevue test with the sensorially deprived in general, its verbal part seems to be suitable for the blind and its perfomance part for the deaf.

The Nebraska Test of Learning Aptitude, devised by Hiskey (1955), is specifically designed for use with deaf children. It has been standardized for the 3 to 11-year-olds and comprises 11 items.

(1) Memory for coloured sticks (the subjeet must reproduce from memory the colour series presented).
(2) Bead stringing.
(3) Pictorial association (selection of a picture related to the series presented).
(4) Block building (using cubes the subject has to reproduce patterns shown in pictures).
(5) Memory for digits.
(6) Completion of drawings (the subject has to draw in the missing part).
(7) Pictorial identification (the subject has to find an identical picture in a series of similar pictures).
(8) Paper folding (the subject has to reproduce patterns presented).
(9) Visual attention span (from one to six picture are exposed briefly, whereafter the subject has to select them from 15 possibilities).
(10) Puzzle block (cubes cut in various parts have to be reassembled).
(11) Pictorial Analogies (analogies are presented through pictures, and the subject has to select a picture which completes the analogy).

Hiskey (1956) employed his battery in a comparative study of the deaf and the hearing. The results largely corroborated those yielded by previous studies. On the average, the deaf scored slightly lower than the hearing. The most distinct differences were those on Pictorial Analogies and Memory. On the other hand, on Block Building and Paper Folding the deaf did as well as, or slightly better than, the hearing subjects. The vocabulary of a deaf child entering a school for the deaf is, as a rule, almost non-existent. The results of the Nebraska test show, however, that what is concerned is by no means general mental retardation, for the purely non-verbal functions are on a normal level. Obviously, the Nebraska test is one of the most adequate means for testing the young children.

At this point attention should still be called to the analysis of the items of the Chicago Non-Verbal Examination mentioned above. The test contains 10 items.

(1) Rate of learning
(2) Categorizing — sorting behaviour
(3) Abstracting — inducting
(4) Synthesizing geometric forms
(5) Noting details of geometric forms
(6) Synthesizing meaningful material
(7) Conceptualizing a sequence of events
(8) Noting absurdities in a picture
(9) Relating detail to a situation
(10) Rate of learning

A detailed comparison of deaf and hearing children on these ten items was published by Blair in 1957. The groups were accurately matched in respect of sex, socio-economic status, chronological age, educational level and, moreover, the total IQ. Nevertheless, even though the total IQ scores of the two groups were highly similar, interesting differences were found on different items. On the first five items the deaf scored lower than the hearing, whereas no differences occurred on the other five items. Since the difference between the total scores was not significant, the differences between the scores on the different items, where such existed, must have been small. In the first five tasks the subject has to deal with abstract and, in a sense, meaningless material. In contrast, the material involved in the other five tasks is concrete and meaningful. A comparison of the results on items 3 and 7 is illustrative. Reasoning of a kind is involved in both instances. Nevertheless, in item 7 the material is of a more concrete and meaningful kind than in item 3. The following general conclusion was drawn by Myklebust (1960) from the results of Blair's study. ". . . When the problem consists of situations or circumstances with which the deaf are familiar, such as pictures, they are not inferior. When the test consists of meaningless material, such as geometric forms, they show inferiority." This interesting conclusion has far-reaching consequences, and it will be discussed in greater detail when the definition of the concreteness-abstractness dimension is taken up for consideration. It should be mentioned that orally and manually taught subjects have not been found to differ on the Chicago Non-Verbal Examination test.

Goodenough's well-known Draw-a-Man Test is, in a sense, comparable to the above multi-dimensional batteries of the IQ type. On account of the relative simple instructions this test has been extensively used with the deaf. According to Goodenough, the test is a measure of mental growth and mental capacity. Witkin, Machover, Fisher, Cleveland and some others have demonstrated that the Draw-a-Man Test can also be used as a projective test of personality.

Here we shall only pay attention to the significance of this test as an indicator of intellectual capacity. From the practical point of view the test has the advantage that it is relatively easy to administer as a group test. The first study of the deaf using this test was the one published by Peterson and Williams (1930). They found the IQ of the deaf to be in average 80. Later results have been contradictory to some extent. Shirley and Goodenough obtained 88 for the IQ of the deaf (1932), and the value obtained by Springer was 96 (1938). Myklebust thinks that the differences may be due to selection: the pupils of different schools may differ in intelligence. Shirley and Goodenough found a correlation of. 33 between the Draw-a-Man Test and the Pintner Non-Language Mental Test ($N = 229$). The correlation is statistically significant, it is true, but it also reveals that, after all, these two tests have very little common variance. It may even be maintained in general that the results of Goodenough's tests have not been highly convincing in respect of their predictive value. In the United States, Goodenough's Draw-a-Man Test was presented to a group of 822 pupils of 41 schools for the deaf. The study covered all the geographical areas of the country and was conducted employing the technique of stratified sampling. Comprehensive summaries of the results have been made by Myklebust. The principal results for the 774 totally deaf included and for a sample of hearing children are shown in Table 2.

Table 2. *Intelligence quotients on the Draw-a-Man Test by age and sex for deaf and hearing school children (according to Myklebust 1960)*

	Deaf			Normal		
	N	Mean	SD	N	Mean	SD
Age seven						
Males	48	100.14	15.88	43	105.88	17.96
Females	29	108.10	15.34	29	113.79	15.39
Total	77	103.14	16.05	72	109.07	17.29
Age nine						
Males	84	100.87	17.80	20	101.30	19.03
Females	85	98.55	16.86	24	106.25	9.08
Total	169	99.70	17.32	44	104.00	14.50
Age eleven						
Males	119	96.30	14.47	33	94.30	13.04
Females	107	92.28	16.36	27	98.37	12.29
Total	226	94.40	15.49	60	96.13	12.77
Age thirteen						
Males	85	87.22	13.17	24	83.96	9.56
Females	86	86.71	10.83	27	88.56	8.25
Total	171	86.96	12.15	51	86.39	9.10
Age fifteen						
Males	69	89.25	9.23	22	92.45	13.88
Females	62	87.61	10.82	25	93.24	7.28
Total	131	88.47	10.01	47	92.87	10.76
Total group						
Males	405	94.60	15.36	142	96.76	16.95
Females	369	92.89	15.67	132	100.21	14.28
Total	774	93.78	15.53	274	98.42	15.79

Although some of the differences are statistically significant, the scores of the deaf and the hearing were both within the normal range and, by and large, similar. In respect of sampling, this study seems more valid than the less extensive studies described in the foregoing. The least one may assert is that verbal retardation does not affect mental growth as measured by the Goodenough test.

Results Related to Various Components of Intelligence

As an introduction to the analysis of various traits we propose to review the study of deaf and hard of hearing children that Treacy undertook using Thurstone's Primary Mental Abilities Test (measuring verbal meaning, space ability, reasoning, perceptual speed and number ability). The results, reported in terms of IQs and standard deviations, are presented in Table 3.

Table 3. *Intelligence quotients on the Primary Mental Abilities Test for deaf and hard of hearing school children (according to Myklebust 1960)*

	Deaf			Hard of Hearing		
	N	Mean	SD	N	Mean	SD
Total quotient	30	94.70	15.3	36	97.25	12.7
Verbal meaning	31	80.19	14.2	36	90.30	10.6
Space ability	37	106.86	24.6	36	100.33	23.7
Number ability	31	98.38	20.2	35	93.48	14.8
Reasoning	25	94.84	19.4	28	106.85	19.5
Perceptual speed	22	104.22	21.5	22	115.68	25.2

The groups differed significantly on verbal meaning and reasoning. It is only natural that the deaf were most definitely inferior to the hard of hearing precisely on verbal ability. One should particularly note that on space ability the deaf did at least as well as the hard of hearing. The studies to be described below support the view that visual ideation resting on immediate perception obviously forms the sphere most definitely independent of verbal retardation. Strange to say, even Treacy did not compute the correlations between the different traits to obtain more accurate knowledge about their interrelations. Apparently, this kind of approach has hitherto been foreign to those dealing with comparative studies of the deaf and the hearing.

Let us now briefly discuss the experiments concerned with memory, abstract thinking and verbal comprehension. A more detailed analysis of abstract thinking will, however, have to wait until the Discussion chapter of this monograph, where the interrelation between that and verbal development will be considered in the light of the results of the present study. The presence of verbal retardation itself in the deaf is so trivial a finding that there is no need to review the studies that have consistently established its occurrence.

Numerous theories of a compensatory development of memory have been advanced concerning both the deaf and the blind. The deaf have been claimed to possess a particularly well developed visual memory and ability for visual perception. In all studies concerning memory, two sub-divisions should be borne in mind. First, commitment to memory may occur through reliance upon different senses. Secondly, there may be differences in the nature of the material to be memorized: the material may be, for instance, verbal, numerical, visual and so on. (Other distinctions may, of course, be made, such as immediate versus delayed recall, simultaneous versus successive memory, and so forth.) Nevertheless, the problems of memory functions facing us in cases of sensory deprivation are more complex than one might suppose at first sight. Neurologically, it has been possible to establish that a perceptual experience acts as an associative or, as it were, catalytic factor in the recall of the interrelations of things, past experiences and pieces of knowledge. The cases of amnestic aphasia have shed plenty of light upon these matters. (For instance, a person who is unable to recall the word 'apple' may be able to do so as soon as he tastes an apple.) And here we meet an essential point emphasized, amongst others, by Myklebust. Let us consider a deaf person, for example. He lacks not only a sensory channel for receiving experiences to be committed to memory. He has also been deprived of the chance of utilizing the associative processes connected with the sense of audition. Thus a problem arises which represents, in a sense, the reverse of those underlying the compensation theories: Does the absence of some particular sense modality lead to general retardation in memory functions? And the matter may even be carried one step further, for one may ask: Does the absence of the possibility of associations of this kind lead to impoverishment of the person's imagery? Hitherto, it has been possible to obtain merely partial elucidation of these questions. In principle, however, specific memory functions entirely independent of auditory associations are distinghuishable. Moreover, equivalent memory performances may be possible with the aid of quite different kinds of psychic functions. We must suppose that a loss of sensory function of a certain kind is accompanied by qualitative changes in the memory functions. An analysis of such qualitative changes through comparisons of the factorial structures of specified domains, such as memory, will certainly be one of the most interesting tasks for future research. In studies with a normal population, the specific tests of memory have yielded, as a rule, relatively low correlations with the tests of general intelligence. It would be interesting and important to know whether these correlative relations are stronger in the deaf than in the hearing. (Our studies with the blind showed that the auditory memory was related to he general ability structure of the blind more intimately than was the case with the seeing.) As already stated, no comparative studies of the factorial structures of the deaf and the hearing have been conducted hitherto. Nevertheless, studies of this kind would form a keystone in the investigation of abstraction ability and verbal retardation in the deaf.

Amazingly few tests of memory have been devised for the deaf. Insofar as such exist, they are mostly included in more extensive batteries of general intelligence tests. Highly interesting memory experiments with the deaf have been conducted by Frisina, Blair and Costello (1955). The test employed by them was the Knox Cube Test, measuring the ability to perceive, organize, retain and reproduce movement patterns. This test thus measures, in a sense, immediate and successive memory. The performance is influenced primarily by visual, motor and kinaesthetic components. Frisina found that feeble-minded deaf children did better on this than on any other of the six mental tests he used. Blair, in turn, compared a group of deaf with an accurately matched group of hearing subjects on the same test. The age range was from 7 to 13 years. All the subjects were of normal intelligence. He found that the deaf were superior to the hearing to a statistically significant degree. Costello's experiments served to confirm the results obtained by Blair. According to Myklebust the results are attributable to the dependence of the deaf upon visual functions that are wholly irrelevant to the hearing. Hence, a test performance of this kind may involve visual functions that are better trained in the deaf or merely latent in the hearing. According to Costello's study, no compensatory tendency of a similar kind was present in the hard of hearing.

Tasks of the memory-for-designs type are very usual in the more comprehensive batteries of general intelligence tests. Blair (1957) used the Graham-Kendall Test, measuring the memory for designs, to compare the deaf with the hearing. The deaf proved to be significantly superior to the hearing. One of the explanations suggested by him is interesting, though, as I see it, partly mistaken: he holds that the performances of the hearing on this test are slowed up, as it were, by their verbal associations. A hearing subject may make statements such as "This looks like a box", "This looks like a letter", and so on. But the deaf only observe and reproduce, as Blair was able to ascertain. It should be emphasized, howerer, that the degree of difficulty of the figure naturally bears upon what happens. One may well assume that verbal associations are of aid in memorizing a complex figure. This question will be discussed in greater detail in a later context.

The motor-kinaesthetic memory of the deaf has been studied by, for example, van der Lugt and Fuller. One of the tests used by both was a test designed by van der Lugt. In this test, the experimenter assists the blindfolded subject in tracing the correct path with his finger, and the subject has to retrace the path immediately afterwards. According to both authors, the deaf were superior to the hearing. Motor kinaesthetic tests of this kind generally tend to be rather unreliable. Before any more far-reaching conclusions can be drawn in this domain, more extensive and systematic studies are necessary.

Blair has also studied the ability of the deaf to remember the location of objects in space, or, as it is termed, their memory for object location. He let his subjects observe each group of objects for 20 minutes, and the subject had to reproduce the group later. In comparing the deaf with the hearing he found that the two groups were equal. Previously, Morsh obtained similar results in experiments of the same sort.

Hiskey and many other workers have found that the deaf are definitely inferior to the hearing on visual digit span. Blair's comprehensive study of the memory abilities of the deaf included a test series for successive memory. The series consisted of three tests: the Picture Memory Span, Domino Span and Digit Span tests. Each test involved memorizing sequences of successively given elements. In the Picture Memory Span test, for instance, the pictures of a key, a house, a ship, etc. were presented to the subject, whose task was to reproduce the sequence. In the Domino Span test, the elements of the successively given sequances were groups of dots, and the subject had to remember the number of dots in each. On each of these tests the deaf did significantly worse than the hearing subjects.

The foregoing may be summarized as follows: the deaf were superior to the hearing on visual memory for movement patterns and designs and on motor-kinaesthetic memory; as regards memory for object location they equalled the hearing; whereas in the tests measuring memory for successively given sequences they were distinctly inferior to the hearing. It might be hypothesized, at least, that in tests of the last-mentioned kind the creation of major concepts of some sort aids the memory processes. In the Picture Memory Span test, for instance, a classification as simple as, let us say, "two pieces of furniture and three animals" may be of help. Facility in creating and becoming aware of such major concepts is doubtless very deficient in the deaf. Considering the bearing of memory upon the learning process and its significance for the development of methods of instruction it is surprising that the number of studies concerned with memory is so small.

Here we shall be brief about the studies of the ability for abstract thinking and reasoning in the deaf. The question will be taken up for more detailed analysis in the Discussion chapter of the present work. — The first significant investigation of abstract conceptualization in the deaf was carried out by Höfler in 1927. He made use of Weigr's Form-Colour test. One of the points he paid attention to — and to which a great deal of attention has later been devoted by numerous other researchers — was the extreme difficulty that the deaf found in changing the criteria of classification. They always clung to a single criterion for sorting, as it were. Höfler reported that only four out of his 30 subjects were able to change the principle of classification spontaneously.

The next fairly widely known study was that conducted by McAndrew in 1948. He employed 25 objects of different shapes and materials. (The five forms used were a square, a circle, a triangle, a rectangle and a semi-circle; the five materials were cork, cardboard, leather, bright glass and dim glass.) As regards intelligance, the feeble-minded were excluded. Their mean age was 11 years 11 months. The task was simply to classify the objects according to each of the two possible criteria in succession. Each subject was allowed to make ten trials. Only four out of a total of 24 subjects succeeded, even though the test was preceded by an exercise in which ten objects were classified according to form and colour.

Oléron (1950) who has focused attention in his studies on the abstract thinking of the deaf, made use of 27 cards which the subject had to classify according to the type, colour and number of the objects depicted. An exercise with a series of blocks preceded the test. The mean age of the subjects was 15 years 7 months, and in this study, too, the feeble-minded were excluded. The test formed, in a sense, a progressive series. If the subject failed to change the principle of classification correctly, the experimenter pointed out the mistake, urging him to try anew. After a second failure the experimenter aided the subject through starting to sort according to the new principle himself. Only six out of the 24 subjects succeeded in performing the classification correctly according to each of the three principles. In a matched group of 25 hearing controls, 15 succeeded.

Even quite far-going conclusions have been drawn from the three studies reviewed above. Attention should, however, be called to the small numbers of subjects, and to the fact that the comparisons with the hearing have been rather defective.

Nevertheless, let us briefly consider some of the assertions advanced in this context, without taking any definite stand toward them. McAndrew's conclusion was that the test performances of the deaf are most nearly comparable to those of the brain-injured persons described by Goldstein — notably aphasics, who are primarily affected by verbal disturbances. It is, in fact, true that precisely difficulties in shifting from one classificatory principle to another are met in cases of brain injury. Goldstein used the term 'concrete attitude' to denote this kind of disorder. Such an attitude manifests itself in that the subject primarily observes the individual characteristics of the object concerned — the objects are to them individuals rather than representatives of certain classes. (Chiefly three types of disorder occur in cases of brain injury of this kind: (1) difficulties in classifying objects simultaneously into several categories; (2) disturbances in arranging objects in spatially meaningful figures — for example, in a straight line; and (3) disturbances in arranging objects into sequences according qualitative or quantitative differences between them — for example, according to size.)

Oléron has strongly and sharply criticized this theory, launched by McAndrew and supported by many others, that the performances of the deaf are analogous to those of aphasics. He calls attention to the following points. (1) Unlike aphasics, the deaf are able to take advantage of the aid advanced by the experimenter; they readily grasp how the task should be performed when the experimenter starts to do the correct kind of sorting. This sort of intervention on the part of the experimenter in Oléron's studies was indeed a fortunate and clever innovation. (2) In experiments where the sorting has to take place exclusively according to colour, the deaf display no behaviour resembling the behaviour of aphasics as described by Goldstein. Heider and Heider (1941) demonstrated that the deaf did not differ from the hearing on colour sorting. (3) The behaviour of deaf children resembles that of normal children; the former are merely retarded several years in comparison with the latter. Therefore, retardation rather than impairment should be spoken of. (4) Such glaring absurdities as

Goldstein reports in the case of aphasics are not encountered in the performances of the deaf. Regarding retardation in the deaf, Oléron advances an explanation of his own. Before a subject is able to carry out sortings he has to make observations. The perceivable characteristics, such as colour, form, size and so on, are sort clues for conceptual classifications. But concepts and attainment of the conceptual level are prerequisites of classification. According to Oléron, however, the perceptual level predominates in the deaf. "The different aspects merge into one another, as it were, rather than appear as separate", he says. "Three green trees, for instance, are seen; but the person does not immediately conceive, let us say, first the number, then the colour and then the kind of the objects." Of course, it is not possible to claim directly and without qualification that the perceptual level is predominant in the deaf and the conceptual level in the hearing. Nor can the line of division between these two be regarded as firm and distinct; it is rather hazy. *But what Oléron intends to maintain is, obviously, that immediate, spontaneous classificatory images come into being more readily in the hearing, whereas the deaf spend more time in operations on the perceptual level.* Thus, the explanation suggested by Oléron is merely a sort of variant of what Goldstein said about aphasics; but it is a variant that leaves something open: fundamentally, the deaf have an ability to shift, with time, on to the conceptual level. Oléron's study, referred to above, involved one further phase: after the termination of the experiments he asked the subject to give an account of the principle of classification. The deaf found this very difficult. A majority of the subjects gave a merely descriptive account. Some were able to describe only the objects and what they themselves or the experimenter had done. Exceedingly few were able to give a logically unambiguous explanation or express the principle in a single word. Some expressed it in concrete terms, such as 'the blue colour', instead of mentioning only 'colour'. Those who did best on the test were also best able to describe the principles underlying the classifications.

Mc Andrew presents another hypothesis too. He thinks that the difficulty in changing the principle of classification may be a result of rigidity of the mental structure of the deaf or, in a sense, of their personality. This rigidity, in turn, might be due to the isolation in which the deaf live. His conjecture is that a similar observation could possibly be made of the blind as well. It may be that McAndrew's contention concerning rigidity is correct, although such rigidity need not have anything to do with the ability to reasoning. There is, in fact, empirical evidence (for example, Juurmaa 1959) to show that the hypothesis is not tenable insofar as the reasoning ability of the blind is concerned.

To sum up the findings of the above sorting experiments presupposing conceptualization, it can be stated that the following kinds of tasks are difficult for the deaf: (1) replacing one principle of classification by another; partly as a consequence of this, (2) disengagement from what is immediately perceived or from a principle of classification once adopted; and (3) explaining the principle of classification.

Raven's well-known matrix test has been used in several studies of the deaf. In Thurstone's factor series, this test represented reasoning. As was evident from the figures in Table 3, in Treacy's experiments the performances of the deaf on this test — though within the normal range — were slightly inferior to those of the hard of hearing. Wright (1955) investigated reasoning in deaf adult college students. The control group of the hearing was accurately matched in respect of intelligence, socio-economic status and years of study. Wright's test battery included Raven's Matrices. The performances of the deaf and the hearing on this test were on exactly the same level. It should be noted, on the other hand, that in Wright's study the hearing were definitely superior to the deaf on arithmetic reasoning. In this study, however, the two groups were matched in respect of general intelligence. Seifert has carried aut very thoroughgoing studies using the Raven test. In these studies, two points deserve attention. For one thing, Seifert (1960) analyzed the growth curves of the deaf and the hearing, comparing various age groups with one another. Up to the age of about 10 or 11 years the hearing were definitely superior to the deaf. Thereafter the growth curves distinctly approached each other, and they coincided around the age of 15 or 16 years. Another of his findings was that the deaf did relatively better on the tests without a time limit than on time-limited tests. When a time limit was applied, the performances of the deaf were below those of the hearing even in the 15 to 16-year-old age group. In testing, the deaf needed incomparably more time than the hearing, but the numbers of correct answers arrived at by them were equal to those reached by the hearing.

II Executation of the Study

A. SUBJECTS AND SAMPLING

In the case of extensive differential psychological studies resting on correlative relations the securing of a sufficiently large series of subjects usually forms a severe practical difficulty. Recourse must almost without exception be made to sizeable groups of individuals meeting regularly and permanently. An excellent opportunity is provided by different kinds of schools.

The subjects of this study were pupils of 12 years or over from the Schools for the Deaf of Turku and Oulu. (They totalled 49 boys and 45 girls.) The Decree Concerning Schools for the Deaf stipulates that, for a child to qualify for admission, he must be unable to learn words through audition. As pointed out previously, this criterion is central from the point of view of the problems of the present study. A few subjects that did not satisfy this criterion with absolute certainty were excluded from the study.

The corresponding control group of hearing subjects (50 boys and 50 girls) was chiefly formed of pupils from Kallio Elementary School. The control group was accurately matched with the group of subjects as regards age.

The age distributions for the boys and girls in the group of the deaf and the corresponding means and standard deviations were as follows.

Age	Boys	Girls
12	3	5
13	7	4
14	16	18
15	5	12
16	12	1
17	–	4
18	4	1
19	1	–
20	1	–
	Total 49	45

$M = 14.9 + 1/2 \quad 15.4 \quad M = 14.4 + 1/2 \quad 14.9$

$\sigma = 1{,}79 \qquad \sigma = 1{,}36$

(The difference between the means of the boys and the girls is not statistically significant.)

Of the subjects, 34 boys and 35 girls were congenitally deaf or had sustained the hearing loss before the age of one. In the remaining cases the hearing loss had taken place between the ages of one and seven. The information available about the precise dates cannot be considered very reliable. In the majority of cases, however, the loss of hearing had occurred around the ages of three or four. It is noteworthy, accordingly, that an overwhelming majority of the subjects were congenitally deaf. The information on these matters cannot be regarded as wholly reliable either. It largely reflects the subjective views of the pupils' parents. It is obvious, however, that the defect in audition has already manifested itself at the age when the child normally learns language.

In the middle range of ages, the number of controls exceeded the number of deaf subjects by one in the case of the boys and by five in the case of the girls; the means and standard deviations were, however, the same for the group of the deaf and the control group.

On account of the comparatively extensive age range, the age variable was likely to affect the test results. From the point of view of the present study, however, this had no essential significance, for the control group was accurately matched with the group of deaf subjects. To form a picture of the discriminative power of the test battery with respect to different traits in hearing adults, the tests were administered to a group of 79 pupils (38 males and 41 females) of the

Vocational School for the Disabled. These were aged between 16 and 22. The oldest control subjects (aged 17 to 20) needed in order to match the control group to the group of the deaf were also members of this group of vocational-school pupils.

The age distribution of the control group of hearing adults was as follows.

Age	Males	Females	Total
16	3	4	7
17	10	9	19
18	21	12	33
19	3	4	7
20	1	6	7
21	–	5	5
22	–	1	1
Total	38	41	79
Mean age	18.21	18.91	18.58

The study deal with school-age individuals, and the group of deaf subjects was a random sample from those subject to the Act concerning Compulsory. Education. It has been discovered in the United States that selection with respect to intelligence and general mental alertness occurs in the classes for the hard of hearing: the intelligent and alert among the hard of hearing are able to attend schools for the normal. In Finland this kind of selection is highly unlikely to occur, for the criterion of deafness applied in deciding whether a child should be admitted to a school for the deaf is relatively restrictive and clear. The group of hearing elementary school pupils was likely to represent a level somewhat below the average for the total population of school children of the same age, because the brightest children over 11 usually attend grammar schools. On the other hand, practical considerations generally prevent the deaf from going to grammar school. Thus, insofar as the hearing are superior to the deaf, this sampling error can be said to be in the safe direction. There were no actually feeble-minded persons either in the group of deaf subjects or among the controls. (Virtually all the feeble-minded deaf are transferred to the School for the Deaf at Jyväskylä.)

B. TESTS

Two points of view were in the foreground in choosing the hypothetical traits to be investigated. One was the desire to analyze the degree of verbal retardation and its effects; the other was the wish to make some of the assertions concerning compensatory developments the subject of study.

For the measurement of verbal ability a total of five tests were devised. Despite their appearance of being reasoning tests structurally, most of these were tests of the vocabulary type. The construction of verbal comprehension tests with a uniformly increasing item difficulty for use with the deaf (tests, for example, in which one out of five words has to be selected on the basis of meaning) is practically impossible; the vocabulary of the deaf is too limited for tests of this kind to yield anything but a negligible dispersion. Another five tests were used to measure the ability for abstract reasoning (two in the original study and three in the continuation study). To get a more detailed picture of the general facility in operating with symbols, the numerical ability was included in the traits to be investigated; two tests were employed to measure this trait.

The traits that have been claimed to show compensatory development in the deaf include, amongst others, visual (spatial) ability, perception and visual memory. In the present study three tests were used to measure visual ability, two tests (both of which were scored for speed and accuracy) represented perception; and another two were employed to measure visual memory.

The following is a brief description of the test battery used.

1. *Naming of Pictures.* The test contained two series of items: (a) nouns and (b) verbs. In the first series the subject was simply shown a picture of the object, and he had to answer, with one word, the question: What is this? The pictures of the second series represented actions, and the subject was required to write down a verb in reply. For example: he runs, he is skiing, etc. The first series contained 35 and the second series 25 items. The correlation between the two series exceeds 80; therefore, a combined variable was employed. The test was administered as a group test using film strips. The time of exposure of each picture was 15 seconds. 2—0 points were scored for each item.

2. *K and S Words.* The task was to write down as many words beginning with k (and, correspondingly, with s) as the subject was

able in 5 minutes. The sum variable served as the final variable. 1—0 points were scored for each word.

3. *Opposites.* The opposite of the given word was to be selected from among four alternatives. The alternatives were so obvious that the test only involved comprehension of the meanings of the words. In this sense it was only a measure of vocabulary.

For example: LONG green short poor ripe

There were 36 items. The time limit was 10 minutes and there were 1—0 points for each item.

4 *Choice Analogies.* This multiple-choice test was of the same type as the preceding one. From among four alternatives the subject had to select a word which belongs to the same category as the given word. He had, in a sense, to answer the question: Which form a pair? Here too the alternatives were wholly obvious.

For example: COAT train car shirt pencil

There were 30 items. The time limit was 7 minutes, and there were 1—0 points for each item.

5. *Information.* This was a combined mastery-of-general-knowledge and vocabulary test. The subject had to choose the one of three alternatives that correctly completed the statement presented to him.

For example: Sweden is a river country moutain.

The taks were so easy that by far the greater part of the variance was related to vocabulary. There were 40 items. All had to complete the test. There were 1—0 points for each item.

6. *Square Test.* The subject had to construct a figure similar to the model out of four different kinds of bits: wholly white; wholly black; divided into black and white halves by a line parallel to two sides; and divided into black and a white halves diagonally. The test is a modification of the Kohs Block Design Test, elaborated by Sauli Häkkinen. The time limit was 12 minutes. There were 12 items and 3—0 points for each item.

7. *Square Completion.* On the left there was one white figure upon a black background and, on the right, four small figures. The subject had to reason out which of the four figures must be combined with the larger figure on the left to make the latter a complete square. There were 40 items. The time limit was 5 minutes, and there were 1—0 points for each item.

8. *Ideational Gestaltung.* In this film strip test the subject was shown two figures at first. One of the sides of each figure was marked with an x -sign. The task was to reason out what kind of figure will

emerge if the two figures are placed so that the sides marked with x coincide. The reasoning had to take place ideationally, without any auxiliary devices. The time limit was 10 seconds. The subject was then shown four figures, of which he had to select the one that corresponded to the combined figure. Thus, the task called for visual ideation, as well as visual memory. The time for the choice was 10 seconds also. The code number of the correct figure was to be written down. There were 26 items and 1—0 points for each item.

9. *Picture Groups.* In this film strip test, five pictures were shown at a time. Four of them belonged together conceptually in one way or another, whereas one differed from the rest. For example, there were four pictures of different trees, the fifth one being a flower. The subject had to write down the code number of the differing picture. Two picture groups were shown simultaneously; the time the subject was allowed for the two tasks together was 40 seconds. There were 32 items and 1—0 points for each item.

10. *Picture Analogies.* In this film strip test there were two pictures, one below the other, on the left. On the right there was one picture on the top and four pictures below it. The task was to reason out which of these four bears a relation to the top picture analogous to the relation between the lower left and the upper left pictures. For example: the locomotive is related to the coach as the horse to the cow, spade, house or sleigh. There were 18 items. The time of exposure was 30 seconds. There were 1—0 points for each item.

11. *Four Simple Uses of Arithmetic.* Problems of mental arithmetic involving addition, subtraction, multiplication and division. There were 81 items. The time limit was 8 minutes, and there were 1—0 points for each item.

12. *Additions and Subtractions.* The test consisted of simple, mechanical addition and subtraction problems. In the reply sheet the numbers were placed one below the other and an empty space was providet for the answer. The time limit was 6 minutes, end there were 1—0 points for each item.

13. *Bourdon—Wiersma Test.* There were 50 rows consisting of different kinds of dot groups, 25 groups in each row. The number of dots varied between 3 and 5, but the shape of the groups varied widely even in cases where the number of dots was the same. The task was to indicate each group consisting of four dots. The number of rows finished served as the speed variable, and that of omissions as the accuracy variable. The time limit was 9 minutes.

14. *Letter Groups.* There were 40 rows consisting of groups of four letters. The subject had to indicate, in each row, the groups that were identical with the group to the left. Every row contained 11 groups. The number of correct markings served as the speed variable, and that of errors as the accuracy variable. The time limit was 6 minutes.

15. *Reproductive Drawing.* In this film strip test, different kinds of figures were exposed for 5 seconds. Following this, the subject had to draw the figure shown to him from memory. The time for drawing was 15 seconds. There were 15 items and 2—0 points for each item. The test resembles the commonly known test of memory for designs.

16. *Tools.* In this film strip test the subject was first shown for five seconds a figure resembling some tool. Thereafter, four figures were shown to him, and he had to indicate the one that was exactly similar to the figure shown before. The differences were in most cases slight. The time for the choice was 10 seconds. There were 16 items and 1—0 points for each item.

Why were just these tests but no others included? The principal reasons were the following. (1) The vocabulary of the deaf cannot possibly be explored by asking them to describe the meaning of the words. Thus, the procedures used here — naming the verbal concept corresponding to a picture and finding the correct alternative through the multiple-choise technique — were regarded as technically the best ones. None of the verbal comprehension tests for the hearing is suitable for use with the deaf. In a first extensive and, consequently, orientative study such as the present one it is impossible to proceed to investigate nuances. One has to start from the assumption that, in the case of the deaf, virtually the entire variance of verbal comprehension is related to vocabulary. The test measuring verbal fluency had to be as simple as possible in order to yield sufficient dispersion. (A test of the phrase-experiment type, for example, could scarcely be employed with the deaf.) (2) The idea underlying the reasoning tests was much the same as that underlying the verbal comprehension tests for the hearing. The choice was also influenced to a large extent by points of view concerning the technique of test instructions. (3) Of the tests of visual ability, the Square Test and Square Completion are based to the largest possible extent upon immediate perception. Moreover, the properties of these tests in the case of normal groups of the hearing are known in detail. The Ideational Gestaltung test was expressly devised so as to be multi-dimensional and require spatial ability independent of perception. (4) It was considered desirable to explore perceptual functions using both meaningful and meaningless optic material. (5) As for the tests of numerical ability and visual memory, the choice was dictated by simplicity of the technique of instructions.

On the basis of the results of this study, additions and improvemetns have been introduced into the test battery employed in practical guidance. Nevertheless, the results reported in the present monograph are, of course, those obtained with the basic battery. The choice of the factors to be studied was already discussed in a previous context.

The reliabilities of the tests are shown in Table 4.

Table 4. The reliabilities of the tests.

	Deaf	Hearing
Naming of Pictures	+ 93	+ 77
K and S Words	+ 88	+ 84
Opposites	+ 96	+ 91
Choice Analogies	+ 86	+ 89
Information	+ 93	+ 86
Square Test	+ 93	+ 87
Square Completion	+ 91	+ 82
Ideational Gestaltung	+ 75	+ 48
Picture Groups	+ 79	+ 91
Picture Analogies	+ 72	+ 71
Four Simple Uses of Arithmetic	+ 94	+ 97
Additions and Subtractions	+ 98	+ 98
Letter Groups, correct	+ 86	+ 94
Reproductive Drawing	+ 69	+ 73
Tools	+ 58	+ 57
	N = 94	N = 100

As is apparent from the table, the reliabilities of the tests are sufficiently high. To be sure, in the time-limited tests, where all the subjects were not able to complete their performances within the time set (the Square Test, Square Completion, Four Simple Uses of Arithmetic, Additions and Subtractions and Letter Groups, correct), the time limit artificially increased the reliability. Sufficiently precise approximations to the reliabilities of these tests are given by their correlations with parallel tests and by their communalities as obtained in the factor analyses. The above realiability coefficients were evaluated through the split-half method.

For special purposes, of which an account will be given in the Discussion chapter, three further tests of reasoning were employed.

(1) *Raven's Matrices.* A submatrix of each of the matrices presented to the subject was missing. The task was to find the rule underlaying the total matrix and select the missing part from among five alternatives. There were 40 items and the time limit was 20 minutes; there was 1 point for each correct answer.

(2) *Picture Series.* Four pictures representing a sequence of events was given in a randomized order. Each figure had a code number and was exposed for 30 seconds from a film strip. The subject had to arrange the code numbers in an order making the picture series meaningful. There were 18 items and 1 point for each correct solution.

(3) *Sorting Test.* The subject had to sort 45 round counters according to the shape, size and number of the figures depicted on them. The counters were sorted into a 30-compartment box so as to facilitate, as much as possible, the finding of a counter identical with a pattern to be presented to the subject later on. The figures depicted were triangles, circles and squares, numbering from one to five on each counter and representing three different sizes. After completing the sorting the subject received 18 model figures and his task was to find the counter corresponding to these as rapidly as possible. The variables employed in the study were the sum total of the times required to find the correct counters and a general score given for the quality of the sorting on a five-point scale.

C. PROBLEMS ASSOCIATED WITH THE TEST INSTRUCTIONS

One of the problems of utmost import in the study of the deaf arises from the difficulties concerning the test instructions. How should the instructions be given? The main possibilities are the use of speechreading, sign language, pantomine, concrete examples and drawings on the black-board, and, finally, the use of written directions. In the present study, all of these techniques were employed. Assistance in giving the instructions to the deaf was tendered by persons who had specialized in speechreading and the sign language of the deaf. Nevertheless, even when all these techniques are utilized, a deaf person of medium or below medium level often finds it hard to grasp what the experimenter is actually aiming at. The scope of a deaf person's experience is more limited than that of a hearing person, and the situation may seem strange to him. Extensive use of examples to be worked through for practice is necessary. If, with regard to each and every example, certainty is reached that even the weakest subject has been able to comprehend, the danger of mistaken interpretations of the instructions can be eliminated. In this investigation it was not considered necessary to give each subject the same number of examples; instead, it was considered essential that, prior to the beginning of the experiment proper, every subject should have conceived the sense of the task in one and the same way.

No reliance can be placed upon the subjects' ability for speechreading. Through sign languange, again, it is often extremely hard, if not impossible, to communicate exact nuances and, in particular, ideas of an abstract kind. Thus, a simultaneous use of all the methods is necessary. Not infrequently, the deaf will readily nod in assent even when they have no idea whatsoever of the task to performed.

Consequently, one must invariably make sure through trials that the subject truly comprehends the matter. After performing a few tasks the subjects were generally able to proceed markedly better. In the practice stage of testing, use was made of two tests (Symmetric Drawing and Wartegg) that do not come within the scope of this study.

One year before starting the experiments proper, preliminary experiments were carried out with ten tests of various types at the School for the Deaf in Turku. This was to form a picture of the difficulties associated with the instructions and of the degree of difficulty of the test tasks.

The experiments were executed in the form of small-group testing. It may take as much as five times as long to give instructions to the deaf as to the hearing persons. Still more time would have been required, however, if use had been made of individual testing. Light signals and knocking on the floor served as signals to start and stop. The attitude of the subjects to the testing was one of active interest almost throughout.

D. STATISTICAL TREATMENT

The empirical study to be reported in the following was — as already stated — differential psychological in nature. Apart from comparisons of the means for the deaf and the hearing, correlative relations provided the basis for the analysis.

The coefficients of correlation were computed using the Bravais-Pearson formula.

The factor analyses were carried out employing at deast one of the following two procedures.

(1) *Objective mathematical orthogonal rotation through the Varimax method, starting from the principal axis matrix.* The previously performed graphical orthogonal rotations were used, insofar as the writer regarded it as appropriate, as a criterion in deciding on the numbers of factors to be extracted. The results of these rotations were consistent with those of the Varimax rotations to such an extent that their presentation in this monograph was considered unnecessary (Juurmaa 1961). Another criterion was provided by the multiple

correlations between the factors yielded by the cosine-solution rotations. In ambiguous cases two different Varimax rotations were carried out, of which the interpretationally clearer was chosen.

(2) *Ahmavaara's Cosine Rotation as elaborated by Touko Markkanen.* Initially, the centroid matrix was used as the starting point for this kind of rotation in all the subject groups. Nevertheless, Markkanen continued to develop his method while the present study was in progress, and cosine rotations based upon the principal axis matrix, also making use of the determinant criterion, were performed for the most important groups: the total group of the deaf and the total control group of hearing elementary-school pupils. The determinant criterion indicates the total amount of interdependence between the axes of the coordinate system. The determinant is to be chosen so as to make the interdependence a minimum; that is, the largest possible determinant is to be chosen. To begin with, the highest possible number of factors was extracted; thereafter those for which the multiple correlation exceeded. 75 were dropped. In the cosine rotations .30 was regarded as the lowest communality for a variable to be employed as a factor test. Since all the rotations were performed by wholly objective mathematical methods, presentation of the centroid and principal axis matrices was regarded as unnecessary.

To compare the factor structures of the total group of the deaf and the total control group of hearing elementary-school pupils, transformation analyses were performed in both directions. (In other words, the factors obtained with the deaf were transformed into the factor space of the hearing, and, correspondingly, the factors of the hearing were transformed into the factor space of the deaf.) The nature of the tables relating to the transformation analyses will be described in more detail in section D.2. of chapter III.

Some of the statistical methods employed in the cosine rotations and transformation analyses have not yet been published in any book or article. Regarding these methods the reader is referred to a book by Ahmavaara and Markkanen, to be published in the near future. Reasons of copyright as well as considerations of space prevent us from giving a detailed account of these methods here. Only the results obtained through these methods will be published and interpreted in this monograph.

The computations requisite for the factor and transformation analyses were performed on the electronic data processing machines of the Finnish Cable Co.

III Results.

A. COMPARISON OF THE DEAF AND THE HEARING BY TEST VARIABLES

The following analysis is exclusively confined to a comparison of the congenitally wholly deaf subjects with a control group of equally aged elementary-school pupils. The results of the two groups are presented in Table 5.

The results set out in the table can briefly be summarized as follows.

(1) On all the verbal tasks the hearing were superior to the deaf and the differences were significant at the 0.1 per cent level. Results of this kind were fully in accord with expectations. It may only be stated that the disability of the deaf is, in fact, a disability in the verbal domain. An observation of interest wast that the difference between the two groups was smallest on the fluency-saturated K and S Words test.

(2) The groups differed on the reasoning tests, too, even though the difference was less distinct. A knowledge of the name of an object may thus be of aid in the process of reasoning; or it may be that this process is slower in the deaf than in the hearing for some other reason. The pivotal points in the pictures were, of course, the relationships between concepts rather than relationships between optic shapes. The extent to which scantiness of vocabulary generally bears upon abstract-conceptual thinking will be taken up for reconsideration in the Discussion chapter.

(3) In a sense the most surprising was the result for numerical ability. At the Institute of Occupational Health a group of congenitally blind persons was compared with a control group of seeing subjects with regard to their ability in mental arithmetic; the blind were found to be superior to the seeing. In contrast, the deaf were

just as definetely inferior to the hearing on numerical as on verbal ability.

(4) In two of the tests of visual ability, namely, the Square Test and the Square Completion test, the two groups were almost equally successful. On the other hand, on Ideational Gestaltung a statistically significant difference occurred in favour of the hearing. The first two test measure a purely concrete kind of visual gestaltung resting upon immediate perception. The test of Ideational Gestaltung, on the other hand, is more representative of operations with abstract material based on memory. In a later context, in discussing the factor analyses, consideration will be given to the possible causes of the difference between the deaf and the hearing in their performances on this test.

(5) In the tests of visual memory virtually no differences were found between the groups. Nevertheless, on the Tools test the hearing females did better than the deaf ones. In this test systematic memorizing plays a more predominant role than in the Reproductive Drawing test.

(6) As for the test of perceptual speed and accuracy, no differences between the groups appeared in the Bourdon-Wiersma test. In contrast, the hearing were definitely superior to the deaf on the Letter

Table 5

Means, standard deviations, significance of the differences between the means and significance of the variance ratios.

The congenitally deaf and the hearing subjects

N: Deaf males = 34
Deaf females = 35
Total group = 69
Hearing males = 50
Hearing females = 50
Total group = 100

Variable		Deaf mean	Deaf SD	Hearing mean	Hearing SD	t	%	F	%
Naming of Pictures	M	69.00	24.16	113.08	5.92	12.378	0.1	16.655	0.1
	F	80.91	18.66	113.80	8.04	11.081	0.1	5.385	0.1
	T	75.13	22.17	113.44	7.07	16.124	0.1	9.834	0.1
Opposites	M	21.85	7.53	35.32	0.93	12.566	0.1	65.674	0.1
	F	23.29	7.15	34.54	3.43	9.649	0.1	4.349	0.1
	T	22.58	7.31	34.93	2.54	15.585	0.1	8.290	0.1

Choice Analogies	M	19.29	5.85	25.64	4.64	5.508	0.1	1.585	10.0
	F	18.89	6.31	26.86	3.92	7.157	0.1	2.594	1.0
	T	19.09	6.04	26.25	4.34	8.952	0.1	1.937	1.0
Information	M	25.50	7.24	38.88	2.26	12.238	0.1	10.227	0.1
	F	25.20	6.43	38.82	1.75	14.265	0.1	13.406	0.1
	T	25.35	6.78	38.85	2.0	18.709	0.1	11.227	0.1
K and S Words	M	29.88	13.25	43.04	12.01	4.662	0.1	1.219	—
	F	38.46	17.73	56.22	15.37	4.895	0.1	1.330	—
	T	34.29	16.19	49.63	15.29	6.215	0.1	1.122	—
Picture Groups	M	15.41	6.24	17.86	5.75	1.843	10.0	1.177	—
	F	15.89	5.28	18.66	5.57	2.290	5.0	1.112	—
	T	15.65	5.74	18.26	5.67	2.917	1.0	1.023	—
Picture Analogies	M	13.44	2.32	14.94	1.79	3.324	1.0	2.310	1.0
	F	12.54	3.31	14.04	2.11	2.545	2.0	2.464	1.0
	T	12.99	2.86	14.49	2.01	3.998	0.1	2.032	1.0
Additions and Subtractions	M	31.21	13.62	47.76	13.04	5.576	0.1	1.091	—
	F	26.11	10.28	48.38	8.50	10.847	0.1	1.462	—
	T	28.62	12.23	48.07	11.01	10.758	0.1	1.233	—
Four Simple Uses	M	19.29	11.14	41.70	15.74	7.110	0.1	1.998	5.0
of Arithmetic	F	16.77	8.28	40.92	9.32	12.215	0.1	1.269	—
	T	18.00	9.81	41.31	12.94	12.614	0.1	1.745	1.0
Square Test	M	20.21	8.11	20.36	7.46	0.064	—	1.183	—
	F	15.14	6.38	17.52	6.81	1.617	—	1.140	—
	T	17.64	7.66	18.94	7.28	1.114	—	1.109	—
Square Completion	M	27.06	5.24	25.92	6.05	0.887	—	1.333	—
	F	21.37	5.47	24.30	4.55	2.674	1.0	1.451	—
	T	24.17	6.05	25.11	5.41	1.054	—	1.250	—
Ideational Gestaltung	M	15.50	5.19	18.44	2.40	3.491	0.1	4.656	0.1
	F	14.56	3.32	17.14	2.17	4.295	0.1	2.347	—
	T	15.03	4.35	17.79	2.35	5.302	0.1	3.413	0.1
Tools	M	9.09	3.63	9.20	2.67	0.159	—	1.855	5.0
	F	8.09	2.53	9.84	2.18	3.395	0.1	1.346	—
	T	8.72	2.93	9.52	2.46	1.912	10.0	1.421	10.0
Reproductive Drawing	M	17.82	4.69	16.49	4.37	0.636	—	1.148	—
	F	16.37	4.13	17.12	4.94	0.730	—	1.431	—
	T	17.09	4.43	16.80	4.68	0.403	—	1.115	—
Bourdon-Wiersma, speed	M	31.91	8.61	32.76	6.69	0.506	—	1.654	10.0
	F	34.17	7.87	33.72	6.73	0.281	—	1.367	—
	T	33.06	8.25	33.24	6.73	0.155	—	1.503	5.0
Bourdon-Wiersma, omissions	M	21.24	21.30	19.76	13.64	0.384	—	2.440	1.0
	F	50.37	71.16	27.62	31.98	1.990	10.0	4.951	0.1
	T	36.01	54.54	23.69	24.90	1.979	5.0	4.789	0.1
Letter Groups, correct	M	37.68	10.94	44.10	8.15	3.068	1.0	1.801	5.0
	F	40.20	10.56	45.08	10.53	2.088	5.0	1.006	—
	T	38.96	10.74	44.59	9.43	3.594	0.1	1.298	—
Letter Groups, errors	M	5.21	4.32	2.02	1.98	4.562	0.1	4.731	0.1
	F	7.29	6.68	2.64	2.46	4.509	0.1	7.377	0.1
	T	6.26	5.70	2.33	2.26	6.227	0.1	6.373	0.1

Groups, where the subject has to operate with verbal symbols. In this tests the two groups differed as regards both speed and accuracy.

Though, here, letters were used merely as optic figures devoid of any symbolic function, the superior verbal facility of the hearing was obviously a favouring factor.

In summary, the deaf were superior to the hearing on none of the variables. With regard to visual ability of a concrete kind, visual memory and perceptual speed and accuracy the groups were most nearly similar. On verbal ability, numerical ability and reasoning, on the other hand, the hearing were definitely superior to the deaf. Since the sampling error is here in the safe direction, the results can be regarded as so much the more convincing.

B. FACTOR STRUCTURE OF THE DEAF

1. Total Group

The following tables show, for the total group of the deaf, the correlation matrix (Table 6), the rotated matrix obtained through the Varimax method (Table 7), the rotated matrix obtained through the cosine solution method as augmented with the determinant criterion (Table 8) and the matrix of the factor correlations (Table 9).

Let us briefly discuss the interpretation of the results as represented by the rotated matrices. The first thing to notice is that the two methods of rotation yielded virtually identical results.

The highest loadings on the first factor were as follows.

	Varimax rotation	Cosine rotation
Naming of Pictures	85	81
K and S Words	58	52
Opposites	55	65
Choice Analogies	75	78
Information	77	79
Picture Groups	53	59

As regards the interpretation of this factor, it is a clear-cut factor of verbal ability, on which, however, the reasoning test based on pictures and one of the tests of numerical ability have notably high loadings. The high loading of the Naming of Pictures test indicates that the variance of this test has principally to do with the command of vocabulary. In this respect the K and S Words test is to the largest degree independent of the other verbal tests.

The highest loadings on the second factor were as follows.

	Varimax rotation	Cosine rotation
Square Test	78	74
Square Completion	69	70
Four Simple Uses of Arithmetic	51	49
Additions and Subtractions	47	51
Reproductive Drawing	47	54

Here, the highest loadings are those of the tests of visual and numerical abilities.

The highest loadings on the third factor were as follows.

	Varimax rotation	Cosine rotation
Ideational Gestaltung	40	41
Picture Analogies	57	50
Tools	57	52

This factor is somewhat difficult to interpret. The three tests have in common a requirement for rapid observation of the test material and rapid reasoning based on this. Moreover, all the three tests made use of film strips, though all the film strip tests did not obtain loadings on this factor. The factor might be characterized as follows; rapidity of detailed observation of the clues of perception and memory.

The highest loadings on the fourth factor were as follows.

	Varimax rotation	Cosine rotation
Additions and Subtractions	45	50
Bourdon—Wiersma, speed	56	55
Letter Groups, correct	69	67

This is a factor of the speed of purely clerical observation of symbols; accordingly, the easier part of the tests of mental arithmetic also fell here. What was concerned in the third factor was, on the other hand, speed of perception of widely differing figures.

The highest loadings on the fifth factor were as follows.

	Varimax rotation	Cosine rotation
Bourdon—Wiersma, omissions	53	56
Letter Groups, erros	57	55

This factor can obviously be interpreted as one perceptual accuracy.

The following general conclusions can be drawn on the basis of the above five factors.

(1) With the deaf, the test battery yields a very clear-cut verbal factor of the mastery of vocabulary.

(2) The reasoning tests based on pictorial symbols do not form a factor on their own; nor do they even fall on one and the same factor each. That the Picture Group test falls on the vocabulary factor serves to demonstrate that mastery of the verbal symbols of pictures essentially speeds up the process of reasoning. On the other hand, in the Picture Analogies test reasoning proper appears to rest more upon operations with images of a concrete type.

(3) Neither does numerical ability constitute a factor on its own. The more difficult of the tests of numerical ability seems to be associated, in part, with facility in operating with verbal symbols, while the easier one has connections with speed of perception and performance. In addition, both of these tests had a high loading on an entirely non-verbal factor representing operations with concrete, visual images. Consequently, in the deaf numerical ability has not differentiated from the rest of the ability structure; instead, it is closely connected with their general, basic mental capacity (which these tests — Square Test and Square Completion — may be maintained to measure in the most concrete way).

(4) Of the tests calling for visual memory, the Ideational Gestaltung and the Tools tests — requiring an active sort of gestaltung — fall on one and the same specific factor, whereas the Reproductive Drawing test — based on passive memorizing — coincides with the ordinary, concrete tests of visual ability.

We shall return to these topics when the deaf are compared with the hearing, as well as in the Discussion chapter of this monograph.

2. Girls

The following tables show, for the deaf girls, the correlation matrix (Table 10), the rotated matrix obtained through the Varimax method (Table 11) and the rotated matrix obtained through the cosine solution, together with the corresponding multiple correlations (Table 12).

The results were much the same, irrespective of the method of rotation. It goes without saying, however, that the numerical values of the loadings are not comparable to one another in an oblique and an orthogonal rotation.

The highest loadings on the first factor were as follows.

	Varimax rotation	Cosine rotation
Naming of Pictures	79	93
K and S Words	50	23
Opposites	67	34
Choice Analogies	76	52
Information	76	78
Picture Groups	63	64
Four Simple Uses of Arithmetic	60	82
Additions and Subtractions	51	66

This is a clear-cut factor of verbal ability. As in the preceding analysis, the Picture Groups test had a high loading on this factor, and, here, the two numerical tests also fell exceedingly clearly on it. Just as in the case of the total group, numerical and verbal abilities seem to be closely associated with each other in the deaf girls. In this sense, the first factor might be termed a general factor concerning operations with symbols.

The highest loadings on the second factor were as follows.

	Varimax rotation	Cosine rotation
K and S Words	53	58
Bourdon—Wiersma, speed	47	27
Letter Groups, correct	75	74

This factor could be termed a clerical speed factor, with a preponderance of verbal material (the K and S Wors and Letter Groups tests).

Table 6

Correlation matrix, all deaf subjects. N = 94

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K and S Words	53																
3. Opposites	53	32															
4. Choice Analogies	67	42	65														
5. Information	71	43	58	67													
6. Square Test	28	07	15	31	36												
7. Square Completion	01	—02	18	24	17	58											
8. Ideational Gestaltung	30	27	33	29	37	46	26										
9. Picture Groups	50	36	43	51	48	25	15	39									
10. Picture Analogies	28	12	32	20	26	25	21	33	19								
11. Four Simple Uses of Arithmetic	52	40	32	47	55	49	29	49	42	24							
12. Additions and Subtractions	41	40	32	41	43	50	33	45	38	22	68						
13. Bourdon—Wiersma, speed	25	38	—05	05	07	23	18	42	14	08	33	37					
14. Letter Groups, correct	23	41	01	05	12	04	12	24	06	09	33	41	43				
15. Bourdon Wiersma, omissions	—05	—19	28	17	14	19	20	05	06	13	00	10	—40	—19			
16. Letter Groups, errors	08	—01	23	18	28	15	06	07	13	07	—01	17	—12	02	34		
17. Reproductive Drawing	14	09	17	22	21	37	50	36	16	20	33	44	21	19	07	14	
18. Tools	28	15	28	29	22	34	40	43	33	37	33	37	24	13	18	09	35

Table 7

Rotated matrix, obtained through Varimax method.
All deaf subjects.

		I	II	III	IV	V	h²
	Naming of Pictures	*.81*	.22	.04	.14	—.06	73
2	K and S Words	*.52*	*.51*	—.07	.07	—.11	55
3	Opposites	*.65*	—.04	.02	.35	.32	65
4	Choice Analogies	*.78*	—.01	.19	.12	.16	68
5	Information	*.79*	.09	.19	.05	.20	71
6	Square Test	.23	.01	*.74*	.10	.03	61
7	Square Completion	.00	—.01	*.70*	.22	.10	55
8	Ideational Gestaltung	.28	.28	.40	.41	—.05	49
9	Picture Groups	*.59*	.07	.16	.23	.01	43
10	Picture Analogies	.20	.03	.17	*.50*	.07	32
11	Four Simple Uses of Arithmetic	*.53*	.35	.49	.04	—.08	65
12	Additions and Subtractions	.37	*.50*	*.51*	.07	.17	68
13	B—W, speed	.07	*.55*	.23	.15	—.37	52
14	Letter Groups, correct	.06	*.67*	.08	.05	—.03	46
15	B—W, omissions	.05	—.31	.17	.12	*.56*	46
16	Letter Groups, errors	.12	.02	.07	.02	*.55*	32
17	Reproductive Drawing	—.04	22	*.54*	.22	.15	41
18	Tools	.18	.11	.37	*.52*	.06	46

Table 8

Rotated matrix, obtained through extended cosine solution method. All deaf subjects.

		I	II	III	IV	V
	Naming of Pictures	*.85*	.00	.00	.00	.00
2	K and S words	*.58*	*.37*	—.14	—.03	—.05
3	Opposites	*.55*	—.21	—.12	.31	.33
4	Choice Analogies	*.75*	—.21	.16	—.11	.21
5	Information	*.77*	—.11	.18	—.11	.27
6	Square Test	.00	00	*.78*	.00	.00
7	Square Completion	—.30	04	*.69*	.20	.03
8	Ideational Gestaltung	.07	.24	.28	*.40*	—.10
9	Picture Groups	*.53*	—.08	.10	.16	.02
10	Picture Analogies	.00	00	.00	*.57*	.00
11	Four Simple Uses of Arithmetic	*.44*	.24	*.51*	—.12	—.05
12	Additions and Subtractions	.18	*.45*	*.47*	—.06	.19
13	B W, speed	.01	*57*	.19	.11	—.38
14	Letter Groups, correct	.00	*.69*	.00	.00	.00
15	B—W, omissions	—.13	—.31	.12	.15	*.53*
16	Letter Groups, errors	.00	.00	.00	.00	*.57*
17	Reproductive Drawing	—.22	.26	*.47*	.20	.11
18	Tools	—.09	.10	.22	*.57*	—.02

Table 9

The matrix of the factor correlations
All deaf subjects

1	1.000	.350	.348	.489	.157
4	.350	1.000	.160	.176	.031
6	.348	.160	1.000	.493	.222
10	.489	.176	.493	1.000	.256
16	.157	.031	.222	.256	1.000
r_m	.567	.354	.518	.610	.281

Table 10
Correlation matrix, deaf girls. N = 45

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K and S Words	56																
3. Opposites	55	40															
4. Choice Analogies	52	37	73														
5. Information	74	45	59	58													
6. Square Test	25	—02	33	36	40												
7. Square Completion	11	—02	38	34	31	58											
8. Ideational Gestaltung	32	36	36	29	28	32	26										
9. Picture Groups	56	27	45	56	47	26	22	33									
10. Picture Analogies	29	21	32	16	19	20	17	17	19								
11. Four Simple Uses of Arithmetic	53	28	34	46	63	40	37	21	36	00							
12. Additions and Subtractions	52	36	38	46	46	41	36	20	35	04	60						
13. Bourdon Wiersma, speed	22	35	—06	01	10	00	13	48	04	—10	21	29					
14. Letter Groups, correct	25	48	—11	—06	10	—21	01	00	01	—05	05	24	37				
15. Bourdon—Wiersma, omissions	—03	—13	33	13	06	23	23	09	13	26	—02	09	—40	—21			
16. Letter Groups, errors	15	—01	30	17	32	23	19	00	09	—25	—05	19	—23	19	44		
17. Reproductive Drawing	16	01	24	22	18	13	30	31	27	—17	21	34	02	00	17	19	
18. Tools	08	00	20	12	10	04	24	21	17	27	08	01	04	03	22	15	29

Table 11

Rotated matrix, obtained through Varimax method.
Deaf girls.

	I	II	III	IV	V	VI	VII	h²
1. Naming of Pictures	*.79*	.32	.08	—.03	.05	.17	.02	77
2. K and S Wirds	*.50*	*.53*	—.10	—.07	—.08	.17	.27	65
3. Opposites	*.67*	—.10	.15	.36	.10	.22	.30	76
4. Choice Analogies	*.76*	—.14	.17	.15	.05	.01	.23	70
5. Information	*.76*	.18	.29	.14	—.01	.07	—.01	72
6. Square Test	.25	—.17	*.71*	.14	—.01	.09	.11	64
7. Square Completion	.13	—.02	*.68*	.15	.26	.07	.14	59
8. Ideational Gestaltung	.25	.11	.21	—.10	.28	.10	*.58*	55
9. Picture Groups	*.63*	—.06	.06	—.00	.30	.07	.09	51
10. Picture Analogies	.17	—.05	.07	—.01	.07	*.66*	.06	48
11. Four Simple Uses of Arithmetic	*.60*	.09	.47	—.23	.08	—.10	—.12	67
12. Additions and Subtractions	*.51*	.29	.45	.02	.11	—.17	—.01	59
13. B—W, speed	.05	.47	.16	—.44	.06	—.11	.39	61
14. Letter Groups, correct	.04	*.75*	—.07	.02	.02	—.07	—.02	58
15. B—W, omissions	.03	—.22	.15	*.57*	.25	.22	—.03	51
16. Letter Groups, errors	.13	.14	.12	*.69*	.10	—.20	—.04	58
17. Reproductive Drawing	.20	—.02	.16	.12	*.51*	—.28	.12	43
18. Tools	.03	.03	.06	.12	*.51*	.22	.07	33

Table 12

Rotated matrix, obtained through extended cosine solution method. Deaf girls.

	I	II	III	IV	V	VI	VII
1. Naming of Pictures	*.93*	.27	—*.63*	.42	—.05	.21	.28
2. K and S Words	.23	*.58*	—.23	.03	—.13	.33	.33
3. Opposites	.34	—.04	.00	.27	.07	.22	.24
4. Choice Analogies	*.52*	—.14	—.03	.10	.09	.14	.16
5. Information	.78	.14	—.21	.35	—.10	.02	.18
6. Square Test	.22	—.14	*.52*	.32	—.49	.06	.26
7. Square Completion	.00	.00	*.81*	.00	.00	.00	.00
8. Ideational Gestaltung	.00	.00	.00	.00	.00	.00	*.85*
9. Picture Groups	*.64*	—.08	—.39	.26	.22	.11	.23
10. Picture Analogies	.00	.00	.00	.00	.00	*.73*	.00
11. Four Simple Uses of Arithmetic	*.82*	.00	.00	.00	.00	.00	.00
12. Additions and Subtractions	*.66*	.35	.07	.34	—.10	—.04	.07
13. B—W, speed	—.10	.27	.18	—*.51*	—.09	.00	*.57*
14. Letter Groups, correct	.00	*.74*	.00	.00	.00	.00	.00
15. B—W, omissions	.00	.00	.00	*.81*	00	.00	.00
16. Letter Groups, errors	.12	.30	.04	*.72*	—.03	—*.53*	.00
17. Reproductive Drawing	.32	—.10	—.06	.07	*.56*	—.40	.12
18. Tools	.00	.00	.00	.00	*.61*	.00	.00
r_m	.653	.362	.736	.656	.650	.413	.469

The highest loadings on the third factor were as follows.

	Varimax rotation	Cosine rotation
Square Test	71	52
Square Completion	68	81
Four Simple Uses of Arithmetic	47	00
Additions and Subtractions	45	07

This is a visual ability factor resting upon immediate, concrete perception. In the cosine solution, the numerical tests do not receive loadings on this factor even though the clusters are quite close to each other. This is exclusively a question of the technique of rotation. According to the orthogonal interpretation, numerical ability is divided between the verbal and visual factors.

The highest loadings on the fourth factor were as follows.

	Varimax rotation	Cosine rotation
Bourdon—Wiersma, speed	—44	—55
Bourdon—Wiersma, omissions	57	81
Letter Groups, errors	69	72

This is a pure factor of perceptual accuracy, on which one of the perceptual speed variables (speed in the Bourdon—Wiersma test) received a strongly negative loading.

The highest loadings on the fifth factor were as follows.

	Varimax rotation	Cosine rotation
Reproductive Drawing	51	56
Tool	51	61

This is an extremely pure factor of visual memory.

The sixth factor was virtually constituted by a single test.

	Varimax rotation	Cosine rotation
Picture Analogies	66	73

The emergence of a test factor of this kind is accountable for as follows. The test possesses no considerably large common variance with any other test but, on the other hand, correlates to some extent with most of them. On the basis of the variance "accumulated" in this way it is in a sense able to constitute a factor in its own right.

The highest loadings on the seventh factor were as follows.

	Varimax rotation	Cosine rotation
Ideational Gestaltung	58	85
Bourdon—Wiersma, speed	39	57

Thus, in this factor the test of Ideational Gestaltung, presupposing perceptual speed and reasoning based thereupon, is associated with a rather mechanical kind of perceptual speed variable. This speed factor might be termed as one of the perception and gestaltung of optic figures.

If the Varimax rotation is carried out so as to yield only six factors, the test factor formed by the Picture Analogies persists, whereas the test of Ideational Gestaltung shifts on to the factor of visual memory and, correspondingly, the Bourdon—Wiersma test receives a very marked negative loading on the factor of perceptual accuracy.

The following general conclusions may be drawn from the factor analysis of the results of the deaf girls.

(1) With regard to their general structure, the first four factors are, by and large, identifiable with the corresponding factors for the total group.

(2) In this analysis, numerical ability is associated with the verbal vocabulary factor more closely than in the preceding analysis.

(3) Perceptual speed is split up between operations with verbal material (Factor 2) and abstract material consisting of geometric forms (Factor 7).

(4) More distinctly than in the preceding analysis, the test of Ideational Gestaltung here differs in nature from the other tests of concrete, immediate visual ability.

(5) With this group the tests of visual memory form a distinct, uniform factor of their own. In the preceding analysis these tests behaved differently; but in this analysis they behaved similarly.

(6) No separate reasoning factor, resting upon optic symbols, emerged in this analysis either.

3. Boys

The following tables show, for the deaf boys, the correlation matrix (Table 13), the rotated matrix obtained through the Varimax method (Table 14) and the rotated matrix obtained through the cosine solution method, together with the corresponding multiple correlations (Table 15).

As appears from the rotated matrices and the multiple correlations, four factors suffice to account for the factor structure of the deaf boys.

The highest loadings on the first factor were as follows.

	Varimax rotation	Cosine rotation
Square Test	57	52
Square Completion	80	77
Reproductive Drawing	72	62
Tools	36	41

Regarding interpretation, this is a pure factor of immediate visual perception of a concrete kind; one of the tests of visual memory, namely Reproductive Drawing, seems to fall here very distinctly.

The highest loadings on the second factor were as follows.

	Varimax rotation	Cosine rotation
Naming of Pictures	87	93
K and S Words	56	50
Opposites	55	53
Choice Analogies	86	86
Information	82	71
Picture Groups	50	35
Four Simple Uses of Arithmetic	44	21

This factor is the same as the verbal factor obtained for the total group; accordingly, the Picture Groups and the more difficult of the two numerical tests fell into this factor here too.

The third factor was constituted by a single test almost exclusively.

	Varimax rotation	Cosine rotation
Bourdon—Wiersma, speed	—47	—58
Bourdon—Wiersma, omissions	60	65

Table 13

Correlation matrix, deaf boys. N = 49

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K and S Words	56																
3. Opposites	52	21															
4. Choice Analogies	82	42	57														
5. Information	74	50	61	77													
6. Square Test	38	25	01	28	33												
7. Square Completion	09	16	02	14	03	54											
8. Ideational Gestaltung	32	31	35	30	42	53	23										
9. Picture Groups	46	46	41	49	51	26	14	46									
10. Picture Analogies	33	23	34	23	30	27	19	41	19								
11. Four Simple Uses of Arithmetic	55	55	30	48	51	55	22	63	47	39							
12. Additions and Subtractions	38	51	29	38	41	55	31	56	42	33	72						
13. Bourdon—Wiersma, speed	22	38	—06	10	06	47	32	40	22	23	44	46					
14. Letter Groups, correct	19	32	11	16	15	27	32	41	08	21	54	53	45				
15. Bourdon—Wiersma, omissions	03	—19	23	22	21	07	01	—02	—01	—08	00	10	—40	—12			
16. Letter Groups, errors	06	04	13	19	24	06	—14	12	18	—12	03	15	02	—15	13		
17. Reproductive Drawing	16	22	12	20	22	48	65	37	08	19	39	49	37	35	—08	06	
18. Tools	41	16	38	41	29	49	40	53	46	42	46	55	40	21	13	03	37

Table 14

Rotated matrix, obtained through Varimax method.
Deaf boys.

		I	II	III	IV	h^2
1.	Naming of Pictures	.12	.87	—.06	.19	81
2.	K and S Words	.08	*.56*	—.42	.29	58
3.	Opposites	—.06	*.55*	.38	.30	54
4.	Choice Analogies	.18	.86	.18	.14	82
5.	Information	.06	*.82*	.17	.26	77
6.	Square Test	*.57*	.17	—.04	.44	55
7.	Square Completion	*.80*	—.02	—.04	.15	66
8.	Ideational Gestaltung	.18	.21	.02	*.75*	64
9.	Picture Groups	—.00	*.50*	.04	.43	44
10.	Picture Analogies	.11	.20	.00	.45	25
11.	Four Simple Uses of Arithmetic	.22	.44	—.20	*.66*	72
12.	Additions and Subtractions	.33	.29	—.08	.69	68
13.	B—W, speed	.31	.05	—.47	.46	53
14.	Letter Groups, correct	.28	08	—.35	.45	41
15.	B—W, omissions	.06	.11	*.60*	—.03	38
16.	Letter Groups, errors	—.07	.17	.19	.07	07
17.	Reproductive Drawing	.72	.08	—.08	.27	60
18.	Tools	.36	.22	.21	*.57*	55

Table 15

Rotated matrix, obtained through extended cosine solution method. Deaf boys.

		I	II	III	IV
1.	Naming of Pictures	.00	*.93*	.00	.00
2.	K and S Words	—.18	*.50*	—.38	.37
3.	Opposites	—.13	*.53*	.34	.15
4.	Choice Analogies	—.05	*86*	.21	.05
5.	Information	—.19	*.71*	.30	.28
6.	Square Test	*.52*	.05	.01	.37
7.	Square Completion	*.77*	.00	.00	.00
8.	Ideational Gestaltung	.03	—.02	.04	*.76*
9.	Picture Groups	—.13	35	—.05	.39
10.	Picture Analogies	.18	.26	—.05	.16
11.	Four Simple Uses of Arithmetic	—.11	.21	—.10	*.81*
12.	Additions and Subtractions	.00	.00	.00	*.88*
13.	B—W, speed	.25	—.01	*—.58*	.42
14.	Letter Groups, correct	.04	—.03	—.26	*.56*
15.	B—W, omissions	.00	00	*.65*	.00
16.	Letter Groups, errors	—.17	—.03	.19	.25
17.	Reproductive Drawing	*.62*	—.04	—.01	.26
18.	Tools	.41	16	.10	.30
	r_m	.470	.464	.063	.597

This is, consequently, a perceptual accuracy factor. The next highest of the loadings on this factor seems to be that of the Opposites test, which thus appears to require not only verbal ability but also carefulness. The variables of perceptual speed obtained high negative loadings on this factor.

A great many tests had loadings on the fourth factor. The highest loadings were as follows.

	Varimax rotation	Cosine rotation
Square Test	44	37
Ideational Gestaltung	75	76
Picture Groups	43	39
Four Simple Uses of Arithmetic	66	81
Additions and Subtractions	69	88
Bourdon—Wiersma, speed	46	42
Letter Groups, correct	45	56
Tools	57	30

This is interpretable as a general speed of perfomance factor. With the boys the speed factor come to play a very decisive role, obviously because of the relatively small degree of differentiation of their ability structure. Verbal ability and perceptual accuracy were, however, independent of this speed factor. The numerical tests and Ideational Gestaltung seem to be most heavily loaded on this perceptual and performance speed factor.

The following remarks should be made concerning the factor analysis of the results of the deaf boys.

(1) In the case of deaf boys, a kind of relatively undifferentiated flexibility factor of speed of perception and performance, related to operating with nonverbal symbols, is very clearly distinguishable from verbal ability proper.

(2) Of the tests of visual memory, one (Reproductive Drawing) is associated with the concrete kind of visual ability, while the other (Tools) is related to the above-mentioned speed factor. The first of these tests presupposes of more a passive, and the second an active kind of mastery of the material to be memorized. With boys the numerical tests seem to be chiefly associated with those measuring speed of visual perception, while in the case of girls they appear to be related more closely to verbal tests.

C. *FACTOR STRUCTURE OF THE HEARING*

Factor analyses were made from all three sets of results; those of the total control group of elementary-school pupils; those of the hearing girls; and those of the hearing boys. To save space, only the results of the Varimax rotations are presented for the two later groups here.

1. *Total Group of Elementary-School Pupils*

The following tables show, for the total group of controls, the correlation matrix (Table 16), the rotated matrix obtained through the Varimax method (Table 17), the rotated matrix obtained through the cosine solution method as augmented with the determinant criterion (Table 18), and the matrix of the factor correlations (Table 19).

The highest loadings on the first factor were as follows.

	Varimax rotation	Cosine rotation
Four Simple Uses of Arithmetic	81	83
Additions and Subtractions	77	84

This is a purely numerical factor; in the case of the hearing it is, consequently, quite distinct.

The highest loadings on the second factor were as follows.

	Varimax rotation	Cosine rotation
Naming of Pictures	58	65
Picture Groups	63	71
Picture Analogies	39	42

In this factor, a vocabulary test consisting of the recognition of pictures is associated with reasoning operating with pictorial symbols. This factor cannot be regarded as a film strip factor, because no other film strip test obtained high loadings on it. Let us term this factor here, hypothetically, a factor concerning recognition of correspondence between pictorial and verbal symbols.

The highest loadings on the third factor were as follows.

	Varimax rotation	Cosine rotation
Bourdon—Wiersma, speed	—72	—73
Bourdon—Wiersma, omissions	79	80

This is a bipolar factor of the speed and accuracy of visual perception.

Table 16

Correlation matrix. Control group of hearing elementary-school pupils
N *= 100 (50 boys + 50 girls).*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K and S Words	28																
3. Opposites	20	19															
4. Choice Analogies	28	38	36														
5. Information	21	08	47	22													
6. Square Test	21	14	19	18	15												
7. Square Completion	20	10	14	—02	08	50											
8. Ideational Gestaltung	18	—06	19	09	—06	30	25										
9. Picture Groups	45	20	30	21	20	22	17	28									
10. Picture Analogies	26	12	21	13	15	31	17	28	32								
11. Four Simple Uses of Arithmetic	07	27	10	19	13	32	25	—01	16	20							
12. Additions and Subtractions	22	31	14	22	13	26	33	00	05	14	68						
13. B—W, speed	06	26	—05	03	—07	13	15	02	—06	06	07	24					
14. Letter Groups, correct	16	31	06	28	12	32	26	11	17	17	34	45	22				
15. B—W, omissions	05	—05	20	27	08	02	03	11	10	06	10	02	—59	—08			
16. Letter Groups, errors	15	—02	20	07	10	05	05	15	24	09	—01	—01	—10	—03	28		
17. Reproductive Drawing	29	23	23	13	05	29	21	22	32	18	08	15	06	25	12	22	
18. Tools	20	27	13	22	04	19	13	22	21	09	04	15	11	35	—01	05	28

Table 17

Rotated matrix, obtained through Varimax method.
Control group of hearing elementary-school pupils.

	I	II	III	IV	V	VI	h2
1. Naming of Pictures	.10	*.58*	—.05	.22	.15	.07	42
2. K and S Words	.28	.19	—.17	.49	.12	—.09	41
3. Opposites	.01	.23	.14	.17	*.61*	.13	49
4. Choice Analogies	.17	.15	.15	.48	.32	—.06	41
5. Information	.10	.12	.03	.00	*.68*	.02	49
6. Square Test	.22	.16	—.04	.14	.13	*.63*	51
7. Square Completion	.24	.11	—.07	.03	.04	*63*	47
8. Ideational Gestaltung	—.13	.29	.09	.11	—.04	.45	33
9. Picture Groups	.03	*.63*	.08	.15	.15	.15	47
10. Picture Analogies	.13	.39	—.02	.02	.14	.27	26
11. Four Simple Uses of Arithmetic	*.81*	.06	.05	.05	.07	.14	69
12. Additions and Subtractions	*.77*	.03	—.09	.23	.08	.16	69
13. B—W, speed	.11	.01	*—.72*	.19	—.04	.10	58
14. Letter Groups, correct	.35	.04	—.14	.48	.03	.26	44
15. B—W, omissions	.07	.08	*.79*	.06	.10	.02	65
16. Letter Groups, errors	—.07	.32	.26	.02	.08	.08	19
17. Reproductive Drawing	.02	.35	.06	.33	.01	.27	31
18. Tools	—.03	.14	—.04	*.54*	—.01	.19	35

Table 18

Rotated matrix, obtained through extended cosine solution method. Control group of hearing elementary-school pupils.

	I	II	III	IV	V	VI
1. Naming of Pictures	.00	*.65*	.00	.00	.00	.00
2. K and S Words	.43	.12	—.20	*.50*	.12	—.37
3. Opposites	—.13	.09	.15	.14	*.59*	.08
4. Choice Analogies	.26	—.00	.13	*.51*	.32	—.32
5. Information	.00	.00	.00	.00	*.69*	.00
6. Square Test	—.02	.01	.02	.13	.10	*.64*
7. Square Completion	.00	.00	.00	.00	.00	*.69*
8. Ideational Gestaltung	—.36	.27	.19	.01	—.13	*.52*
9. Picture Groups	—.15	*.71*	.15	—.11	—.02	.15
10. Picture Analogies	—.06	*.42*	.04	—.15	.02	.31
11. Four Simple Uses of Arithmetic	*.83*	.00	.00	.00	.00	.00
12. Additions and Subtractions	*.84*	—.08	—.14	.24	.05	—.06
13. B—W, speed	.18	.00	*—.73*	.26	.04	.01
14. Letter Groups, correct	.40	—.14	—.14	*.56*	.06	.03
15. B—W, omissions	.00	.00	*.80*	.00	.00	.00
16. Letter Groups, errors	—.20	.36	.31	—.13	—.03	.12
17. Reproductive Drawing	—.09	.31	.13	.23	—.07	.19
18. Tools	.00	.00	.00	*.59*	.00	.00

Table 19

Intercorrelations of the factors for the total group of elementary-school pupils (TT')

1	1.000	.3907	.3168	.2646	.0912	.5468
5	.3907	1.000	.1624	.2380	.1836	.0232
7	.3168	.1624	1.000	.5126	—.0129	.3587
11	.2646	.2380	.5126	1.000	.1651	.0798
15	.0912	.1836	—.0129	.1651	1.000	.0340
18	.5468	.0232	.3587	.0798	.0340	1.000
r_m	.6790	.4880	.6160	.5810	.2630	.6400

The highest loadings on the fourth factor were as follows.

	Varimax rotation	Cosine rotation
K and S Words	49	50
Choice Analogies	48	51
Letter Groups, correct	48	56
Tools	54	59

This factor is rather difficult to interpret. It consists, in fact, of tests possessing small common variance in the control group. Nor is any of the loadings high. We propose to call it a speed of ideation factor.

The highest loadings on the fifth factor were as follows.

	Varimax rotation	Cosine rotation
Opposites	61	59
Information	68	69

This is, apparently, a verbal factor. Nevertheless, apart from these two, no other verbal tests received marked loadings on it; and because these other verbal tests are quite easy for the hearing in particular, the factor is likely to be a pure carefulness factor.

The highest loadings on the sixth factor were as follows.

	Varimax rotation	Cosine rotation
Square Test	63	64
Square Completion	63	69
Ideational Gestaltung	45	52

This is a pure factor of visual ability, consequently, the test of Ideational Gestaltung also received a high loading on it.

The following general conclusions can be drawn from the foregoing analysis.

(1) The verbal tests did not behave uniformly; instead, the way in which they fell into the various factors obviously depended on the nonverbal material involved in each of them.

(2) Contrary to the case with the deaf, the tests of visual ability quite distinctly constituted a factor on their own.

(3) With the hearing there emerged a factor of recognition of the correspondence between pictorial and verbal symbols. In the case of

the deaf, the tests measuring this phenomenon coincided with the tests of verbal ability proper.

(4) Numerical ability appeared as an independent factor.

(5) The common variance of the tests of visual memory was very small.

2. Girls

The following tables show, for the hearing girls, the correlation matrix (Table 20) and the rotated matrix obtained from the principal axis matrix through the Varimax method (Table 21).

The present study is chiefly concerned with the differentiation of the ability structure of the deaf, and in the following merely the total group of the deaf and the total group of hearing elementary-school pupils will be compared with each other in detail. In consequence, the factors received for the control groups of girls, boys and adults will only be named here.

The first factor shown in Table 21 bears much resemblance to the factor of recognition of correspondence between pictorial and verbal symbols that was obtained for the total group of hearing subjects. It should be noted, however, that the test of Ideational Gestaltung, presupposing the abilities of visual gestaltung and memory, also fall on this factor. The second factor is a purely numerical one. A high loading on it was also received by the variable of 'correct performances' on the Letter Group test, indicative of clerical speed in the handling of letter symbols. The third factor is a bipolar speed-accuracy factor characterized by the Bourdon—Wiersma test. The fourth factor is one of immediate, concrete visual ability. As in the total group of the hearing, the fifth factor is no doubt most nearly a verbal carefulness factor.

A more detailed comparison of the foregoing with the other factor analyses will be undertaken in the next chapter.

3. Boys

The following tables show, for the hearing boys, the correlation matrix (Table 22) and the rotated matrix obtained from the principal axis matrix through the Varimax method (Table 23).

The tests of visual ability and visual memory are located in the first factor. With the boys, the test of Ideational Gestaltung behaved similarly to the other test of visual ability. The second factor corre-

Table 20

Correlation matrix. Control group of elementary-school pupils, girls.

N = 50.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K. and S Words	27																
3. Opposites	10	25															
4. Choice Analogies	32	39	33														
5. Information	14	07	35	15													
6. Square Test	38	24	24	36	32												
7. Square Completion	29	14	12	17	10	51											
8. Ideational Gestaltung	46	21	33	31	02	34	27										
9. Picture Groups	62	37	30	49	23	35	28	40									
10. Picture Analogies	36	15	22	44	29	15	—08	33	49								
11. Four Simple Uses of Arithmetic	06	13	—02	30	—05	23	17	—14	29	27							
12. Additions and Subtractions	14	03	10	20	06	33	27	09	25	18	62						
13. B—W, speed	—17	07	—06	00	03	00	—01	—03	—17	05	—05	04					
14. Letter Groups, correct	23	15	11	22	28	31	32	14	28	29	44	57	03				
15. B—W, omissions	23	22	28	34	07	22	25	15	35	24	38	17	—60	11			
16. Letter Groups, errors	35	14	32	33	20	30	24	13	42	23	14	09	—21	10	26		
17. Reproductive Drawing	45	24	30	18	19	20	14	25	36	18	—05	11	03	22	18	35	
18. Tools	31	21	27	23	19	28	15	27	29	22	09	24	15	43	—04	26	30

Table 21

Rotated matrix, obtained through Varimax method.
Control group of hearing elementary-school pupils, girls.

	I	II	III	IV	V	h^2
1. Naming of Pictures	*.71*	.02	—.10	.29	.05	60
2. K and S Words	.44	.08	—.02	.04	.13	22
3. Opposites	.26	—.01	—.12	.04	*.55*	39
4. Choice Analogies	*.54*	.28	—.14	—.06	.23	45
5. Information	.08	.07	.03	.04	*.59*	36
6. Square Test	.30	.26	—.05	*.50*	.28	49
7. Square Completion	.16	.20	—.10	*.66*	.07	52
8. Ideational Gestaltung	*.58*	—.08	.03	.25	.09	41
9. Picture Groups	*.71*	.23	—.20	.09	.20	65
10. Picture Analogies	*.53*	.28	—.02	—.30	.24	51
11. Four Simple Uses of Arithmetic	.08	*.80*	—.22	—.04	—.08	70
12. Additions and Subtractions	.07	*.75*	.02	.22	.05	62
13. B—W, speed	—.01	.07	*.76*	—.06	.02	59
14. Letter Groups, correct	.16	*.62*	.13	.24	.25	55
15. B—W, omissions	.23	.22	*—.73*	.06	.13	65
16. Letter Groups, errors	.33	.05	—.26	.15	.37	34
17. Reproductive Drawing	.41	—.04	.01	.18	.34	32
18. Tools	.33	.20	.26	.18	.34	36

Table 22

Correlation matrix. Control group of elementary-school pupils, boys.

N = 50.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Naming of Pictures																	
2. K and S Words	27																
3. Opposites	33	28															
4. Choice Analogies	22	29	46														
5. Information	30	17	66	33													
6. Square Test	10	22	10	10	—06												
7. Square Completion	17	23	12	—12	04	47											
8. Ideational Gestaltung	01	—08	—01	01	—19	19	15										
9. Picture Groups	29	—01	31	—12	16	12	10	21									
10. Picture Analogies	24	01	17	—05	00	40	30	17	19								
11. Four Simple Uses of Arithmetic	07	38	23	12	28	41	32	10	08	19							
12. Additions and Subtractions	28	58	18	24	21	23	37	—06	—12	12	71						
13. B—W, speed	24	42	—03	04	—18	28	32	10	05	11	14	38					
14. Letter Groups, correct	08	50	01	33	—09	37	24	13	01	09	30	35	43				
15. B—W, omissions	—12	—30	07	24	11	—23	—21	03	—19	—16	—09	—11	—58	—33			
16. Letter Groups, errors	—02	—07	00	—16	—06	—25	—19	10	05	—08	—10	—10	03	—19	28		
17. Reproductive Drawing	14	22	15	07	—13	40	31	24	28	20	18	19	09	30	05	08	
18. Tools	09	26	03	18	—08	17	18	28	11	05	00	09	05	26	04	—10	24

Table 23

Rotated matrix, obtained through. Varimax method.
Control group of hearing elementary-school pupils, boys.

		I	II	III	IV	V	h²
1.	Naming of Pictures	.13	.48	—.23	.10	.04	31
2.	K and S Words	.02	.20	—.42	.49	.37	59
3.	Opposites	.08	*.80*	.09	.17	.12	70
4.	Choice Analogies	—.04	.33	.11	*.62*	.11	52
5.	Information	—.25	*.75*	.16	.04	.23	71
6.	Square Test	*.54*	.02	—.23	.02	.37	48
7.	Square Completion	.43	.07	—.27	—.10	.40	43
8.	Ideational Gestaltung	*.50*	—.07	.04	.05	—.07	26
9.	Picture Groups	.37	.39	—.11	—.17	—.15	35
10.	Picture Analogies	.44	.19	—.13	—.23	.17	33
11.	Four Simple Uses of Arithmetic	.15	.15	—.04	.03	*.81*	70
12.	Additions and Subtractions	—.01	.12	—.23	.28	*.76*	72
13.	B W, speed	.12	—.04	*—.72*	.15	.14	58
14.	Letter Groups, correct	.26	—.07	—.42	.48	.25	54
15.	B—W, omissions	—.03	—.01	*.79*	.17	—.04	66
16.	Letter Groups, errors	.00	—.02	.19	—.03	—.17	07
17.	Reproductive Drawing	*.60*	.05	—.01	.18	.12	41
18.	Tools	.37	—.02	—.03	.36	—.03	27

Table 24

Correlation matrix. Adult control group. N = 79

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Naming of Pictures																		
2. K and S Words	19																	
3. Opposites	38	32																
4. Choice Analogies	28	44	33															
5. Information	41	12	46	20														
6. Square Test	09	—02	39	00	17													
7. Square Completion	09	07	19	—06	—06	39												
8. Ideational Gestaltung	05	09	30	11	—08	51	24											
9. Picture Groups	44	04	34	13	24	12	21	25										
10. Picture Analogies	32	07	33	—07	17	39	32	34	43									
11. Four Simple Uses of Arithmetic	07	16	13	14	18	16	25	00	13	19								
12. Additions and Subtractions	18	17	12	07	10	06	26	—19	20	20	64							
13. Bourdon—Wiersma, speed	15	27	23	03	—04	22	30	05	19	19	22	34						
14. Letter Groups, correct	06	08	05	—10	03	06	28	—20	13	09	38	45	56					
15. Bourdon—Wiersma, omissions	—01	—01	07	12	21	—12	—21	—01	05	—07	—06	—07	—58	—13				
16. Letter Groups, errors	—04	—05	18	00	06	04	05	19	08	02	06	08	—14	—07	16			
17. Reproductive Drawing	18	13	24	—11	05	33	44	26	21	23	07	14	21	15	02	10		
18. Tools	—03	18	19	—03	17	26	43	14	09	11	14	19	25	29	—11	18	31	
SD	6.70	16.09	3.73	2.43	1.85	6.94	5.22	2.71	4.08	2.65	12.83	10.38	7.03	8.84	14.10	1.88	4.89	2.54

Table 25

Rotated matrix, obtained through Varimax method.
Adult control group.

	I	II	III	IV	V	VI	h^2
1. Naming of Pictures	.19	.04	.03	—.08	*.67*	—.02	49
2. K and S Words	*.64*	.09	.00	—.10	.08	.14	45
3. Opposites	.40	.02	.28	.08	.49	.23	54
4. Choice Analogis	*.66*	.05	.03	.07	.17	—.16	50
5. Information	.22	.06	—.11	.25	*.55*	.11	44
6. Square Test	.01	.05	*.60*	—.04	.15	.31	48
7. Square Completion	—.07	.23	36	—.16	.07	*.50*	47
8. Ideational Gestaltung	.11	—.15	*.73*	.07	.05	.11	59
9. Picture Groups	—.01	.13	.22	—.03	*.59*	.06	42
10. Picture Analogies	—.11	.17	.45	—.09	.45	.10	46
11. Four Simpe Uses of Arithmetic	.13	*.79*	.10	.02	.06	.06	66
12. Additions and Subtractions	.06	*.77*	— 08	—.08	.16	.16	66
13. B—W, speed	.16	.25	.07	—*.68*	.13	.33	68
14. Letter Groups, correct	—.06	.47	—.21	—.34	.10	.39	55
15. B—W, omissions	.04	—.05	—.12	*.72*	.12	—.07	56
16. Letter Groups, errors	.01	.06	.14	.32	—.01	.16	15
17. Reproductive Drawing	—.04	.03	.27	.01	.18	*.53*	39
18. Tools	.10	.12	09	.00	.00	*.65*	46

sponds to the verbal carefulness factor obtained in the factor analyses for the hearing girls and the total group of hearing. In the case of the boys, the Naming of Pictures and Picture Groups tests are associated with this verbal carefulness factor; as we saw, in the case of girls these tests possessed common variance with the Ideational Gestaltung test. The third factor is virtually identical with the bipolar Bourdon—Wiersma factor yielded by the preceding analysis. The fourth factor may be regarded as one of verbal speed. To account for the Letter Group test falling into this factor it may be assumed that the ability to memorize and combine letter patterns rapidly implies comparatively good reading facility and a high reading speed. The fifth factor is an extremely pure numerical ability factor.

This analysis will be compared with the other factor analyses in the next chapter.

4. *Adults*

All of the factor analyses reviewed in the foregoing were made from the results of school-age subjects. To form a picture of the functioning of the test battery with adults — in whom maturation and differentiation of various abilities has virtually come to an end — it was administered to a control group of adults too. The assembly of a corresponding group of deaf adults would have been an extremely difficult task. Nevertheless, since vocational guidance will be extended to cover adults, too, a similar series of deaf adults will be accumulated in the course of time. The factor analysis performed from the results of the adult group indicates the adequacy of the battery for use with normal adults.

The following tables show, for the group of hearing adults, the correlation matrix (Table 24) and the rotated matrix obtained from the principal axis matrix through the Varimax method (Table 25).

The first factor is obviously one of verbal intelligence The second is a numerical factor, with which clerical speed, too, is partly associated. The third factor is one of visual ability. It is noteworthy that, in the analysis of adults, this factor is entirely determined by the Ideational Gestaltung. The loading of the Picture Analogies test on this factor is surprisingly high. The fourth factor is a bipolar perceptual accuracy-speed factor measured by the Bourdon-Wiersma test. The fifth factor obviously corresponds to the previously obtained factors of recognition of correspondence between pictorial

Table 26. The factorial structure of the test battery with the deaf and the hearing.

Factor	Total group of deaf	Total group of hearing elementary school pupils	Deaf girls	Hearing girls	Deaf boys	Hearing boys	Hearing adults
1. General verbal ability	Verbal tests Picture Groups Four Simple Uses		Verbal tests Picture groups Numerical tests		Verbal tests Picture groups Four Simple Uses		
2. Verbal carefulness		Verbal carefulness (Opposites, Information)		Verbal carefulness (Opposites, Information)		Verbal carefulness (Opposites, Information) Correspondence between pictorial and verbal symbols	
3. Verbal intelligence proper						Verbal intelligence (Choice Analogies, K & S Words, Letter Groups, correct)	Verbal intelligence (K & S Words, Choice Analogies)
4. Recognition of correspondence between pictorial and verbal symbols		Recognition of correspondence between pictorial and verbal symbols		Recognition of correspondence between pictorial and verbal symbols			Recognition of correspondence between pictorial and verbal symbols + verbal carefulness
5. Picture Analogies			Picture Analogies				
6. Numerical ability		Numerical ability		Numerical ability		Numerical ability	Numerical ability
7. Visual ability	Visual ability (Square, Square Completion) Numerical ability	Visual ability (Square, Square Completion, Ideational Gestaltung)	Visual ability (Square, Square Completion) Numerical ability	Visual ability (Square, Square Completion)	Visual ability (Square, Square Completion), Visual memory	Visual ability (Square, Square Completion, Ideational Gestaltung) Visual memory	Visual ability (Square, Square Completion, Ideational Gestaltung)
8. Visual memory			Visual memory				Visual memory Optic details (Square Completion)
9. Clues of perception and memory	Clues of perception and memory (Picture Analogies, Ideational Gestaltung, Tools)						
10. Clerical speed	Clerical speed (Bourdon—Wiersma, speed, Letter Groups, correct, K & S Words, Additions & Subtractions)		Clerical speed (Bourdon—Wiersma, speed, Letter Groups, correct, K & S Words				
11. Clerical accuracy	Clerical accuracy (Bourdon—Wiersma, accuracy, Letter Groups, errors		Clerical accuracy (Bourdon—Wiersma, accuracy, Letter Groups, errors				
12. Bourdon—Wiersma, bipolar		Bourdon—Wiersma bipolar		Bourdon—Wiersma bipolar	Bourdon—Wiersma bipolar	Bourdon—Wiersma bipolar	Bourdon—Wiersma bipolar
13. Speed of gestaltung			Speed of gestaltung				
14. ——		Undifferentiated speed of ideation					
15. ——					Undifferentiated speed of performande		

and verbal symbols. In this analysis, the variance of the Opposites and Information tests — referred to as 'verbal carefulness' in the foregoing — is accounted for principally by this factor. The sixth factor is one of visual memory, on which the Square Completion test, requiring a detailed and concrete kind of visual ability, also received a high loading. This factor might be termed one of perception of, and memory for, optic details.

D. COMPARATIVE ANALYSIS OF THE FACTOR STRUCTURES OF THE DEAF AND THE HEARING

1. *Descriptive Comparison of the Factor Analyses.*

To facilitate comparison, the factors obtained in all of the analyses discussed in the foregoing have been presented side by side in Table 26. The groups of deaf and hearing corresponding to each other are represented by columns adjacent to each other. Each of the numbers to the left refers to a separate factor. In some cases two or more factors have been named in the various subject group columns opposite to one of these numbered factor. In such cases the factors have been thought to represent virtually one and the same mental function. The table is divided by horizontal lines into four more or less homogeneous "sectors". The first five factors indicate how verbal functions, reasoning functions operating with pictorial symbols and, in part, numerical abilities have been differentiated in the different groups of subjects. The next four factors characterize the interrelations of the variances of numerical and visual abilities and visual memory. The following four factors represent the variances of perceptual speed and accuracy and clerical fluency. In addition to these there are two factors that cannot be located in a natural way in any of these sectors. Consequently, the division into sectors merely indicates the relations of interdependence among the factors yielded by the analyses performed in this study. The table thus shows, the component factors between which the multidimensional factors obtained for any group are possibly split in the other groups. Only the names of the factors or the tests have been indicated in the table. The loading have been set out in the preceding tables.

The following general conclusions may be presented to summarize the findings.

a. Verbal functions — reasoning based upon pictorial symbols — numerical ability.

— For each group of the deaf there emerged a general verbal ability factor, upon which the more reliable of the reasoning tests based on pictorial symbols had a high loading. A high loading on this factor was also obtained, in all of the groups of deaf subjects, by the more difficult of the numerical tests. With the deaf girls, both tests of numerical ability fell partly into this factor. In a sense, then, we are here concerned with a general, undifferentiated ability to operate with symbols. No factor corresponding to this one was obtained for the hearing.

— A factor primarily based upon the K and S Words and Choice Analogies made its appearance in two of the groups of hearing subjects (hearing adults and hearing elementary-school boys). These two are the verbal tests in which the dispersion of performances was greatest among the hearing. In this sense, this might be termed a verbal intelligence factor in the case of the hearing.

— One further factor for the hearing, formed principally by the Picture Naming, Picture Groups and Picture Analogies tests, belongs to this sector. It was referred to as a factor of the recognition of correspondence between pictorial and verbal symbols. In the group of hearing girls, the Ideational Gestaltung test also fell into this factor. No corresponding factor emerged for the deaf.

— In the case of the hearing there occurred, further, a factor constituted by the Opposites and Information tests; no factor corresponding to this emerged in the case of the deaf. These two tests had small dispersion and the factor was termed a verbal carefulness factor. In the group of hearing boys, as well as in that of hearing adults, the tests of verbal carefulness were closely related to the above-mentioned factor. In Table 26 each of the factors was determined according to the tests having highest loadings on it.

— The above remarks may be summarized by stating that two factors for the hearing correspond to the general verbal functions factor obtained for the deaf: either a verbal carefulness factor and a recognition of correspondence between pictorial and verbal symbols factor, or a verbal intelligence factor proper and a combined factor constituted by verbal carefulness and recognition of correspondence between pictorial and verbal symbols. The test factor (Picture Analogies) extracted for the deaf girls will be disregarded here. Interpretation of the factors will be considered in greater detail in the Discussion chapter below.

b. Numerical ability — visual ability — visual memory

— No pure factor of numerical ability was obtained for any of the groups of deaf subjects. By contrast, such a factor was found for every group of hearing subjects.

— A pure factor of visual memory only occurred in the group of deaf girls. In the control group of adults it occurred in a relatively pure form too; in this instance a single test outside the visual memory group, namely, Square Completion, requiring attention to concrete details was associated with this factor.

— With deaf and hearing boys alike, visual ability and visual memory formed an single common factor. In the other groups the tests of visual memory were split between different factors.

— The visual tests behaved quite consistently in the analyses. The Square test was a common element in all of the factors of visual ability. Another test falling into this factor in all of the analyses for the deaf was Square Completion, whereas the Ideational Gestaltung test was not involved in this factor in any of the analyses. Thus, merely a specific visual factor associated with concrete perception emerged for the deaf. The same was true for the hearing elementary-school girls. By contrast, in the other hearing groups a common visual factor occurred, constituted by all of the three tests of visual ability; in the control group of hearing adults, the loading of the Ideational Gestaltung test was, in fact, the highest among the loadings on this factor. (The loading of the Square Completion test was low, because a marked proportion of its variance had shifted onto the visual memory factor.) Consequently, we are justified in concluding that different kinds of mental functions are involved when the deaf and hearing performe on Ideational Gestaltung, which requires, in a sense, an abstract kind of vivid imagery and memory, independent of immediate perception. For the deaf girls, too, there appeared a difference depending on whether visualization was concrete or abstract. (As is known, girls are inferior to boys in visual ability.)

— One further factor that may be regarded as belonging to this group is the factor obtained with the total group of the deaf and formed by the Ideational Gestaltung, Picture Analogies and Tools test. This was interpreted as a clues of perception and memory factor.

c. Perceptual ability — clerical ability

— Only for the total group of the deaf and for the group of deaf girls did there appear distinct perceptual speed and perceptual accuracy factors measured by two different test. For the other groups a bipolar speed — accuracy factor measured by the Bourdon—Wiersma test corresponded to these two.

— The hearing were distinctly superior to the deaf on both the Letter Group test variables, and the dispersion of the hearing with respect to the accuracy variable was so small as to make the entire variable obviousl unreliable. In the groups of hearing girls and adults the speed variable of the test was related to numerical speed, but in the case of the hearing boys to verbal intelligence. Since girls and adults represent a higher level of verbal development than elementary-school boys, verbal ability does not, obviously, operate in them as a factor causing variance here.

— In addition, the factor for the deaf girls, determined by the test of Ideational Gestaltung and the speed variable of the Bourdon—Wiersma test was included in this group. It was thought that, in the case of the girls, the variance in the Ideational Gestaltung test was partly due to differences in perceptual speed; that is, to the extent to which they were able to gather perceptual material requitise for the test within the prescribed time.

d. Two relatively undifferentiated factors remain. With deaf boys in general, the speed of perfomance obviously functions as a general variance-generating factor to such an extent that most of the test requiring speed have received loadings on one and the same factor. The ideational speed factor received for the total group of the hearing is more difficult to interpret. It has probably been occasioned largely significance from poit of view of the present study. The factor structure of this subject group, in terms of five factors, will be considered in the next section.

2. *Transformation analysis of the factor structures of the total groups of the deaf and the hearing*

The above descriptive comparison was supplemented by a detailed mathematical comparison between the total groups of the deaf and the hearing elementary-school pupils. The comparison was carried out employing the transformation analysis technique elaborated by Ahmavaara and Markkanen.

Table 27 represents the rotated matrix of the total group of the deaf, obtained from the principal axis matrix through applying the cosine solution as supplemented with the determinant criterion; the factor correlation matrix associated with the foregoing and the respective multiple correlations are shown in Table 28. The corresponding matrices for the hearing are shown in Tables 29 and 30 respectively. (Tables 27 and 28 are, in fact, the same as Tables 8 and 9 respectively; they are only presented here anew for easier reference.)

The values of the determinants for the deaf and the hearing are given in Table 31.

Table 32 shows the matrix of the transformation from the deaf to the hearing and Table 33 the matrix of the transformation from the hearing to the deaf.

If the Σx^2-value is very close to zero or definitely above 1, it implies that in the second group, the factor does not exist. In the case at hand, this seeems not to have happened.

The intercorrelation matrices of the transformed factors are given in Tables 34 and 35. They show, in addition, the multiple correlation (^{r}m) of each factor with the other transformed factors.

The results of comparison through transformation analysis by test variables (vectors) are shown in Tables 36 and 37; the changes in both length and location are involved. The total amounts of abnormal transformation are indicated below the columns. The higher the numerical value indicated, the larger is the change.

Table 27. The rotated factor matrix obtained through the cosine solution method. The total group of deaf subjects.

	I	II	III	IV	V
1. Naming of Pictures	.853	.000	.000	.000	.000
2. K and S Words	.579	—.135	—.034	.374	—.045
3. Opposites	.546	—.115	.313	—.213	.329
4. Choice Analogies	.748	164	—.108	—.207	.207
5. Information	.767	.178	—.112	—.107	.267
6. Square Test	.000	.782	.000	.000	.000
7. Square Completion	—.299	.690	.201	.044	.027
8. Ideational Gestaltung	.070	.275	.395	.242	—.096
9. Picture Groups	.530	.097	.158	—.075	.018
10. Picture Analogies	.000	.000	.567	.000	.000
11. Four Simple Uses of Arithmetic	.435	.509	—.122	.244	—.051
12. Additions and Subtractions	.184	.467	—.062	.453	.194
13. Bourdon—Wiersma, speed	.008	.185	.114	.566	.378
14. Letter Groups, correct	.000	.000	.000	.685	.000
15. Bourdon—Wiesma, omissions	—.126	.119	.148	—.309	.532
16. Letter Groups, errors	.000	.000	.000	.000	.570
17. Reproductive Drawing	—.223	.474	.197	.262	.109
18. Tools	—.089	.215	.565	.100	—.023
	3.984	3.904	2.310	2.059	1.659

Table 28. The intercorrelations of the factor for the total group of deaf subjects and the corresponding multiple correlations

	I	II	III	IV	V
I	1.000	.348	.489	.350	.157
II	.348	1.000	.493	.160	.222
III	.489	.493	1.000	.176	.256
IV	.350	.160	.176	1.000	.031
V	.157	.222	.256	.031	1.000
r_m	.567	.518	.610	.354	.281

Table 29. The rotated factor matrix obtained through the cosine solution method. The total group of hearing elementary-school pupils.

	I	II	III	IV	V
1. Naming of Pictures	.397	.219	.351	—.137	.041
2. K and S Words	.640	.000	.000	.000	.000
3. Opposites	.159	.585	.183	—.108	.138
4. Choice Analogies	.562	.162	—.017	—.105	.300
5. Information	.000	.684	.000	.000	.000
6. Square Test	—.086	.112	.576	.458	—.221
7. Square Completion	—.223	.049	.551	.541	—.276
8. Ideational Gestaltung	.000	.000	.567	.000	.000
9. Picture Groups	.286	.258	.451	—.154	.121
10. Picture Analogies	.021	.224	.408	.129	—.075
11. Four Simple Uses of Arithmetic	.000	.000	.000	.811	.000
12. Additions and Subtractions	.181	—.041	.021	.741	—.103
13. Bourdon—Wiersma, speed	.230	—.027	.125	.129	—.709
14. Letter Groups, correct	.411	—.132	.208	.327	—.112
15. Bourdon—Wiersma, omissions	.000	.000	.000	.000	.801
16. Letter Groups, errors	.058	.133	.228	—.145	.271
17. Reproductive Drawing	.333	—.014	.430	—.048	.089
18. Tools	.532	—.153	.275	—.121	.052
	3.503	2.060	4.358	2.319	.319

Table 30. The intercorrelations of the factors for the total group of hearing elementary-school pupils and the corresponding multiple correlations

	I	II	III	IV	V
I	1.000	.294	.037	.475	—.115
II	.294	1.000	.002	.287	.171
III	.037	.002	1.000	—.019	.218
IV	.475	.287	—.019	1.000	.190
V	—.115	.171	.218	.190	1.000
r_m	.562	.379	.256	.552	.416

Table 31. The values of the determinants for the deaf and the hearing

Hearing	.5648	Deaf	.4554

Table 32. The matrix of transformation (deaf → hearing)

	1	2	3	4	5	Σx^2
	.5240	—.0565	—.0259	.3280	—.1279	.4024
2	.5707	.1264	—.0814	—.4085	—.1172	.5289
3	.5855	—.3657	.5343	.0181	.0884	.7716
4	.5271	.5413	—.0379	.1501	.2270	.6463
5	.4124	—.6211	—.4647	.0020	.1670	.7997

Table 33. The matrix of transformation (hearing → deaf)

	1	2	3	4	5	Σx^2
	.9123	—.1908	—.5392	.0433	.1409	1.1812
2	.9164	.6585	—.4265	.0336	—.1270	1.4726
3	.5347	—.0972	.6429	—.2125	.0694	.7586
4	.7426	—.1803	.1499	.2930	—.1073	.7038
5	.1419	.6640	.3854	.1855	.0953	.6531

Table 34. The correlations of the factors of the deaf as transformed into the factor space of the hearing

	1	2	3	4	5
	1.0000	.3793	.5537	.5231	.4275
2	.3793	1.0000	.3552	.4864	.2679
3	.5537	.3552	1.0000	.1604	.2996
4	.5231	.4864	.1604	1.0000	—.0877
5	.4275	.2679	.2996	—.0877	1.0000
D	.6090	.7804	.7835	.6649	.7800
r_m	7932	.6253	.6214	.7469	.6258

Table 35. The correlations of the factors of the hearing as transformed into the factor space of the deaf

	1	2	3	4	5
1	1.0000	.7006	.1693	.6894	—.2091
2	.7006	1.0000	.1285	.5121	.4048
3	.1693	.1285	1.0000	.6039	.3215
4	.6894	.5121	.6039	1.0000	.1292
5	—.2091	.4048	.3215	.1292	1.0000
D	.3275	.3743	.6776	.5093	.4683
r_m	.9448	.9273	.7354	.8606	.8836

Table 36.

Total abnormal transformation (the changes in length and location of the test variable vectors; deaf → hearing)

J	= 1
1	0.0911
2	0.0346
3	0.0918
4	0.1198
5	0.1631
6	0.0525
7	0.0389
8	0.1724
9	0.0810
10	0.0955
11	0.2016
12	0.0984
13	0.1033
14	0.0450
15	0.1031
16	0.1121
17	0.1314
18	0.1316
Σ	1.8672

Table 37.

Total abnormal transformation (the changes in length and location of the test variable vectors; hearing → deaf).

J	= 1
1	0.1453
2	0.0260
3	0.0604
4	0.0988
5	0.0463
6	0.0754
7	0.0427
8	0.1858
9	0.0536
10	0.1290
11	0.0819
12	0.0310
13	0.0388
14	0.1962
15	0.0191
16	0.1583
17	0.1133
18	0.1683
Σ	1.6702

Tables 38 and 39 represent the changes in location alone, that is, the cosines of the angles between the vectors and their transforms. A low value indicates a large change in location.

Since the technique developed by Markkanen and utilized here is quite new, no reference material can, of course, be available. Therefore, no very detailed interpretation have been ventured in the following. Only the direction of the results and the extent to which they are similar to the other results obtained in this study will be considered.

An interpretation of the rotated matrix for the hearing in terms of six factors was presented in the foregoing. Here it was necessary to restrict the number of factors so as to make it equal to the number of the factors for the deaf. Consequently, if the factoring had been continued, and additional factor, namely, that of the recognition of correspondence between pictorial and verbal symbols would have emerged. The interpretations will not be reconsidered in other respects at this point. As is evidenced by the multiple correlations (Table 30), in this transformation analysis the five factors for the hearing are distinctly separate from one another, the highest multiple correlation not even amounting to .60.

Comparing the determinants with one another it is seen that the factors for the deaf are less differentiated — or more closely interdependent — than the factors for the hearing.

Tables 32 and 33 show that when the factors for the deaf are transformed into the factor space of the hearing, the factor of clerical accuracy and that of the clues of perception and memory are the most invariant ones. In transforming the factors of the hearing into the factor space of the deaf, the factor measuring the speed of undifferentiated ideation and the factor of visual ability remained most invariant. It is curious and interesting that expressly the factors for which no corresponding factors were obtained in the separate factor analyses of the other group tend to remain invariant — in the formal, computational sense of the word.

When compared with the original factor correlation tables, Tables 34 and 35 indicate that the transformations in either direction caused a marked increase in the multiple correlations. This is, in fact, what usually happens in transformation analysis. A point of some interest is that the multiple correlations of the factors of the deaf, as transformed into the factor space of the hearing, are distinctly lower than those of the factors of the hearing, as transformed into the factor

Table 38.

The changes in the location of the test variable vectors (deaf → hearing).

J	= 1
1	0.8609
2	0.9679
3	0.9001
4	0.8373
5	0.8103
6	0.9519
7	0.9718
8	0.7321
9	0.9206
10	0.8036
11	0.8358
12	0.9271
13	0.9093
14	0.9491
15	0.9385
16	0.7572
17	0.7731
18	0.7876
Σ	15.6342

Table 39.

The changes in the location of the test variable vectors (hearing → deaf).

J	= 1
1	0.9015
2	0.9770
3	0.9596
4	0.9263
5	0.9672
6	0.9369
7	0.9608
8	0.7887
9	0.9404
10	0.7944
11	0.9403
12	0.9795
13	0.9624
14	0.7883
15	0.9790
16	0.7185
17	0.8529
18	0.7987
Σ	16.1724

space of the deaf. This conforms to the result yielded by the comparison of the determinants, according to which the hearing show more differentiation of functions in these tests than the deaf.

Tables 36 and 37 show that the total amount of abnormal transformation is larger when the factors of the deaf are transformed into the factor space of the hearing than in the reverse case. This is probably due to purely technical reasons: the change is likely to be generally greater in shifting from less differentiated to more differentiated subjects than in shifting from more to less differentiated ones. A further contributory factor may, however, be that the test battery was designed for the deaf, so that the reliability and validity of the tests were higher with the deaf than with the hearing. Transformation in the direction from the deaf to the hearing occasioned the largest amount of abnormal transformation in the case of the Four Simple Uses of Arithmetic, Ideational Gestaltung and Information tests. A fairly large amount occurred in the case of visual memory as well. When the transformation was in the opposite direction, abnormal transformation was largest in the 'correct' variable of the Letter Groups test and in the Ideational Gestaltung and Tools tests.

As will be presented in greater detail in the Discussion chapter, the deaf and the hearing seem to use largely different functions in performing the tasks involved in the Ideational Gestaltung test (and the Tools test). This result seems natural, indeed, and it is also compatible with the results of the preceding factor analyses.

The Information test and the Four Simple Uses of Arithmetic, in turn, seem to possess a structure that makes them particulary "easy" for the hearing. (In the Information test, carefulness accounts for the largest part of the variance in the case of the hearing; in the Four Simple Uses of Arithmetic, again, the constantly changing nature of the items and, in particular, the multiplication and division problems caused obvious difficulties to the deaf.)

Tables 38 and 39 reveal that, insofar as the changes in location alone are taken into account, abnormal transformation was most marked in the 'errors' variable of the Letter Groups test, in Ideational Gestaltung and in the Tools test. An explanation concerning the Ideational Gestaltung and Tools tests was already given above. The instability of the 'errors' variable of the Letter Groups test, again, may be attributable to the low reliability of this test. All in all, Tables 38 and 39 show that, on the average, the changes in location resulting from the transformations were quite slight. (The figures in these tables indicate, in fact, the correlations of the transforms with the corresponding variables of the latter space.)

These tables furnish a foundation for further studies. As more information is accumulated, more light will be shed on the psychological interpretations that should be given to the different numerical values and the differences between them.

IV Discussion

The study reported here was orientative. The aim was to give a crude picture of the ways in which various ability traits are interrelated in the deaf and the hearing; and the degree of differentiation of the ability structure of the deaf. The study was intended as a background structure to which more detailed analyses of various specific problems could be related as investigation of the set of problems advances. The results obtained so far warrant an analysis of certain central problems at this point. The discussion that follows will primarily concern the congenitally totally deaf.

Verbal retardation

The most crucial problem the deaf have to cope with is associated with retardation of verbal development. Their fundamental disability lies in this domain. In the present study this was borne out extremely clearly by the differences between the mean scores of the deaf and the hearing on all the verbal tests. It is highly difficult, if not impossible, to devise a verbal test sufficiently difficult for the hearing but not too difficult for the deaf. Hence, there is the danger that even if the test is reliable with the hearing, the factor causing variance may be, for example, carefulness. When research continues, the factor structures should also be compared in instances where the verbal tests administered to the hearing have been designed, as regards their degree of difficulty, expressly for them. At this stage it was not yet possible to form an accurate picture of the relative degrees of difficulty of the tests for the deaf and the hearing. To be sure, difficulties in the interpretation of the results might also arise if the tests represented two distinctly different levels of difficulty.

Though the tests were of the vocabulary type, it is difficult to estimate, in the absence of sufficient material for comparison, the average extent of the vocabulary of the deaf. The first series in the

Picture Naming test depicted concrete objects and the second series concrete activities. The deaf differed from the hearing to a statistically significant extent on each item. Obviously, the two groups would have differed still more definitely if use had been made of abstract nouns, adjectives and verbs. In this study the measurements pertained to the passive vocabulary of the deaf, which always exceeds, of course, the active vocabulary to some extent. Emotional attitudes have caused even the experts to hold widely divergent views about the size of the vocabulary of the deaf. Conjectures have been made that the vocabulary of the congenitally deaf leaving school is no more than 500 words on the average. Judging from the results of the present study, such an estimate appears quite realistic.

Consequently, there is empirical evidence to show that the body of verbal concepts that a congenitally totally deaf person is able to master is, even after he has received instruction in speech reading throughout his school years, so scanty as to permit only very restricted possibilities for the development of high-level, nuanced mental content. One interesting and even significant aspect of the acquisition of a body of concepts is this. It is possible, in principle, that a person with a high-level basic verbal aptitude will lack an ability for visual or kinaesthetic gestaltung of the movement patterns of the lips and will remain, in consequence, relatively undeveloped in verbal ability. The inherited basic capacity of the central, verbal functions may even represent a truly high level; but in the absence of sufficient material to operate with this is of no avail. The verbal ability of deaf person may consequently seem to be low because the ability functions associated with visual or kinaesthetic imagery, but independent of verbal talent, are operating, before the verbal domain is reached, as a kind of eliminating agency. No similar phenomenon is met with in the hearing. Little or no attention has so far been devoted to this question. In practice, the consequences of verbal inability are likely to be the same irrespective of the factors behind it. It is possible, however, that considerable changes in the deaf's rank order in verbal ability could be brought about through varying the methods used in teaching concepts. The fact that, according to Myklebust's findings, the correlations between educational achievement and non-verbal tests are lower for the deaf than for the hearing also seems to support this view. Systematic research on speech-reading ability and the effects of different methods of instruction is a necessity. A deaf person with a weak ability for speech reading is confined to a vicious circle, as it were. In the absence of a sufficient frame of reference, it is difficult for him to learn new concepts through "anticipatory guesses". On the other hand, in order to acquire a sufficient frame of reference he ought to be able to speech-read.

There has been a great deal of dispute about whether verbal retardation in the deaf is specific or whether its effects extend to other mental functions as well. This question entails far-reaching consequences, particularly as regards the instruction of the deaf. Moreover, for the psychology of thinking, for example, the study of the congenitally totally deaf furnishes invaluable information about, say, the interrelations between language and the higher thought processes.

Reasoning (the abstractness — concreteness dimension of thinking)

Several researchers hold that the deaf particularly experience retardation in abstract thinking. This kind of retardation has been supposed to be directly interrelated with verbal retardation. A formulation of this kind amounts, however, to oversimplification. Conceptual confusion has led to a great deal of futile dispute. In the following an attempt will be made to discover what kinds of thought processes the term 'abstractness' has been associated with. How are the performances of the deaf and the hearing related to each other with respect to specific, distinguishable aspects of abstract thinking? What is the significance of verbal retardation with regard to these aspects? And how should the research results be interpreted when seen against this background?

What is meant by 'abstracting ability'? Three main aspects may be distinguished. First, the term may refer to thought processes whereby a more general concept is formed out of a less general concept or concepts. If abstraction is distinguished from mere ideation, abstraction amounts, in a broader sense, to classification, to the naming of classes and to the mastery of increasingly more general concepts and their interrelations. The second aspect exists because some concepts are in themselves more concrete and tangible (house, stone, etc.), while others are more abstract and intangible (faith, justice, etc.). The words denoting classes of concrete classes (car, ship, etc. — means of transportation) are easier to comprehend than those denoting classes of abstract classes (Christianity, Buddhism, etc. — religions). The third aspect with which the term 'abstractness' has been associated is the distinction between what is perceptual and what is purely ideational. (The Latin word *abs-trahere* means separation from a perceived context.) As far as the first aspect is concerned it is difficult to speak about 'concreteness' and define it accurately. It is more natural to speak of different levels of abstractness or, better still, of different levels of conceptualization. Nor is it easy to draw a hard and fast line between the abstract and the concrete in regard to the second aspect. It is only with the third aspect that one can speak, in a natural way, about what is concrete and tied up with perception — as distinct from what is purely ideational. This distinction should be kept in mind when speaking of the concreteness or abstractness of the deaf's thinking.

What, then, is the role played by language as regards the hierarchy of conceptual abstracting? Does the child learn a name for a pre-existing, internally organized concept, or does an image come into being only with the aid of a symbol? There has been a great deal of merely apparent dispute, reducible to this question. Goldstein and Scheerer (1941), for example, stated: "Conceptualization need in no way be identical with the conscious awareness of the word corresponding to the concept." The same was emphasized by M. Eberhard (1940) who stated that in teaching the deaf it is essential to realize that the child is seeking a symbol for an already organized idea.

The question posed above does not, in fact, involve two mutually exclusive alternatives; rather, it involves two possibilities which are realized to varying extents in reality. At a certain level, of course, the assertions of Goldstein and Eberhard hold true. To take a fictitious example, we may imagine a deaf child who does not know a single word. When he walks in a forest, an insight-like classification into various species of trees may come into being in his mind — so that he has concepts without names. Such a classification, based on concrete similarity, may actually be regarded as the first level of abstract thinking. As stated above, the body of concepts available to the deaf is highly limited. It is exceedingly difficult to master the relationships between different conceptual classes without any concepts or with few concepts. The number of images for which there is room in consciousness is, in a sense, limited. A symbol serves to free energy, as it were; it makes the image, as a concept, easier to master, so that space is prepared for new images and relationships between them. The storing of images in the form of symbols can be regarded as the very backbone of the development of science: after a certain level of "storing" has been reached in this way, the next stage is easier to attain.

In this sense it is just as impossible to reach any high level of verbal-conceptual thinking with a scanty store of verbal symbols as it is to master the most advanced branches of mathematics without mathematical symbols. It is true that man constantly seeks symbols for new images that have already been organized to a greater or less extent, but, after passing a certain limit, new images cannot come into being without a certain pre-existing body of concepts. According to Myklebust's study (1960), the deaf use significantly fewer pronouns, prepositions and conjunctions in story composition tests than the hearing. These words have been taught to them and they are familiar with them. The reason why the deaf use them less frequently than the hearing may simply be that they feel less need for them: they advance less frequently to the stage where relationships between systems of concepts form the material operated with.

It may be maintained that in the learning of verbal symbols the deaf remain largely at an "ostensive" level, or a level where the concepts are learned through demonstration. Hence, the concepts that are difficult or impossible to teach through demonstration remain foreign to them. Osgood distinguishes three aspects — or levels — in the characteristics underlying concept formation. The first is formed by the identical elements. The person learns to name the object according to certain common perceivable and concrete elements. The second level is constituted by common relations (for example, coin, wheel and sun). The third, which is usually referred to as the abstract level, consists of the learning of a major concept. The person learns to associate a certain concept, which is derivable from neither common, external, concrete characteristics nor relations, with certain objects or phenomena. As regards the first two aspects, concept formation takes place relatively spontaneously in the deaf too. The third aspect, however, is found difficult by them. The formation of major concepts is a non-spontaneous process in the deaf. It should be borne in mind, however, that — as already stated (cf. p. 120) — classes (major concepts) are easier to comprehend if their elements are concrete classes than in cases where the elements are abstract classes.

In the present study the deaf were found to be significantly inferior to the hearing on the Picture Groups and Picture Analogies tests, presupposing abstract reasoning. In the factor analyses, again, the variance of the Picture Groups test (which meets the criteria of a good test best) coincided largely with that of verbal ability. As optic symbols, the pictures were doubtless well known to the subjects, but the process of reasoning was no doubt slowed down by their unfamiliarity with the verbal symbols. In many instances the deaf person was likely to know the names of the five pictures presented to him, without knowing the name of the major concept through which one of the pictures was to be omitted. (Whether this is so or not will be checked in continuation studies.) This made the classification "energetically" markedly difficult. The phenomenon can be accounted for in another way, too, which will be discussed in the following.

Various researchers (for example, Oléron, Höfler and McAndrew) have discovered the deaf to be definitely inferior to the hearing on reasoning tests where flexible classifications have to be carried out according to different criteria (colour, shape, size, number, etc.). Their behaviour considerably resembles that of the brain-injured patients described by Goldstein. But Oléron sharply rejects theories assuming an analogy between the deaf and the brain-injured. The performances of deaf children do not remind one of those of brain-injured persons; rather, they are reminiscent of those of normal children one or two years younger. In the test variants employed by him, the deaf were able, for instance, to make use of the clues for classification given by the experimenter, whereas the brain-injured were not able to do so. Oléron states emphatically that in the face of test material the concrete, perceived details are predominant for the deaf and the classificatory principles for the hearing. In other words, spontaneous classificatory images are weaker in the deaf than in the hearing. Likewise, the deaf display considerable rigidity in shifting from one classificatory principle to another. McAndrew regards characterological rigidity as a central factor in the inferior performances of the deaf. (The study of the deaf clearly demonstrates that no sharp line of division can be drawn between ability traits and characterological traits. A restricted body of concepts almost necessarily causes autism of a kind, as well as the rigidity associated with it.) It is possible that the performances of the deaf on the Picture Groups and Picture Analogies tests are also affected by a lengthier dwelling upon concrete details, as well as by slowness in giving up a mistaken principle of classification and finding a correct one.

The deaf do markedly better on reasoning tasks involving ideation based upon immediate perception than on tasks associated with non-concrete ideation. The storing of images in consciousness is less imperative in the former than in the latter case. If concrete reasoning is distinguished from abstract reasoning in this sense — which would, conceptually, be the clearest procedure — the deaf are likely to equal the hearing in the former. According to Seifert, for example, deaf and hearing adults do equally well on Raven's matrices provided there is no time limit. Niskanen arrived at a similar result in experiments where a time limit was applied in this test. His subjects were pupils of the schools for the deaf.

Oléron has emphasized that the deaf are inferior to the hearing expressly in deductive reasoning. In other word, they find it particularly difficult to apply a general law or principle to single instances. Nevertheless, the essential differences between the deaf and the hearing in reasoning are hardly related to the deductiveness — inductiveness aspect. The essential factors are these: the nature of the material to be handled — its concrete or formal (abstract) character; and whether reasoning is based on immediate sensations or is, through memory, independent of sensations. In tasks where concrete material is presented and reasoning is tied up with immediate sensations the deaf equal the hearing. Myklebust places particular emphasis upon the concreteness of the test material. The deaf and the hearing do equally well on tests, for example, where pictures representing certain sequences of events are to be arranged in the correct order; but the deaf prove inferior if geometric forms, for example, are to be arranged according to some prescribed principle.

Within the framework of the present project we carried out a study in which the intercorrelations of the reasoning tests were computed. To be sure, the study was performed with a rather small group of subjects only. The correlations are set out in Table 40 (see Appendix, p. 110).

The correlations are low almost throughout. It is noteworthy, in particular, that Raven's Matrices test has little common variance with the other reasoning tests. For hearing normal groups the correlation of this test with other reasoning tests is generally of the order of .50. In the case of the deaf, the variance appears to be largely based upon visual ability alone. Also the correlations of the Sorting test are relatively low. That Picture Series is the test which most clearly possesses common variance with the other tests supports the assumption that the reasoning tests most relevant for the deaf are concrete tests based upon immediate perception. It may be hypothesized that the intercorrelations of different kinds of reasoning tests are lower for the deaf than for the hearing. The explanation may be that variance in these tests is due to some factor different from pure reasoning. Let us assume, for the sake of argument, that, of the tests in Table 40, Picture Groups discriminates with respect to verbal ability; Raven's Matrices with respect to visual ability; and the Sorting Test, say, with respect to rigidity. The contribution of reasoning proper is most distinctly brought to the fore by the Picture Series test. This hypothesis furnishes many starting points for future study.

It would be entirely trivial to discuss what the basic capacity of the deaf for abstract thinking is. Their basic capacity is, of course, the same as that of the hearing. But, as a secondary factor, verbal retardation renders high-level abstract reasoning exceedingly difficult in the energetic respect. In this sense the factor which the present writer termed the 'energetic principle' assumes a pivotal position among the problems of the deaf's abstract thinking. In addition, the body of the deaf's material knowledge is smaller than that of the hearing, so that the deaf often suffer from an inadequate supply of the information necessary for the process of reasoning. (For example, they do not know, perhaps, the function of an object, even though they may recognize it visually, and the requisite classification may be based precisely on the function.)

Correspondence between Pictorial and Verbal Symbols

The emergence with the hearing of a factor termed recognition of correspondence between pictorial and verbal symbols was an unexpected result. What is the nature of this correspondence? As stated above, the reasoning process in the deaf is rendered slow or difficult by their possibly not knowing the verbal correlate of a pictorial symbol. A phenomenon similar in principle obviously occurs in the hearing: those who are unable, promptly and spontaneously, to find an accurate verbal symbol for a pictorial symbol also experience difficulty in discovering an adequate major concept. (Let us assume that there are pictures representing a necklace, a breastpin, a bracelet, etc. If a person calls them a string, a pin and a band, for instance, it is certainly more difficult for him to realize that they are all 'ornaments' than it is for one who has assigned them their accurate verbal symbols.) Generally speaking, it is the lack of verbal symbols that makes reasoning difficult for the deaf; but for the hearing it is the vagueness of such symbols that makes it difficult. Amazingly, in the hearing the speed of operating with verbal material, as well as verbal intelligence proper, is to a marked degree independent of this ability to recognize the correspondence between pictorial and verbal symbols. A detailed discussion of this problem does not come within the scope of the present study, but the results provide hints as to how the question should be analyzed.

Numerical Ability

Is verbal retardation the reason why the deaf are also quite definitely inferior to the hearing in numerical speed? It is difficult to give any unmbiguous answer to this question. An explanation might be sought mainly in two directions: in a general lack of training in operating with symbols or in the methods of instruction.

The correlations and the results of the factor analysis show that, in the case of the deaf, the verbal and numerical tests have a great deal of common variance. The more difficult of the numerical tests, in particular, was closely associated with the verbal factor. This seems to imply, then, that a general factor concerning operating with symbols is only differentiated after considerable training in the verbal and numerical abilities. The factor responsible for the common variance might to a large extent be unfamiliarity with abstract symbols and lack of training in using them. Vernon, for example, refers to the initially quite close interdependence between verbal and numerical abilities. (An example in a sense analogous to this would be provided by conscious use of foreing-language verbal symbols in mathematical operations. Even if we had an accurate knowledge of the foreign-language numerals concerned, their employment would markedly retard the processes of computation. We have not developed a routine for the use of these symbols.) As our subjects were school children, account must be taken of the possibility that the teaching methods used with the deaf and the hearing differ significantly in this respect. To realize this we need only think of the extra time required for teaching the verbal symbols of mathematical signs to the deaf. Very little keen attention has so far been devoted to this numerical retardation. The deaf have been found to be below the hearing in arithmetical reasoning (Wright, for example). In the absence of comparable data from different countries, however, it is impossible to conclude how much the verbal ability of the deaf depends upon the school system and teaching methods. The studies conducted in Finland suggest, however, that verbal and numerical retardation are clearly uniform phenomena. As regards comparisons with other groups of sensorially deprived persons, a study of the present writer indicated that the congenitally totally blind did somewhat better than seeing subjects on the mental arithmetic tests (Juurmaa 1959).

Alleged Compensatory Developments

Not being able to hear, the deaf have to acquire their material knowledge of the external world almost exclusively through vision and, consequently, with the aid of visual images. For the interpretation of objects and events, they have to depend upon visual gestalten and gestaltung. This has led to numerous theories about compensatory developments of abilities related to operating with visual images. Visual memory, visual (spatial) ability and perceptual speed and accuracy have been the traits chiefly asserted to show this kind of compensatory development.

Memory and Imagination

Regarding memory, the deaf also lack the associative factors deriving from audition that are of aid in recalling. Does this lead, it has been asked, to general retardation in memory? This is, however, no precise formulation of the problem at hand. The memory functions have been found to depend largely, and in specific ways, upon the sense modality involved, on the one hand, and the material to be memorized, on the other. It has been discovered, for example, that the mechanical memory for words, based upon audition, is better developed in the blind than in the seeing, even though the latter have the possibility of reinforcing their memory with associations related to visual images (Juurmaa 1959). But the question can be posed somewhat differently: What significance have auditory images as a factor associating images based on experience? In other words: In what ways do the auditory associative images enrich imagination? The imagination of the deaf is unlikely to be as rich as that of hearing persons. The restricted body of concepts at the disposal of the deaf will work in the same direction. The smaller the number of available symbols, the less the possibility of associations. In this latter respect, then, the deaf are in a definitely weaker position than the blind. Hence, we cannot speak of a general retardation of memory, but it may be possible to speak of a general retardation in the spontaneous association of images. With regard to certain specific memory functions the deaf may even be better developed than the hearing.

In the present study, use was made of two tests of visual memory: the Reproductive Drawing and Tools tests. The deaf and the hearing did practically equally well on both. No compensatory tendency made its appearance, according to this study. The two tests may be asserted to differ from each other in that the Reproductive Drawing test chiefly requires a passive, receptive kind of memory, whereas the Tools test presupposes active gestaltung. Some researchers consider that the deaf are superior to the hearing on test of the former kind (that is, on the memory-for-designs tests). Judging by the factor analyses of the present study, at least partially different functions are utilized by the deaf and the hearing in their performances on these tests. The deaf resort, perhaps, to visual functions that are, as a rule, useless or irrelevant for the hearing. On this point our data are insufficient for more detailed interpretations. To explore the functions used by the deaf, an extensive study working exclusively with various tests of visual memory and gestaltung ought to be performed. It would be interesting and important to know, for instance, whether the significance of verbal ability grows as the optic figures become more difficult and complex, According to the present study the deaf and the hearing obtain results that are, quantitatively, virtually equal, eventhough the functions used are partly different.

Visual Ability

The deaf and the hearing represented about the same level in the tests of visual ability (the Square and Square Completion tests) that required operations with visual images tied up with immediate perception. On the other hand, the hearing proved superior to the deaf on the Ideational Gestaltung test, presupposing operations with memorized spatial relationships. A comparison of the factor structures revealed that, in this test, too, the functions used by the deaf and the hearing were partly different. These results agree with our hypotheses. At this point we propose to focus our attention exclusively on the interpretation of the performances on the Ideational Gestaltung test. The results of the Square Test and Square Completion demonstrate the existence of a purely non-verbal domain of mental abilities, independent of verbal retardation. In this sense the assertions of some previous researchers were too pessimistic.

In the case of the hearing, the Ideational Gestaltung test is clearly connected with the visual factor, but with the deaf it is remarkably multi-dimensional. The variance this test has in common with verbal ability and perceptual speed is larger than in the case of any other test of visual ability. On a speculative basis, a number of different interpretations could be advanced.One possible interpretation is the following. In the hearing the rapid memorizing and gestaltung of the figures takes place largely through verbal concepts. But let us consider the factor formed, for the deaf, by Ideational Gestaltung, Picture Analogies and Tools tests. There is little doubt that, in the performances on all three of these tests, the hearing operate partly with verbal concepts. (In the Ideational Gestaltong or Tools tests, for example, they are likely to reason: "this side against that side", and so on; in the Picture Analogies test, again, they are likely to make direct use of the names of the objects and events represented by the pictures.) Nevertheless, for the hearing these verbal performances are too easy to cause variance; the variance is accounted for by other functions. By contrast, with deaf persons these verbal elements are likely to result in variance. As a consequence, a test that is non-verbal for the hearing is, in a sense, verbal for the deaf. In principle, two main possibilities should be taken into account here. First, with the deaf, this verbal variance results in the emergence of a factor, constituted by these three tests, that has no counterpart among the factors for the hearing. As appears from Tables 8 and 9, this factor correlates relatively strongly with the verbal factor. Secondly, the deaf may make use of functions (associated with perceptual and gestaltung abilities) that are irrelevant for the hearing. For example, a lack of "binding" concepts must be compensated for through intensified perceptual speed (the performances of the deaf girls on Ideational Gestaltung). Perhaps, too, in the deaf there develops a routine for the gestaltung and perception of optic details for the purposes of visual memory. It was precisely in this sense that the factor obtained for the deaf was referred to, hypothetically, as one of the clues for perception and memory.

Perceptual Speed and Accuracy

As for perceptual speed and accuracy, the deaf and the hearing did equally well on the variables of the Bourdon-Wiersma test. This test is, in fact, entirely non-verbal and based on direct, concrete perception. It should only be pointed out that the deaf did not display any compensatory tendency in this test either. In the Letter Groups test, again, where the letters were merely optic figures devoid of any symbolic meaning, the deaf fell below the hearing in both speed an accuracy. The results of the Bourdon-Wiersma test make it clear that characterological, temperamental differences were not concerned. The result merits attention. One would expect the deaf to have so much training in the use of letters that an "acquaintance quality" of this kind would no longer be capable of causing variance. Nevertheless, the perceptual functions obviously depend to a high degree upon the amount of training that the person has had with the material to be perceived. The hearing are more familiar than the deaf with operations with letters. In all probability, auditory images also aided them in remembering the original letter group. On the other hand, syllable associations were scarcely of any help, for the letter combinations employed could hardly be conceived to form syllables in the Finnish language.

Compensation Theories

What conclusions about compensatory developments in the deaf can now be drawn from our results? Do the deaf display any compensatory tendencies at all? Our results suggest, in fact, that the deaf are not superior to the hearing in any trait: the means of the deaf were in no instance significantly higher than those of the hearing. The point is, however, what kind of meaning we attach to the term 'compensation'. This concept has often been understood in too narrow a sense. Most frequently the term is used to refer to the quantitative intensification of some specific trait. Even so, it would, of course, be impossible to conceive of it as a structural superiority of the deaf; only development due to training could be involved. Upon this kind of foundation fantastic theories have been built concerning the deaf's ability for visual perception and the sensitiveness of the blind's sense of touch. Nevertheless, attempts at empirical verification of such hypotheses have in most cases proved them to be untenable. It is likely, indeed, that those with no sensory defect have in any case received sufficient training, so that, in experimental situations where their motivation is the same as that of the sensorially deprived, their performances are about equally good.

Yet it is most appropriate to employ the term 'compensation' in another sense: to refer to a wider range of phenomena than the quantitative growth of certain specific traits. The following possibilities might be distinguished. (1) The deaf and the hearing resort to different functions in order to perform an identical task. The inferiority of one function is compensated for by employing another. Particularly in the case of multi-dimensional tests, even slight nuances in the change of functions can often be brought clearly into relief. (2) Functions which are latent in the hearing, who do not need them, are actualized in the deaf. This topic has not been studied in detail. A phenomenon of this kind might occur, for instance, in connection with the functions tied up with the sense of vibration. One other possibility worth mentioning is that detailed comparisons of the factor structures of the deaf and the hearing might reveal, with an exclusive use of tests of visual ability, a function in the deaf that has remained latent in the hearing. (3) Compensation may occur, further, with such factors as motivation, satiation and endurance. It has been maintained, for example, that the deaf are superior to the hearing in the duration of perceptual accuracy.

Change of function, actualization of latent functions and motivation are the directions in which the possibilities of compensation should be sought.

Differentiation of Ability Structure

Our study showed that the ability structure of the deaf is less differentiated than that of the hearing. The number of factors has generally been assumed to be an indication of the level of development, in the sense that the higher the level of development the larger the number of emerging factors. That is, as a rule, the case with age and intelligence, for instance. But this is no truly general law. Technically, precisely the opposite may be the case as well. Let us consider a fictitious example. A factor analysis is made from the results of a test battery including four tests of visual ability. When the subjects are normal persons, these tests usually form a clear-cut visual ability factor. Nevertheless, with the deaf the case is different: two of these tests produce variance with respect to verbal ability as well. As a result, two factors may emerge for the deaf, corresponding to a single factor for the hearing. This possibility is the more likely if the battery includes no other verbal tests. In other words, a trait producing no variance at a higher level may result in the emergence of additional factors at a lower level. Nor are we justified in concluding that the functions met with in the supposedly more developed group will not occur at all in the less differentiated group, or that such functions will not be operative at all. Let us consider the verbal carefulness factor. There is no doubt that carefulness gives rise to variance with the deaf, too, but merely as a secondary factor. Here, the higher level of development manifests itself in such a form that what was assumed to be a primary factor no longer produces any dispersion; the result is that a secondary factor comes to predominate in the picture.

Consequently, mathematically condensed information is not in itself able to give much guidance in the interpretation of the results. To be more specific, it would be senseless to maintain, for example, that the hearing are, judging from the results of the present study, more differentiated in carefulness than the deaf. (Carefulness is without doubt a factor giving rise to independent variance with the deaf, too, but here it only plays the role of a secondary factor.) Nor would it be legitimate to assert that visual ability is more differentiated in the deaf simply because its variance is split up between two factors. A certain particular group may generally be maintained to be more differentiated than certain other group or groups if it displays, in certain test variables, variance incapable of interpretation in terms of the mental functions that are supposed to cause variance — in the case of test variables and batteries of a similar kind — with the other group or groups. The problem involved is qualitative rather than quantitative: the point is the presence or absence of independent variance with respect to test variables of a specific type. For example, the variance in visual ability possibly occurring with the deaf ascribable to an ability (verbal ability) which is clearly differentiated in the hearing, too, although it does not cause dispersion with them in this instance.

Hampering factor of a kind — and, in a sense, a source of error — was formed in this study by the small standard deviations of the hearing in the verbal tests. These differed distinctly from the standard deviations of the deaf, for whom the tests were designed. The reliabilities for the hearing were, however, surprisingly high. This may signify that the tests are relatively reliable measures of some trait other than verbal ability. The information provided by the differences between the means is not affected by this circumstance. On the other hand, the intercorrelations of the verbal tests and, perhaps, their correlations with some other variables may be lower than they would have been if the tests had been devised, as regards their degree of difficulty, for use with the hearing. Studies with samples from normal populations have shown that verbal tests of normal difficulty correlate — obviously on account of an actual reasoning or verbal comprehension variance — to the extent of about 40 with the reasoning tests employed in the present study; by .20—.30 with the tests of visual ability; and by .10—.20 with numerical tests. These correlations suggest the existence of a relatively clear-cut verbal comprehension factor and a reasoning — verbal comprehension factor possibly correlated with it, as well as the emergence of distinct numerical and visual factors just as in the analyses of the present study. If the comparison of the factorial structures had been carried out using different verbal tests for the deaf and the hearing, the mathematical result might have suggested the two groups to be more similar in the degree of differentiation than they appeared to be according to this study. As the present author sees it, the psychological information would nonetheless have been the same as here; for the fact that variance of the verbal tests was split up between different factors received an interpretation which appears natural at least in this stage and was not regarded as an indication of differentiation.

As stated above, the number of factors has been considered an indication of differentiation. The validity of such comparisons depends, of course, upon the criterion for the termination of factorization. No absolute criterion exists. Hence, it is essential that the criteria adopted should be applied uniformly to all the groups to be compared. But the foregoing discussion has also shown that the number of factors is only a rather crude indicator of the degree of differentiation. What is involved is, fundamentally, an analysis of the factors causing variance in performances. And the factors may be of almost any kind whatsoever; they may be trivial technical shortcomings (such as unintended differences in illumination) but also mental functions postulated by the research hypotheses. Interpretation of the mathematical analyses must be based upon the available psychological reference knowledge, and such an interpretation is, in a sense, always hypothetical.

What arguments can now be adduced in support of the assertion that the ability structure of the deaf is less differentiated than that of the hearing? At this stage the main points to be made are as follows. That the deaf's ability functions are less differentiated than those of the hearing is principally evidenced by the larger common variance that verbal, numerical and at least certain kinds of reasoning tests have in the case of the deaf. On the other hand, at least the present test battery yielded, with the deaf, no factor incapable of interpretation in terms of the ability traits differentiated also in the hearing. Further research may be able to show whether these interpretations are correct or not. The material presented in this monograph will serve as a frame of reference when research is continued. It should also be pointed out that most of the tests employed were speed tests. What kinds of results regarding differentiation would have emerged if use had been made of power tests? Are the correlations of speed and power tests similar for the deaf and the hearing? These exceedingly important questions are likely to be subjected to study in relatively near future.

The study reported here dealt with children and adolescents. In the deaf, certain traits are likely to develop more slowly than in normal persons and attain their maximum at a more advanced age. A comparison of deaf adults with hearing adults would probably give results to some extent different from those obtained in this study. A detailed comparison of growth curves would be important from the point of view of the education of the deaf, for example. Comparing the factor structures of the deaf and the hearing by age groups one might receive detailed knowledge about the functional differences between these groups. Moreover, research concerning the sensorially deprived will certainly yield invaluable knowledge about the differentiation and compensation phenomena of mental functions.

Summary

The study concerned analysis of the ability structure of the deaf and comparison of the ability structures of the deaf and the hearing, primarily with respect to the following hypothetical factors: verbal ability, reasoning, visual ability (spatial), visual memory and perceptual speed and accuracy. (Two or three tests were designed to measure each of the factors and the study dealt with a total of 18 variables.)

Subjects. The subjects were pupils of schools for the deaf, aged 12—17 (49 boys and 45 girls). The corresponding control group, made up of hearing elementary-school pupils, was accurately matched as regards age. As for the sampling, the groups were representative of their respective populations, except for the circumstance that the group of hearing subjects was likely to be below the average in intelligence because the brightest children over 11 usually attend grammar schools. Thus, insofar as the hearing are superior to the deaf, this sampling error can be said to be in the safe direction.

Tests. Two points of view were in the foreground in choosing the traits to be investigated. One was the desire to analyze the effects of verbal retardation; the other was the wish to make some of the assertions concerning compensatory developments the subject of investigation. The tests have been described on pp. 00—00. A separate chapter is devoted to the discussion of the difficulties concerning test instructions in the case of the deaf.

Statistical Treatment. The study was differential psychological in nature. Apart from comparisons of the means for the deaf and the hearing, correlative relations provided the basis for the analysis. Factor analyses were made separately for the following groups: the total group of the deaf, the deaf girls, the deaf boys, the total group of hearing elementary-school pupils, the hearing boys, the hearing girls, and, finally, the control group of hearing adults. The factor analyses were carried out employing at least one of the following two procedures. (1) Objective mathematical orthogonal rotation through the Varimax method, starting from the principal axis matrix. (2) Ahmavaara—Markkanen's Cosine Rotation, starting either from the principal axis matrix or from the centroid matrix. Rotation was carried out through the Varimax method for all the groups. For all the groups of the deaf and the total group of hearing elementary-school

children, the results of both the objective rotation methods are presented side by side. To facilitate comparison, the factors obtained in all the analyses have been presented side by side in Table 26. A descriptive account of the extent to which the deaf and the hearing use the same functions in performing identical tasks is based on this table. To compare the factor structures of the total group of the deaf and the total group of hearing elementary-school pupils, transformation analyses were performed in both directions. (In other words, the factors obtained with the deaf were transformed into the factor space of the hearing, and, correspondingly, the factors of the hearing were transformed into the factor space of the deaf.)

Results; Comparison of the Means. The deaf were superior to the hearing on none of the variables. With regard to visual ability of a concrete kind, visual memory and perceptual speed and accuracy, the groups were most nearly similar. Nevertheless, on the test of perceptual ability where letters served exclusively as optic, perceptual material devoid of any symbolic function the hearing were definitely superior to the deaf, just as they were above the deaf on the test of non-concrete visualization. On verbal ability, numerical ability and reasoning the hearing were definitely superior to the deaf. Since the sampling error was here in the safe direction, the results can be regarded as so much the more convincing.

Comparison of the Factor Structures. Considered as a whole, the factor structure of the deaf proved less differentiated than that of the hearing. The principal results were as follows. (1) For each group of the deaf there emerged a general verbal ability factor, on which the more reliable of the reasoning tests, based on pictorial symbols, and the more difficult of the numerical tests had high loadings. What was involved was, perhaps, a general, undifferentiated ability to operate with symbols. No corresponding factor was obtained for the hearing. (2) The standard deviations of the verbal tests were small for the hearing, and the tests were possibly split up between different factors on the basis of non-verbal variance. Two tests with the lowest standard deviations constituted a factor on their own. This was termed a verbal carefulness factor. Correspondingly, two tests with a higher discriminative power formed a factor regarded as the verbal intelligence factor proper for the hearing. (3) The most amazing result with the hearing was a factor constituted by three tests, one of which simply involved the naming of optic figures, while the other two were concerned with reasoning based upon pictorial symbols.

This was referred to as a factor of the recognition of correspondence between pictorial and verbal symbols. (4) No pure factor of numerical ability was obtained for any of the groups of deaf subjects. By contrast, such a factor was found for every group of hearing subjects. In the case of the deaf, numerical ability was associated partly with verbal ability and partly with visual ability. (5) The visual tests based upon immediate perception formed a factor on their own with the deaf; the test which required operating with spatial images, independent of perception, was separate from this factor. It was assumed that the variance of the last-mentioned test was partly associated with verbal ability and perceptual speed. A distinct, uniform factor formed by all the tests of visual ability emerged for the hearing. — The tables concerned with transformation analysis contain specific information about the invariance of the variables and factors in shifting from one group to another. The factor structure of the test battery — or, in a sense, its power of differentiation — was also checked employing the group of 16 to 22-years-old subjects with normal audition. The results are presented in this monograph.

In the Discussion chapter of this monograph, the possible interpretations of the results are considered by factors. Particular attention is devoted to the nature of the abstract thinking of the deaf and, especially, to the significance of verbal retardation for it. Particular consideration is also given to numerical retardation in the deaf. Certain points of view brought to the fore by research concerning the deaf and the sensorially deprived in general are also indicated in this context.

Appendix

Table 40. The intercorrelations of the various reasoning-tests.

Deaf boys. N=30	1	2	3	4	5	6
1 Picture Analogies						
2 Picture Groups	32					
3 Raven's Matrices	—08	13				
4 Picture Series	25	53	28			
5 Sorting Test (time)	07	12	—09	26		
6 Sorting Test (quality)	—25	06	29	41	42	

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