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THE NEW SOUTH AFRICAN INDIVIDUAL SCALE AS A MEASURE OF GROUP DIFFERENCES IN COGNITIVE FUNCTIONING

A Dissertation presented to the Department of Education of the University of the Witwatersrand

in fulfilment of the requirements for the Degree of Master of Education

by

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DECLARATION BY CANDIDATE

1) This dissertation is my own work.

2) It has not been submitted to any other University.

Diana Dubb

C O N T E N T S

			Page No.
CHAPTER 1	-	INTRODUCTION : PURPOSE OF STUDY	1 - 4
CHAPTER 2	-	THE WISC AS A MEASURE OF GROUP DIFFERENCES IN COGNITIVE DEVELOPMENT - A REVIEW OF EARLIER RESEARCH	5 - 18
CHAPTER 3	-	PROFILES AS A FUNCTION OF INTER-TEST CORRELATION AND ERRORS IN STANDARDISATION ...	19 - 32
CHAPTER 4	-	THE PRESENT STUDY : SUBJECTS AND TESTS ...	33 - 44
CHAPTER 5	-	PRELIMINARY ANALYSIS OF TEST DATA : GROUP DIFFERENCES ...	45 - 60
CHAPTER 6	-	COMPLETE ANALYSIS OF THE NSAIS DATA : COMPARISON OF GROUP PROFILES AND DISCUSSION OF RESULTS	61 - 77
CHAPTER 7	-	SUMMARY AND CONCLUSIONS	78 - 84
APPENDIX I	-	ANALYSIS OF WISC DATA PRESENTED IN LEEDS STUDY	85 - 94
APPENDIX II	-	APRAXIA	95 - 100
APPENDIX III	-	RESULTS OF TESTING ON NSAIS, VERNON GRADED READING TEST AND GOODENOUGH DRAW-A-MAN TEST	101 - 104
BIBLIOGRAPHY		... ...	105 - 108

Chapter 1

INTRODUCTION : PURPOSE OF STUDY

In earlier years tests of intelligence provided only a single intelligence quotient which could be regarded as verbal or non-verbal, depending on the nature of the test. The appearance of the Wechsler Tests marked a new departure in the construction of intelligence tests in that the test material was arranged to form ten sub-tests dealing with different aspects of cognitive development. As a result, the Wechsler Test not only provides both a verbal and non-verbal intelligence quotient but also standardised measures of development for ten different aspects of intellectual functioning.

A popular method for depicting the results of any one subject on a Wechsler test is to construct a profile of his standardised scores on the ten sub-tests. The resulting pattern shows more or less at a glance the variability in performance of the testee for the ten different aspects covered by the test. This is obviously much more informative, and therefore meaningful, than a single IQ or a pair of IQ's, verbal and performance; although it must still be recognized that the material of the ten sub-tests is only a limited sample of the whole range of cognitive functioning.

It was soon realised that the Wechsler tests could be used to provide a pattern of cognitive functioning not only for individual testees but also for groups of individuals selected according to different criteria, the idea being that each group would show a pattern of functioning characteristic

of that group. Since the appearance of the Wechsler tests and of the Wechsler Individual Scale for Children (WISC) in particular, there have been many investigations of this kind. The results of these studies, however, have not been as clearcut as one could wish.

As is explained later in Chapter 2, one of the main reasons for inconsistencies in the results of these studies is the non-random nature of many of the samples tested. In the case where a random sample of subjects is taken from a given population, one should obtain test results which, within the limits of sampling error, are representative of the population as a whole: and other random samples should give the same results (again within the limits of sampling error). But where a sample cannot be regarded as a random sample from a parent population but is either a special group of testees or a sample from such a special group, then results are obtained which are typical of that group and which do not necessarily have the representative character of a sample from the general population selected in accordance with the principles of random sampling. In the literature this distinction is not appreciated.

The design of the New South African Individual Scale (NSAIS) is obviously similar to that of the WISC. Like the WISC therefore, the NSAIS lends itself to the study of patterns of cognitive functioning for different groups of subjects.

In the present investigation, the NSAIS was given to two groups of subjects:

(a) a group of children of normal and above normal intelligence presenting various degrees of learning difficulty, and

(b) a group of children again of normal and above normal intelligence but of superior scholastic ability.

At the beginning of the study, the primary purpose had been to study the pattern of cognitive functioning of the retarded group. The decision to include the superior group was made initially with no clearly defined objective other than the idea that it might serve as a sort of 'control' group against which the retarded group could be compared. It was realised, of course, that the pattern of functioning of a superior group might be of interest and have some intrinsic value of its own;but as already stated, the intention was mainly to have another group providing some kind of 'control' data.

The importance of having a second group for comparison purposes was not fully realised until an analysis of the resulting data was carried out. This analysis made it quite clear that the application of a test, such as the WISC or the NSAIS does not necessarily give a valid picture of cognitive functioning; the pattern obtained can just as easily be a reflection of errors of standardisation or bias in the application of the test by the tester.

An important aspect of the study is therefore an examination of the rationale underlying the use of tests such as WISC and NSAIS for studying patterns of cognitive development.

Briefly, the arrangement of this study is as follows:-

Following this chapter, Chapter 2 presents a review of earlier studies in which the WISC has been used to study patterns of cognitive functioning.

Chapter 3 then deals with the rationale of such studies. This has never been presented in any previous study. In particular, it is shown how the patterns of functioning obtained can be spuriously affected by errors of standardisation or tester bias.

Chapter 4 deals with the selection of the subjects used in the present study and gives an account of the different tests which were applied. Because of the considerable amount of data which was available in respect of the retarded group, it was possible to split this group into three sub-groups for the subsequent statistical analysis.

The next two chapters, 5 and 6, are concerned with the statistical analysis of the test data. Chapter 5 is a preliminary analysis of group differences - in particular the differences between the three sub-groups of retarded children.

In Chapter 6 is found the main statistical analysis of the study in which a complete statistical analysis of the NSAIS patterns for all the groups is carried out. It is this analysis which makes clear the limitations of studies of this kind.

The concluding chapter, Chapter 7, summarises the study and its conclusions.

Chapter 2

THE WISC AS A MEASURE OF GROUP DIFFERENCES IN COGNITIVE DEVELOPMENT - A REVIEW OF EARLIER RESEARCH

The Wechsler Individual Scale for Children (WISC) has been used to measure differences in cognitive functioning for various groups of children. Four main types of group have been tested:

(i) groups with reading difficulties;
(ii) groups showing symptoms of cerebral dysfunctioning;
(iii) groups suffering from psychopathic disorders;
(iv) mentally retarded groups.

In this chapter we shall give a review of the studies falling under (i) and (ii) since the present investigation is concerned with children falling under these categories. Furthermore, since this investigation is concerned also with the pattern of cognitive functioning of a 'superior' group, any earlier studies involving normal or superior children will be included in the review.

Before proceeding with our task it will be helpful to the reader if a brief description of the WISC is first presented.

Description of WISC

This test has grown logically out of the Wechsler Bellevue Intelligence Scale which was devised for use with American adolescents and adults. The WISC was standardized on a sample of 100 boys and 100 girls for each age level ranging from 5 to 15 years. This involved a total of 2,200 subjects chosen to match the census description as regards sex, geographic region, rural-urban residence, race, father's occupation and education. The test is divided into verbal and performance scales giving rise to a Verbal I.Q., Performance I.Q. and Full Scale I.Q. The mean scaled score for each sub-test is 10 with a Standard Deviation of 3.

Sub-Tests

Five verbal and five performance tests make up the battery. Two additional tests are provided - one on the Verbal Scale and one on the Performance Scale to be used as supplementary, alternative or additional tests.

The Verbal Tests are: General Information, Comprehension, Similarities, Arithmetic, Vocabulary. Digit Span is the additional test.

The Performance Tests are: Picture Completion, Picture Arrangement, Block Design, Object Assembly and Coding (Digit Symbol). Mazes is the additional test.

(a) Verbal tests:

(i) General Information. This consists of 30 questions concerned with information gained from experience, education and cultural background.

(ii) Comprehension. The responses are based on general knowledge and social judgement. The subject is required to make generalizations based on knowledge acquired in his social milieu.

(iii) Similarities. This test involves the abstracting of logical relationships between objects and ideas.

(iv) Arithmetic. This consists of 16 arithmetical problems orally presented.

(v) Vocabulary. The subject is asked to define 40 words.

(vi) Digit Span. This is the supplementary test. The subject is asked to repeat series of digits forwards and backwards

(b) Performance tests:

(vii) Picture Completion. The subject is asked to identify the missing part of each of 20 pictures.

(viii) Picture Arrangement. The subject must piece togetner 3 or more cartoon panels presented in random order, to form a coherent story.

(ix) Block Design. The subject is asked to use coloured blocks to form a pattern presented on a card.

(x) Object Assembly. The child attempts to assemble 4 objects, a manikin, a horse, a face and a car, from isolated pieces.

(xi) Coding (Digit Symbol). The person is required to insert the appropriate code symbol under a given number.

(xii) Mazes. The subject is asked to draw a correct path through mazes of increasing difficulty.

Scoring of WISC

Raw scores are derived from each sub-test which are converted to scaled scores which in turn are summated and converted to Verbal I.Q., Performance I.Q., and Full Scale I.Q.

Review of Earlier Research

As stated at the beginning of the chapter, the review will be confined mainly to two classes of studies:

(a) those where the WISC was applied to groups with reading difficulties;

(b) those where the test was applied to groups showing symptoms of cerebral dysfunctioning.

But it will also include :

(c) four studies where the WISC has been applied to normal or superior children.

Although it may not always be expressed explicitly, the underlying assumption of all the studies, whether type (a), (b) or (c), is that there is one pattern of functioning which is characteristic of all groups within the type studied.

As indicated in the first chapter, this assumption is only valid if the groups can be regarded as random samples from the

same parent population. Thus, if we wish to study the cognitive functioning of pupils with reading difficulties, and we want a result which is general for backward readers in the parent population, it would be necessary to choose a random sample of pupils from all those with reading quotients less than some arbitrary figure, e.g. 85. Only then could we be sure of arriving at conclusions which would be characteristic of backward readers generally - always, of course, within the limits of sampling error.

The studies reported in the literature, almost invariably, do not involve random samples of pupils from the general population. In nearly all cases it has been a matter of testing a group from some school or clinic. Such a group cannot be accepted as a random sample from the general population. At best it can only be representative of the sub-population of pupils attending the school or clinic, and it is impossible to take the results from any one study in isolation and draw any justifiable conclusions in respect of the general population. However, by examining the results of the different studies together, it might be possible to reach conclusions which could reasonably be regarded as being of a generalised nature.

Before attempting to derive any overall conclusions, it should be noted that all the studies reviewed below have dealt with the pattern of group cognitive functioning in terms of two aspects:

(i) The sub-tests of the WISC on which the group obtained the lowest scores. (In the case of inferior groups, such as poor readers or groups suffering from cerebral dysfunctioning, this would appear to be probably as good a way as any of stating briefly the general pattern of cognitive functioning).

(ii) The Verbal-Performance I.Q. discrepancy, i.e., the difference in magnitude and sign between the means of the verbal and non-verbal I.Q.'s for the group.

The tables, which appear on subsequent pages and which summarise the results of the studies, present both these aspects.

(a) Studies of WISC Pattern of Cognitive Functioning for Groups with Reading Difficulties

Tables 2.1, 2.2 and 2.3 give a summary of the data for published studies of this nature. Table 2.1 gives general information about the studies and also some indication of the I.Q. discrepancy for each study. It will be seen that in nearly all cases the mean verbal I.Q. for the groups is lower than the mean non-verbal I.Q. The only exception is Group 2 in the Kinsbourne study. Stroud and Blommers, and Burks and Bruce do not give any breakdown of scores and no measure of the I.Q. discrepancy, therefore, is available.

It is reasonable to conclude that although these studies did not include random samples of pupils from the general population, the overall results are probably very similar to those which would have been obtained if a truly random sample taken from the population had been used.

As far as the other aspect of these studies is concerned - namely the sub-tests on which the groups scored their lowest scores - this information is presented in Table 2.2. It will be seen that out of the 16 studies, as many as 14 showed low scores for Arithmetic; 11 showed low scores for Coding (Digit Symbol), 9 for Information and 11 for Vocabulary.

Only 6 of the studies named the sub-tests in which the groups obtained their highest scores. The data are given in Table 2.3. No further comment will be made on this Table until Chapter 3.

TABLE 2.1

WISC STUDIES OF GROUPS WITH READING DIFFICULTIES

No. of Study	Author(s)	Source, Age and Size of Sample*		WISC I.Q. Range
1	GRAHAM	Experimental (31) Educational Clinic 8 yrs - 16 yrs 11 mths Control - None		$I.Q._{v}$ = 98.9 $I.Q._{nv}$ = 101.7
2	McLEOD	Experimental (116) Clinic 12 yrs -6 mths (Mean Age) Control (117) Source not stated 12 yrs 0 mths		$I.Q._{v}$ = 93 $I.Q._{nv}$ = 97 $I.Q._{v}$ = 110 $I.Q._{nv}$ = 106
3	ALTUS	Experimental (25) Guidance Clinic 3rd - 8th Grade Control - None		$I.Q._{v}$ = 97.8 $I.Q._{nv}$ = 100.4
4	STROUD & BLOMMERS	Experimental (205) Clinic 3rd - 6th Grade Control - None		Full I.Q. = 89 (No breakdown)
5	NEVILLE	Experimental (35) Reading Centre 3rd Grade Control (35) Reading Centre 3rd Grade		$I.Q._{v}$ = 95.3 $I.Q._{nv}$ = 105.9 $I.Q._{v}$ = 101.4 $I.Q._{nv}$ = 99.2
6	HIRST	Experimental (30) Reading Centre 8 yrs - 13.6 yrs Control - None		$I.Q._{v}$ = 100.5 $I.Q._{nv}$ = 111.6
7	BURKS & BRUCE	Experimental (31) Not stated 3rd - 8th Grade Control - None		Full I.Q. = 101 (No breakdown)
8	KINSBOURNE	Experimental (13 divided into 2 groups) Neurological Practice 8 yrs - 14 yrs (1 case 31 yrs old) Control - None	Group 1 Group 2	$I.Q._{v}$ = 72 - 105 $I.Q._{nv}$ = 101 - 150 $I.Q._{v}$ = 86 - 128 $I.Q._{nv}$ = 53 - 108
9	RABINOVITCH	Experimental (2 groups) Guidance Clinic Group 1 (15) Primary Reading Retards 10 yrs 3 mths - 16 yrs 3 mths Group 2 (20) Secondary Reading Retards 10 yrs 2 mths - 15 yrs 1 mth Control - None	Group 1 Group 2	Full I.Q. = 91.8 Verbal < Non-verbal Full I.Q. = 94.6 Verbal < Non-verbal

*Size of sample(s) shown by number in brackets

TABLE 2.1 contd.-

WISC STUDIES OF GROUPS WITH READING DIFFICULTIES

No. of Study	Author(s)	Source, Age and Size of Sample*	WISC I.Q. Scores
10	SHELDON & GORTON	Experimental (11) Remedial Clinic 7 yrs - 14 yrs 8 mths Control (11) Unknown 7 yrs - 14 yrs 8 mths	Full I.Q. = 100.3 Verbal < Non-verbal Full Scale I.Q. = 100
11	DOCKRELL	Experimental (34) Clinic 8 yrs 2 mths - 14 yrs 9 mths Control - Not stated	Full I.Q. = 104.5 Verbal < Non-verbal
12	KALLIS & GRABOW	Experimental (37) Reading Clinic : 9 yrs - 14 yrs Control - None	Full I.Q. = 99.2 Verbal < Non-verbal
13	PATERRA	Experimental (33) Schools: 6 yrs - 14 yrs 6 mths Control - None	Full I.Q. = 107.6 Verbal < Non-verbal
14	BELMONT & BIRCH	Experimental (150) Schools 9 yrs 4 mths - 10 yrs 4 mths Control (50) Schools 9 yrs 4 mths - 10 yrs 4 mths	$I.Q._v$ = 94.8 $I.Q._{nv}$ = 102 $I.Q._v$ = 100.5 $I.Q._{nv}$ = 95.6
15	REED	Experimental (87) Schools - 4th grade 9 yrs 3 mths - 10 yrs 7 mths Control (56) School 9 yrs 3 mths - 10 yrs 7 mths	Full I.Q. = 103.6 Verbal < Non-verbal Full I.Q. = 105.2
16	ROBECK	Experimental (80) Reading Clinic 6 yrs 10 mths - 13 yrs 9 mths Control - None	Full I.Q. = 108.5 Verbal < Non-verbal

*Size of sample(s) shown by numbers in brackets

TABLE 2.2

WISC STUDIES OF GROUPS WITH READING DIFFICULTIES :
SUB-TESTS ON WHICH POOR READERS OBTAINED LOWEST SCORES*

Number of Study (See Table 2.1)	VERBAL SUB-TESTS						NON-VERBAL SUB-TESTS				
	Information	Comprehension	Similarities	Arithmetic	Vocabulary	Digit Span	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding
1				X	X	X					X
2	X			X	X	X					X
3	X			X							X
4				X	X				X	X	
5	X			X		X					
6				X	X	X					X
7	X			X							X
8 Group 1					X	X					
Group 2									X	X	
9 Group 1					X						
Group 2					X						X
10	X			X	X						X
11	X			X	X						X
12	X			X							X
13				X	X						
14	X			X	X						
15			X	X		X					X
16	X			X		X					X
TOTAL	9		1	14	11	7			2	2	11

*Thexe are indicated for each study by an X

TABLE 2.3

SIX WISC STUDIES OF GROUPS WITH READING DIFFICULTIES SHOWING SUB-TESTS ON WHICH POOR READERS OBTAINED HIGHEST SCORES*

Sub-Test	Number of Study (as in Table 2.1)															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Verbal																	
Information																	-
Comprehension	X						X										2
Similarities	X																1
Arithmetic																	-
Vocabulary			X														1
Digit Span																	-
Non-verbal																	
Picture Completion	X	X	X				X										4
Picture Arrangement	X		X			X	X	X									5
Block Design	X					X		X									3
Object Assembly	X						X										2
Coding																	-

*These are indicated for each study by an X

(b) WISC Studies of Groups Showing Symptoms of Cerebral Dysfunctioning

A summary of the studies of this type is given in Table 2.4. In all these the investigators were concerned mainly with the magnitude and sign of the I.Q. discrepancy. In only one of the studies, that of Heilbrun, was a lower verbal I.Q. obtained for the cerebral dysfunctioning group. This might be explained by the fact that the speech centre is localised in the left hemisphere and the lower verbal I.Q. was actually obtained by the children showing left side involvement.

(c) WISC Studies of Superior Groups

The data for these studies are given in Tables 2.5, 2.6 and 2.7.

It will be seen that superior children tend to be up on the verbal sub-tests and down on the non-verbal sub-tests (relatively), i.e. they tend to have a higher verbal than non-verbal I.Q. This, of course, is the reverse of the situation in the case of groups with reading difficulty.

Tables 2.6 and 2.7 will be referred to again in Chapter 3.

TABLE 2.4

WISC STUDIES OF GROUPS WITH CEREBRAL DYSFUNCTIONING

No. of Study	Author(s)	Source, Age and Size of Sample	I.Q. Discrepancy
1	Hallbrun	**Experimental** Clinic, 71 children with a) left involvement b) right involvement c) both hemispheres d) unidentified **Control** Clinic: 29 children	(a) group $IQ_v < IQ_{nv}$ (significant) (c) group $IQ_v < IQ_{nv}$ (non-significant)
2	Stevens, Boydstun, Dykman, Peters	**Experimental** Medical Refer: 1 26 children: 6-12 years **Control** 26 children: 6-12 years Same socio-economic group	$IQ_{nv} < IQ_v$ (non-significant)
3	Holroyd & Wright	**Experimental** Hospital 20 children chosen on the basis of minimum discrepancy 25 points (+ or -) between IQ_v and IQ_{nv} **Control** Hospital: 20 children matched for full IQ No IQ discrepancy	More neurological abnormality in Experimental Group and in particular for children with + discrepancy ($IQ_v > IQ_{nv}$)
4	Paine	**Experimental** Medical Referral: 83 cases 8 years 4 months (Mean age) **Control** None	$IQ_v > IQ_{nv}$ (significant)
5	Warrington James & Kinebourne	**Experimental** Referral: 50 cases divided into a) left sided lesions b) right sided lesions **Control** : None	$IQ_v > IQ_{nv}$
6	Back & Lam	**Experimental** Hospital: 104 children, 6-15 years 3 groups a) Organic impairment b) Suspected organicity c) Non-organic **Control**: None	(a) $IQ_v > IQ_{nv}$
7	Newman & Loos	**Experimental** Clinic: 128 - 3 groups of children a) Mentally deficient (familial) b) Mentally deficient (undifferentiated) c) Brain injured **Control**: None	(c) $IQ_v > IQ_{nv}$
8	Gubbay, Ellis, Walton & Court	**Experimental** Not stated 21 apraxic children 9 yrs 5 mths - 12 yrs 6 mths **Control** School: 10 children 9 yrs - 10 yrs 2 mths (Mean 10 yrs)	$IQ_v > IQ_{nv}$ (significant)
9	Brenner,	**Experimental** School : 14 children with apraxia 8 - 9 years **Control** School: 14 children, 8-9 years	$IQ_v > IQ_{nv}$ (significant)

TABLE 2.5

WISC STUDIES OF SUPERIOR GROUPS

No. of Study	Author(s)	Source, Age & Size Sample(s)*	WISC IQ
1	Levinson	Experimental (64) Jewish elementary school 11.3 years Control WAIS standardisation	IQ_v = 125.08 IQ_{nv} = 114.05
2	Gallagher & Lucito	Experimental (50) School : 7 - 11 years Control WISC standardisation	Full IQ 125 - 145
3	Thompson & Finley	Experimental (400) School : 10.2 years Control WISC standardisation	IQ_v = 131.31 IQ_{nv} = 127.65
4	Burks & Bruce	Experimental (11) Not stated 3rd - 11th grades Control : None	Full IQ = 117

*Size of sample(s) shown by numbers in brackets.

TABLE 2.6

WISC STUDIES OF SUPERIOR GROUPS : SUB-TESTS IN WHICH GOOD READERS OBTAINED HIGHEST SCORES*

Sub-tests	No. of Study 1	2	3	4	Total
Verbal					
Information	X	X	X	X	4
Comprehension	X		X		2
Similarities	X	X	X	X	4
Arithmetic					-
Vocabulary		X			1
Digit Span		X			-
Non-verbal					
Picture Completion				X	1
Picture Arrangement					-
Block Design					-
Object Assembly					-
Coding					-

*These are indicated for each study by an X

TABLE 2.7

WISC STUDIES OF SUPERIOR GROUPS : SUB-TESTS IN WHICH GOOD READERS OBTAINED LOWEST SCORES*

Sub-tests	No. of Study 1	2	3	4	Total
Verbal					
Information					-
Comprehension					-
Similarities					-
Arithmetic					-
Vocabulary					-
Digit Span		X			1
Non-verbal					
Picture Completion	X	X			2
Picture Arrangement		X	X	X	3
Block Design	X				1
Object Assembly			X		1
Coding	X		X	X	3

*These are indicated for each study by an X

Chapter 3

PROFILES AS A FUNCTION OF INTER-TEST CORRELATION AND ERRORS IN STANDARDISATION

(a) The Relationship between Profiles and Inter-Test Correlations

The point has already been made that, when the cognitive pattern on the WISC has been obtained for a group with certain characteristics, e.g., poor reading ability, the result can only be generalized if the group has been selected from the general population in accordance with the principles of random sampling. Results obtained from non-random groups, e.g., a school or clinic group, apply only to the sub-population attending that school or clinic; although, as has been recognized above, the general character of a number of such studies is probably the same as could be obtained from a truly random sample.

When one considers the cognitive pattern for groups selected from the general population in accordance with random sampling, the problem is considerably simplified and, in the opinion of the writer, becomes much more intelligible if one thinks in terms of inter-test correlations and the measures of regression that go with them.

Let us first consider the case of the WISC pattern of cognitive functioning for poor readers in a given population - let us say of mean Reading Quotient = 80, the standard deviation of the Reading Quotient for the population being taken as 15. Now let the correlation for the population between reading (as measured by the R.Q.) and one of the WISC sub-tests be denoted by ρ Then if we assume that the WISC is standardised for the

population being considered, the mean and standard deviation for any one sub-test (for the population) is 10 and 3 respectively. And from the usual regression equation

$$\frac{Y - \mu y}{\sigma y} = \rho \frac{X - \mu x}{\sigma x} \quad - \quad (A)$$

where, in our case,

$$\mu y = 10 \qquad \mu x = 100$$
$$\sigma y = 3 \qquad \sigma x = 15 \qquad \text{and } X = 80,$$

we obtain $Y = 10 - \frac{20 \times 3}{15}\rho$ i.e. $Y = 10 - 4\rho$ -- (B)

That is, knowing the value of ρ for the sub-test, we can calculate the mean score on that sub-test for our poor readers.

In fact, it will be seen that the profile of cognitive functioning for our poor readers is simply a linear function of the correlations between the WISC sub-tests and the reading test from which the Reading Quotients were derived.

It follows that a study of the pattern of cognitive functioning for poor readers in the general population becomes simply a matter of obtaining the correlations between the WISC sub-tests and whatever one is using as a measure of reading ability. The remarkable thing is that in none of the studies reported have any of the investigators concerned shown an awareness of this fact. It is also somewhat strange that the author has failed to come across any study which gives any correlations between reading and the WISC sub-tests for

the general population.[1]

In order to illustrate the derivation of the pattern of cognitive functioning for poor readers, given the correlations between the WISC sub-tests and reading, we shall assume that the correlations are as shown in Table 3.1.

TABLE 3.1

ASSUMED CORRELATIONS BETWEEN WISC SUB-TESTS AND READING

WISC Sub-Test	Correlation with Reading (ρ)	$10 - 4\rho$
Information	.60	7.6
Comprehension	.40	8.4
Similarities	.35	8.6
Arithmetic	.55	7.8
Vocabulary	.60	7.6
Digit Span	.30	8.8
Picture Completion	.25	9.0
Picture Arrangement	.25	9.0
Block Design	.35	8.6
Object Assembly	.30	8.8
Coding (Digit Symbol)	.45	8.2

[1] Later in the chapter reference will be made to a study carried out at Leeds. This study presents data which can be analysed to provide estimates of correlation with reading in the case of four of the WISC sub-tests. The analysis is presented in Appendix I at the end of the dissertation (pp 85-94).

The last column of Table 3.1 gives the values of 10 - 4ρ corresponding to the assumed correlations. As shown above, these are the mean WISC sub-test scores for poor readers of mean Reading Quotient = 80 - if we can assume the correlations to be correct. It will be seen that with the correlations given in Table 3.1 the lowest WISC sub-test scores for poor readers are Information, Arithmetic, Vocabulary, and Coding - the mean result obtained from published studies of this kind. Of course in choosing the correlations given in Table 3.1 this result was borne in mind.

(b) Profiles and Errors in Standardisation

The possibility of inaccuracy in the standardisations of the WISC is important in using sub-test scores to obtain a pattern of cognitive functioning for a group. Inaccuracy of standardisation occurs when the population mean on any sub-test is not 10, the stated standardised mean - the norm. (There is also an error in standardisation when any of the sub-test standard deviations is not 3 for the parent population). Such inaccuracy could be present even for the population in which the WISC was originally standardised - an American population - but is much more likely to be present in the case of non-American populations for which the WISC has not been standardised.

In determining the effects of inaccuracies in standardisation (in respect of sub-test means) we shall consider the two methods, already discussed, of deriving patterns of cognitive functioning:

(i) where the group being studied is tested on the WISC and sub-test means are obtained; and

(ii) where the group is a random sample from the parent population and the pattern of cognitive functioning is derived from known correlations between the WISC sub-tests and the variable (e.g., reading ability) used in selecting the group.

In the case of (i), it will be seen that the errors of standardisation will be compounded with the 'true' variations in group cognitive functioning from sub-test to sub-test. Furthermore, if the magnitudes of the errors are unknown, it becomes impossible to assign any measure of validity to the pattern of variation of scores on the sub-tests as obtained for the given group. There is a distinct possibility that the errors of standardisation could be of the same order as the true variations from sub-test to sub-test and this could lead to a gross distortion of the true pattern. Studies using control groups where the object is to compare differences between the groups on the sub-tests, will obviously avoid the difficulty of errors in standardisation; the errors will be common to the scores of both groups and will therefore cancel out when differences are taken. This applies to few of the earlier studies. The present investigation falls into this category.

In the case of (ii), the method depends on the assumption that the sub-test means for the population are 10 (and the standard deviations 3). The method, therefore, gives the pattern of functioning which would be obtained with correct standardisation but would obviously differ from the pattern obtained by method (i) by the amounts of the standardisation inaccuracies (if sampling errors are ignored).

(c) A Re-examination of Earlier Studies

It is of interest to re-examine the earlier WISC studies, reviewed in the previous chapter, in the light of the ideas expressed in sections (a) and (b) above.

The point has been made that profiles are a linear function of inter-test correlations. It follows that if we take (random) samples of poor and good readers, the profiles should be inversely related - provided that there are no errors of standardisation in respect of the sub-tests. That is, where the one profile goes down, the other profile should go up. Or, putting it another way, we can say that poor readers should get their lowest scores on the sub-tests in which good readers get their highest scores and vice versa. If in the case of any one sub-test we found that this generalisation did not hold, then we can suspect an error of standardisation. Also it should be possible to determine the direction of the error, i.e. whether the standardisation is inflated (positively biased) or deflated (negatively biased).

The tables provided in Tables 2.2, 2.3, 2.6 and 2.7 of Chapter 2 lend themselves to a test of this kind. From Table 2.2, one is able to read off for each sub-test the proportion of studies in which poor readers obtained one of their lowest scores for that test; and from Table 2.6 one can read off for each sub-test the proportion of studies in which good readers obtained one of their highest scores. These two sets of data are incorporated in Table 3.2. In a similar manner, Table 3.3 was drawn up.

TABLE 3.2

WISC STUDIES OF POOR AND GOOD READERS : PROPORTIONS OF STUDIES PER SUB TEST IN WHICH POOR READERS OBTAINED LOW SCORES AND GOOD READERS HIGH SCORES RELATIVE TO THEIR GROUP

Sub-Test	Proportion of Studies showing Low Scores for Poor Readers[1]	Proportion of Studies showing High Scores for Good Readers
Information	9 out of 18	4 out of 4
Comprehension	0 " " 18	2 " " 4
Similarities	1 " " 18	4 " " 4
Arithmetic	14 " " 18	0 " " 4
Vocabulary	11 " " 18	1 " " 4
Digit Span	7 " " 18	0 " " 4
Picture Completion	0 " " 18	1 " " 4
Picture Arrangement	0 " " 18	0 " " 4
Block Design	2 " " 18	0 " " 4
Object Assembly	2 " " 18	0 " " 4
Coding	11 " " 18	0 " " 4

[1] Studies 8 and 9 (Table 2.1) each have two separate experimental groups. The total number of studies is therefore taken as 18 and not 16.

TABLE 3.3

WISC STUDIES OF POOR AND GOOD READERS : PROPORTIONS OF STUDIES PER SUB-TEST IN WHICH POOR READERS OBTAINED HIGH SCORES AND GOOD READERS LOW SCORES RELATIVE TO THEIR GROUP

Sub-Test	Proportion of Studies showing High Scores for Poor Readers	Proportion of Studies showing Low Scores for Good Readers
Information	0 out of 6	0 out of 4
Comprehension	2 " " 6	0 " " 4
Similarities	1 " " 6	0 " " 4
Arithmetic	0 " " 6	0 " " 4
Vocabulary	1 " " 6	0 " " 4
Digit Span	0 " " 6	1 " " 4
Picture Completion	4 " " 6	2 " " 4
Picture Arrangement	5 " " 6	3 " " 4
Block Design	3 " " 6	1 " " 4
Object Assembly	2 " " 6	1 " " 4
Coding	0 " " 6	3 " " 4

From these two tables, 3.2 and 3.3, it is possible to decide in the case of each sub-test (a) whether the standardisation is likely to be biased and (b) the direction of this bias. The results are set out in Table 3.4 and should be self-explanatory.

It would appear from this analysis that for the studies reviewed, the WISC standardisation is probably inflated for sub-tests Comprehension and Similarities, probably deflated for sub-tests Arithmetic and Coding and perhaps deflated for Digit Span.

It is not possible to give an estimate of the magnitude of these likely cases of bias but they could seriously invalidate studies in which the WISC is used as a means of obtaining the pattern of cognitive functioning for a group of subjects.

TABLE 3.4

WISC SUB TESTS : ESTIMATES OF BIAS IN STANDARDISATION

DERIVED FROM TABLES 3.2 AND 3.3

Sub-Test	Comments on Proportions given in Table 3.2	Comments on Proportions given in Table 3.3	General Estimate of Bias
Information	Proportions consistent. No bias.	No contradiction in proportions	No bias
Comprehension	Some contradiction Norms perhaps inflated	Some contradiction Norms perhaps inflated	Norms probably inflated
Similarities	Proportions at variance. Norms probably inflated.	Little contradiction (Slight inflation)	Norms probably inflated
Arithmetic	Proportions greatly at variance. Suggests norms deflated.	No apparent contradiction	Norms probably deflated
Vocabulary	Some contradiction. Perhaps slight deflation.	Slight contradiction.Suggests inflation	No bias
Digit Span	Some contradiction Norms perhaps deflated	Slight contradiction. (Slight deflation)	Norms perhaps deflated.
Picture Completion	Slight contradiction. (Slight inflation).	Results consistent	No bias
Picture Arrangement	No contradiction	Results consistent	No bias
Block Design	Slight contradiction. (Slight deflation)	Results consistent. (Slight inflation)	No bias
Object Assembly	Slight contradiction. (Slight deflation)	Results consistent. (Slight inflation)	No bias
Coding	Proportions at variance Norms probably deflated	Proportions at variance Norms probably deflated	Norms probably deflated

(d) Multivariate Selection of Groups

So far in considering the selection of a group for the purpose of profile analysis, we have been dealing either with an 'intact' group taken from, say, a school or clinic, or a group selected randomly from the parent population according to some variable, e.g., reading ability. It is, of course, possible to select a group by taking into account two or more variables. Thus we might apply the WISC to a group of average intelligence ($90 \leq$ I.Q. ≤ 110) and of low reading ability (R.Q. ≤ 85). When a group is selected according to two or more variables, we are dealing with what might be termed multivariate selection (as opposed to univariate selection). Once again, results will have greater generality if multivariate selection is applied to a large parent population and not to a comparatively small 'intact' group.

Some of the reported studies involve multivariate selection but only one of these involves multivariate selection as applied to a parent population. This is a study carried out at Leeds by Lovell, Shapton and Warren.[1] We shall use the data of this study to illustrate how regression analysis can be applied in order to determine sub-test performances for group(s) selected by multivariate selection.

As the title indicates, the primary purpose of the Leeds study was to examine some cognitive abilities of backward

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[1] Lovell, K., Shapton D. and Warren, N.S. (1964). A Study of Some Cognitive and Other Disabilities in Backward Readers of Average Intelligence as Assessed by a Non-Verbal Test. Brit.J.Educ.Psychol., 34, 58-64.

readers with average intelligence as assessed by a non-verbal test. The method used consisted of comparing two groups, of 50 pupils each:

(a) a backward group with reading quotients less than 80 and with a normal range of non-verbal intelligence (90 - 131);

(b) a non-backward group th average R.Q. of 106 (S.D. = 6.3) and matched with the backward group for non-verbal intelligence.

Among the tests applied were the four WISC sub-tests: Vocabulary, Block Designs, Object Assembly and Coding. (It might be noted that by using a control group, the investigators in the Leeds study avoided the difficulties of errors in standardisation both with regard to means and standard deviations).

When the two groups were compared on the 4 WISC sub-tests, it was found that the group differences were all in favour of the non-backward group, the differences for Vocabulary and Coding reaching the 1 per cent level of significance, Block Designs the 2 per cent level and the difference for Object Assembly failing to reach any acceptable level of significance.

It will now be shown that with any knowledge of the inter-test correlations involved, these differences follow automatically from a regression analysis.

Let x_1, x_2, x_3 be 3 standardised variates (mean = 0, S.D. = 1) representing WISC sub-test, reading and non-verbal intelligence respectively.

Then x_1 can be estimated from x_2 and x_3 by means of the following regression equation:

$$\hat{x}_i = a\,x_2 + b\,x_3 \qquad \text{(1)}$$

$$\text{where } a + b\,r_{23} = r_{12} \qquad \text{(2)}$$

$$\text{and } a r_{23} + b = r_{13} \qquad \text{(3)}$$

r_{12}, r_{23}, r_{13} representing the correlations between the three variables.

That is, knowing the values of the three correlations, we can determine the values of a and b; and knowing the latter, we can substitute in (1) and determine $\hat{x}_1$ for any given values of x_2 and x_3.

We shall illustrate the method for the Coding sub-test, using the data provided in the Leeds study.

According to the analysis presented in Appendix I, pp. the correlations between the three variables x_1, x_2 and x_3 are:

whence $r12 = 0.43$; $r13 = 0.65$; and $r23 = 0.37$;

$a = 0.22$; and $b = 0.57$.

(In Appendix I, the correlations have been derived from the Leeds study data but they might well have been obtainable from some other source. It makes no difference to the argument.)

For the backward group, the mean values of x_2 and x_3 are

$\bar{x}_2 = -\,{}^{23}/_{15}$ and $\bar{x}_3 = {}^{4}/_{15}$ (see Appendix 1); and for the non-backward group, the values are

$\bar{x}_2 = {}^{9}/_{15}$ and $\bar{x}_3 = {}^{4}/_{15}$.

It follows from equation (1) that the corresponding values of x_1 for the two groups are - 0.16 and + 0.28 respectively. Converted to WISC measures, these values give

WISC sub-test scor of 9.6 and 10.9 respectively, the values actually obtained in the Leeds study.

That is, from a knowledge of the inter-test correlations one can use regression analysis to derive WISC sub-test scores for any group, provided of course we kn the mean scores of the group in respect of the independent variates (i.e. the variates on which the multivariate selection was carried out). Where the correlations are known there is, therefore, no need actually to carry out empirical study, i.e. to select groups and test. (To simplify the argument, we have ignored errors in WISC standardisation.)

Furthermore, it might be argued that the whole procedure adopted in the Leeds study is quite unnecessary. There will always be a difference between the backward and non-backward group in favour of the latter provided the partial correlation between WISC sub-test and reading, non-verbal intelligence constant, is positive. And, for cognitive measures, i.e. abilities, partial correlations are normally positive.

Chapter 4

THE PRESENT STUDY : SUBJECTS AND TESTS

It will be remembered from Chapter 1 that the present investigation involved the testing of two groups of subjects:-

(a) a group of children of normal or above normal intelligence presenting learning difficulties;

(b) a group with normal or above normal intelligence but with average or superior scholastic performance.

For convenience we shall refer to these groups as the R and S groups respectively (R = retarded and S = superior).

The Selection of the Groups

The R group: This group consisted of 60 children selected from a private school in Johannesburg which provides special educational facilities for children of normal or above normal intelligence, who are handicapped by learning difficulties.

The 60 children were selected on the basis of two criteria:

(i) that they had either a verbal or non-verbal I.Q. score (as determined by the NSAIS) of 90 or above;

and (ii) that they had a Reading Age (RA), as determined by the Vernon Graded Word Reading Test, of at least 1 year below their chronological age.

When the selection had been carried out it was found that the group consisted of 49 boys and 11 girls. Also the age range for the group was 6 years 9 months to 12 years 5 months.

The S group: The superior group of 60 children was selected from a private Jewish primary school. The selection was made according to the following criteria:

(a) that they matched the R group in terms of age and sex;

(b) that each member of the group had an NSAIS verbal or non-verbal I.Q. of 110 or above;

(c) that the Vernon Graded Reading Age of each member was at C.A. (Chronological Age) or above.

It will be seen that both the NSAIS and the Vernon Reading Test had to be applied to both groups. In addition, both groups were given the Goodenough Draw-A-Man test. (Since this is always given at the school for the retarded children and since it permits easy administration, it was also given to the S group.)

These three tests were the only tests given to the S group, but in the case of the retarded children, as is the standard practice at their school, a comprehensive battery of tests was given in addition to these three tests. On the basis of these additional test data, it was possible to sub-divide the R group into three sub-groups. But before the details of this sub-division are given, a brief description of all the tests involved in this study is now presented.

The Tests

A - The tests applied both to the R and S groups

1) The NSAIS
2) The Vernon Graded Word List
3) The Goodenough Draw-a-Man test.

Description of Tests

New South African Individual Scale of Intelligence

(A fuller description of the test is presented in the second part of the manual of the New South African Individual Scale.[25]

The NSAIS was formulated and standardised for South

African children by the National Bureau of Educational and Social Research in 1964. The scale tests individuals ranging from 5 years to 17 years of age. The test was standardised on 2,600 children drawn from the white school population of the Republic and South West Africa. The battery consists of 9 sub-sections - 5 verbal and 4 non-verbal tests. The Verbal Tests are:-

(i) Vocabulary

The subject is asked to match given stimulus words to relevant pictures.

(ii) Comprehension

Questions are given to assess the subject's judgement of everyday situations and general knowledge.

(iii) Verbal Reasoning

The pupil is asked to formulate relationships between two objects or ideas.

(iv) Problems

These are arithmetic problems, 9 of which are orally presented and 6 are presented both orally and on cards. Time limits are imposed and time bonuses are awarded for the last 7 items.

(v) Memory

A short story is read to the subject who is asked to repeat as many facts as he can remember.

The Non-Verbal Tests are:-

(i) Pattern Completion

The subject is asked to complete patterns employing

previously demonstrated principles, within set time limits. Bonus points are given for completion within time limits.

(ii) Blocks

A picture pattern is presented and the subject is asked to construct a similar pattern using coloured blocks. Time is taken into account and bonus points are awarded.

(iii) Absurdities

The subject is asked to indicate an absurdity present in each of 15 pictures. A time limit is set and bonus points are awarded for speed.

(iv) Form Board

This consists of a board containing 6 figures with a lid. Each figure can be constructed out of 3 or 4 loose coloured pieces which are fixed in the lid before the test. The subject is asked to complete the figures by putting together their component parts. The score for each item is dependent on the time taken to complete the item.

Raw scores are assigned to each item of the sub-tests. These are converted into scaled scores by means of tables provided. The scaled scores are added and converted to a Verbal I.Q. Score, Non-Verbal I.Q. Score and Full I.Q. Score. Power Scores and Power plus Time Scores are obtained for each.

2) Vernon Graded Word List

This test is Vernon's standardisation of the Burt Graded Word List. The test consists of 130 words and is given individually. The subject is asked to read as many words as he can. Reading age is derived from the following formula:

$$\frac{\text{No. of Words Read}}{10} + 5$$

Reading Quotient is determined as follows:-

$$\frac{\text{Reading Age}}{\text{Chronological Age}} \times 100$$

3) Goodenough Draw-a-Man Test

The subject is asked to "Make a Picture of a man". A scale of 51 points has been drawn up by means of which the subject is rated.

B - The Tests applied only to the R group

1) The Neurological tests
2) Tests for apraxia
3) Visuo Motor Tests
4) Visual Perception Tests
5) Auditory Perception Tests

Description of Tests

1) Neurological Tests

These are administered by a neurologist and involve a detailed sensory and motor assessment, including the cranial nerves. The tests fall into four groups

I. Sensation:

The modalities tested are;

a) pain, light touch and temperature - the exteroceptive sensations derived from sources outside the body;
b) sense of position and deep pain - proprioceptive sensations derived from the body itself;
c) stereognosis, graphaesthesia and two point discrimination - combined, cortical sensations.

Tests Used (eyes closed throughout tests of sensory system)

a) Pain - response to pin prick
Touch - response to stroking with cotton wool
Temperature - differentiation between hot and cold

b) Position sense - child's arm is placed in a particular position. It is then moved and he is asked to replace it himself and then to do likewise with the opposite arm.

c) Stereognosis- the ability to recognise an object purely by the feel of its shape and size. The child is asked to recognise some familiar, easily identifiable object placed in his hand.

Graphaesthesia - the ability to recognise letters or numbers written on the skin with a blunt point.

Two-point discrimination - the detection that a stimulus consists of two blunt points when simultaneously applied.

d) Test for finger agnosia - the child is asked to identify which finger is touched and which missed.

II. Motor System

Six aspects of motor functioning are assessed -

a) Gross motor co-ordination

Walking, running, walking on tip-toe, hopping and skipping.

b) Fine motor co-ordination

(i) Picking up a pin

(ii) Touching the thumb with each finger in turn (Associated movements of the non-dominant hand are noted.)

(iii) Threading a needle

(iv) Cutting with a pair of scissors

c) Writing

(i) Copying shapes

(ii) Writing numbers

(iii) Copying a sentence

(iv) Writing a sentence from dictation

d) Cerebellar functioning

(i) Quick repetitive movements (dysdiadochokinesis)

(ii) Tapping knee with opposite heel

(iii) Ability to touch nose with finger with eyes closed

(iv) Type of speech pattern

(v) Presence of nystagmus (flickering eye movements)

e) Equilibrium

(i) Toe-heel walking

(ii) Presence of Romberg's sign, i.e. swaying from the heels slightly when eyes are open but markedly when closed

(iii) Posture

(iv) Gait

f) Reflexes

g) Motor Power

Muscles are examined to detect wasting or hypertrophy; tremors; muscle tone and muscle power.

III. Cranial Nerves

Functioning of the 12 cranial nerves is assessed. Important aspects are:

(a) Smell

(b) Visual - acuity
visual fields
fundi
eye movements, including presence or absence of squint
nystagmus
downward gaze

(c) Facial sensation and asymmetry

(d) Tongue movements and deviations

(e) Hearing - superficial test using tuning fork, watch
[illegible]k and voice

IV. Dominance

Three aspects :-

(a) Which hand appears dominant?

(b) Which foot appears dominant?

(c) Which eye and ear appears dominant?

2. Tests for Apraxia

(a) Child is asked to put out his arms, show his teeth and other simple movements. If he is unable to perform these actions he is observed to see whether he can perform these movements automatically.

(b) He is asked to perform more difficult combinations of movements: opening a box of matches and taking out a match; miming actions, e.g. playing a piano or hammering a nail.

(c) He is given a number of sticks and asked to form a square, a triangle and a diamond. If unable to do so spontaneously he is asked to copy these.

(d) He is asked to build a tower and copy patterns using Koh's blocks.

(e) He is asked to identify body parts by pointing on himself and examiner.

(f) Imitation of movements involving directional concepts : left-right, up-down, on vertical, horizontal and diagonal planes.

(g) Drawing of lines involving left-right, up-down and diagonal concepts.

(h) Ability to dress himself (to recognise presence of dressing apraxia).

3. Visuo-Motor Tests

(a) Peg Mosaics (fitting pegs into holes)

(b) Block building, construction of block patterns

(c) Copying stick patterns

(d) Paper and Pencil activities

(i) copying dot patterns

(ii) maze tests

(iii) drawing a man

(iv) joining dots

(v) copying numbers, letters, sentences

(vi) writing from dictation

(vii) spontaneous writing

(viii) free drawing

4. Visual Perception Tests

(a) Similarities and differences

(i) perceiving likenesses and differences in pictures

(ii) matching digits, letters, words

(b) Spatial judgment

(i) judging position of object in relation to oneself

(ii) judging position of object in relation to other objects

(iii) puzzle completion

(iv) completion of missing parts of graphic shapes.

(c) Colour perception

(i) naming primary colours

(ii) matching primary colours

(d) Perceptual constancy involving size and shape constancy

(i) matching graphic shapes, e.g., circles, squares for size and shape

(ii) formboard matching of two dimensional shapes

(e) Figure-ground perception

(i) identifying (by tracing) figures embedded in a confusing background

(ii) identifying central stimulus figure from a confusing background

5. Auditory Perception Test

The Wepman test for auditory perception was used The child is asked to decide whether similar pairs of orally presented words are the same or different. He stands with his back to the examiner

In addition to the above tests, various items of background information were available from case histories which were routinely taken from each child in the R group. This background

material included information on the presence or absence of

(1) birth trauma

(2) late speech development

(3) family incidence of difficulty.

On the basis of the test battery and the case histories, the children of the R group were classified into two groups, those having difficulty and those having no difficulty, for each of a number of areas. These areas are Auditory Perception; Visual Perception; Visuo-Motor Ability; Laterality and Body Image.

Furthermore, as many as 32 of these 60 children were "found" to present obvious symptoms of cerebral dysfunctioning. Of these, 20 (all boys) were put in the special category of apraxia, a form of dysfunctioning which is characterised by impairment of visuo-motor performance. (For a fuller description, see Appendix II, pp.95-100).

For convenience of presentation the group of 60 children will be referred to later as group R (R for retarded). When we wish to refer to the sub-group of 20 apraxics we shall use the notation of $R_{(n+a)}$ (retarded-neurologically involved with apraxia). For the remaining 12 children - 11 boys and 1 girl - presenting obvious symptoms of neurological dysfunctioning, we shall use $R_{(n-a)}$ (retarded-neurologically involved but no apraxia) and for the sub-group of 28 children - 18 boys and 10 girls - we shall use the notation $R_{(-n)}$ (retarded but no obvious neurological symptoms).

Our retarded group R can therefore be regarded as consisting of 3 sub-groups - $R_{(n+a)}$, $R_{(n-a)}$ and $R_{(-n)}$ with 20, 12 and 28 children, respectively.

It will be seen, therefore, that in carrying out a statistical analysis of the data, as is shown in the following chapters, this could be done in terms of 4 groups:

(a) 3 R Groups { $R_{(-n)}$ (28 pupils); $R_{(n+a)}$ (2[illegible] pils); $R_{(n-a)}$ (12 [illegible] pils)

and (b) S Group consisting of 60 pupils.

It might be noted that the number of girls involved was small. The groups consisted predominantly of boys (in the case of the $R_{(n+a)}$ group - [illegible] boys). A simple statistical analysis showed that the results of the small number of girls involved in each group did not differ significantly from those of the boys in the group. Consequently, in the statistical analysis of the data which follows the sex factor is ignored.

It must also be noted that the diagnosis of each child was made by a neurologist and therapists in terms of an overall clinical subjective impression and not in terms of any statistic or statistics derived objectively from the child's performance on the test battery. It should be pointed out, however, that the results of the NSAIS were known to them prior to making the diagnosis and may thus have been a factor influencing this diagnosis.

Note: The actual data obtained from testing will be found in Appendix III. (pp.101-104).

Chapter 5.

PRELIMINARY ANALYSIS OF TEST DATA : GROUP DIFFERENCES

Mean I.Q.'s and R.Q.'s

Table 5.1 presents the mean Intelligence and Reading Quotients for the R and S groups as derived from the NSAIS, the Vernon Reading Test and the Goodenough. In the case of the R group, the means are also given for the $R_{(-n)}$ and $R_{(+n)}$ sub-groups. (For simplicity of presentation, the $R_{(+n)}$ group, i.e. the neurological group, has at this stage not been sub-divided further into the apraxics and non-apraxics).

Table 5.1 also gives the mean I.Q. discrepancy for the groups as obtained from the NSAIS. We shall define the discrepancy as the Verbal I.Q. minus the Non-verbal I.Q., i.e. I.Q. Discrepancy = $I.Q._{v} - I.Q._{nv}$.

TABLE 5.1

MEAN I.Q.'s AND R.Q.'s FOR R AND S GROUPS AND SUB-GROUPS $R_{(-n)}$ AND $R_{(+n)}$

	R Group (60 Pupils)			S Group (N 60)
	$R_{(-n)}$ (28)	$R_{(+n)}$ (N 32)	Total (N 60)	
NSAIS				
IQ_v	110.00	111.03	110.55	125.22
IQ_{nv}	110.40	107.94	109.07	117.33
Full IQ	111.28	109.81	110.97	124.38
$IQ_v - IQ_{nv}$ (IQ discrepancy)	- 0.40	+ 3.09	+ 1.48	+ 7.89
Vernon R.Q.	80.32	79.13	79.68	115.2[illegible]
Goodenough Quotient	88.32	91.31	89.92	101.75

An examination of Table 5.1 shows:-

(a) that the S group is vastly superior to the R group. The superiority is greatest for reading - a difference of more than 25 points. Next comes the Verbal I.Q., a difference of slightly less than 15 points. The difference on the Goodenough is about 11.8 points. And last comes the Non-Verbal I.Q. with a difference of about 8.2.

(b) that, whereas the I.Q. discrepancy is as great as + 7.89 points for the S group, it is only + 1.48 for the R group and most of the latter figure is due to the figure of + 3.09 obtained for the $R_{(+n)}$ group.

We shall now consider the corresponding data for the three sub-groups, $R_{(-n)}$, $R_{(n+a)}$ and $R_{(n-a)}$, i.e. the R_n group is being split up into its two components, the apraxic and the non-apraxic. The data are presented in Table 5.2.

TABLE 5.2

MEAN I.Q.'s AND R.Q.'s FOR THE THREE R SUB-GROUPS, $R_{(-n)}$, $R_{(n+a)}$ and $R_{(n-a)}$

NSAIS	$R_{(-n)}$ (non-neurological) (N 28)	$R_{(n+a)}$ (apraxic) (N 20)	$R_{(n-a)}$ (non apraxic) (N 12)
$I.Q._v$	110.00	115.25	104.00
$I.Q._{nv}$	110.40	104.6	113.5
Full I.Q.	111.28	111.90	109.2
$I.Q._v - I.Q._{nv}$ (I.Q. Discrepancy)	- 0.40	+ 11.65	- 9.5
Vernon I.Q.	80.32	83.15	72.42
Goodenough Quotient	88.32	93.6	87.5

It is apparent from Table 5.2 that a considerable difference exists between the two neurological sub-groups. In the case of $R_{(n+a)}$ the apraxics, the Verbal I.Q. is considerably higher than the non-Verbal I.Q. and the result is an I.Q. discrepancy of + 11.65. In the case of $R_{(n-a)}$ the non-apraxics, the reverse situation holds; the non-Verbal I.Q. is now higher than the Verbal and an I.Q. discrepancy of - 9.5 is obtained.

The Verbal I.Q. of the apraxics is more than 11 points higher than the same I.Q. for the non-apraxics and this difference is almost matched by the difference between the R.Q.'s for the two groups. The Vernon R.Q. for the apraxics is 10.73 points higher than what it is for the non-apraxics.

Another matter which demands comment is the resemblance between the S group and the $R_{(n+a)}$ group (the apraxics) in that both groups show a high positive I.Q. discrepancy (+ 7.89 and 11.65 respectively). It would be absurd to suggest that the S group show a measure of apraxia. The difference between verbal and non-verbal functioning for the S group is more easily explained in terms of their cultural background and schooling. The Jewish population tends to emphasize verbal rather than non-verbal activities and in addition there is the possibility that schooling is verbally rather than manually orientated. (Similar results have been found by Levinson[18] in America and interpreted in terms of sub-cultural values.) Thus it might be suggested that this group is markedly superior verbally rather than inferior non-verbally (the apraxic case) and that it is the superiority that causes the discrepancy.

Histograms showing Distribution of I.Q. Discrepancy for the 4 Groups

The above simple analysis shows that besides the general superiority of the S group over the R group and the low R.Q. of the $R_{(n-a)}$ group in comparison with the other two R sub-groups, the four groups do show significant differences in the matter of I.Q. discrepancy.

In order to investigate the differences further, histograms were drawn, showing the distribution of the I.Q. discrepancy for each of the groups. These histograms are shown in Figures 5.1 - 5.4, presenting, respectively, the histograms for the S group and the three R sub-groups, $R_{(-n)}$, $R_{(n+a)}$ and $R_{(n-a)}$.

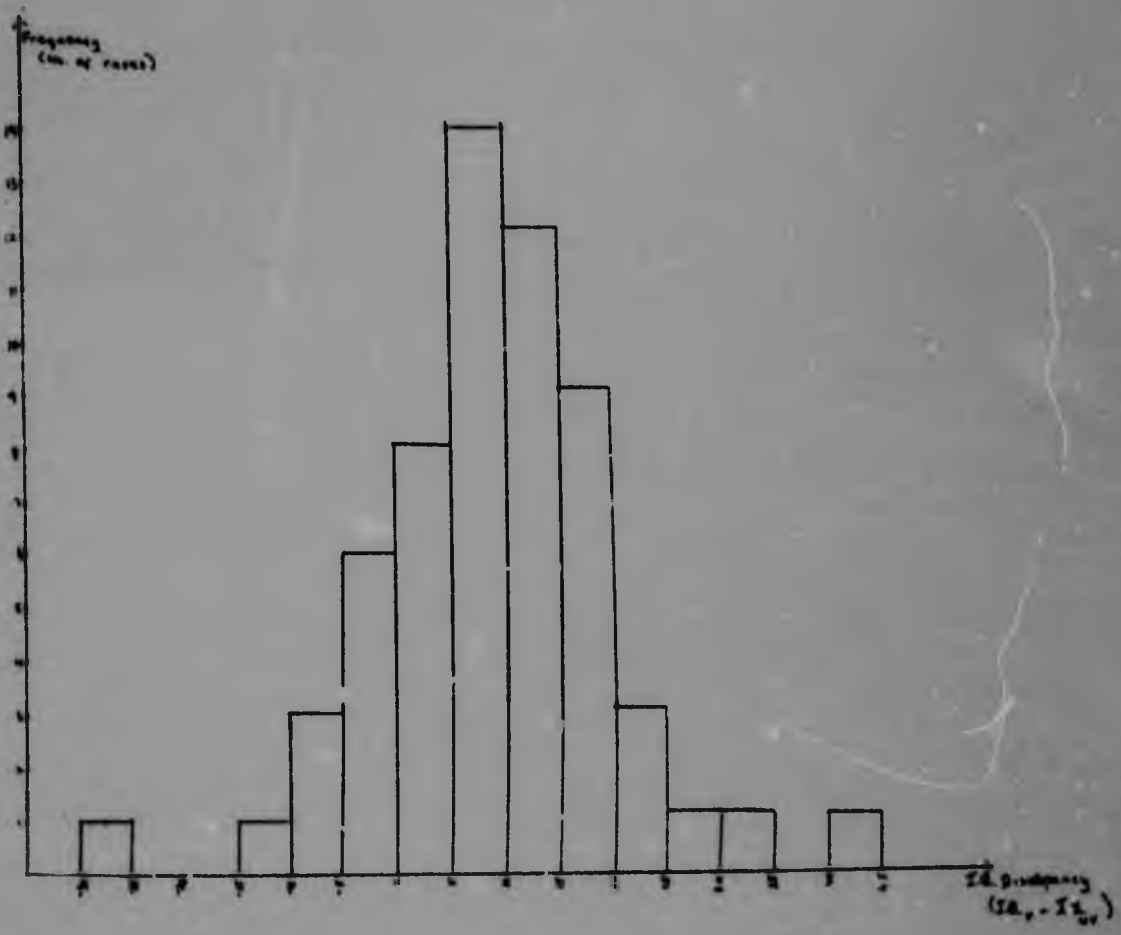


Fig. 5.1. Histogram showing distribution of I.Q. discrepancy ($I.Q._{v} - I.Q._{nv}$) for the S Group (the Superior Group).

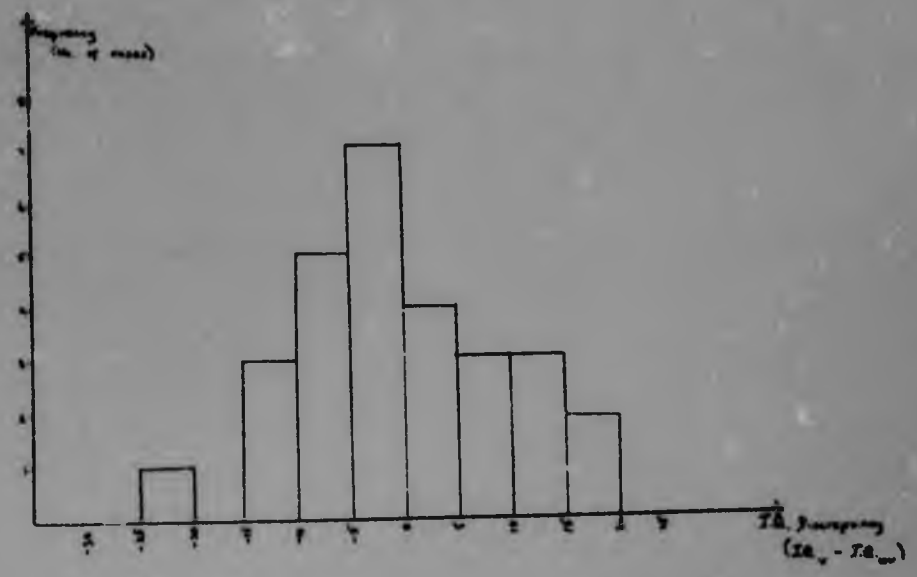


Fig. 5.2. Histogram showing distribution of I.Q. discrepancy ($I.Q._v - I.Q._{nv}$) for the $R_{(-n)}$ Group (the non-Neurological Group)

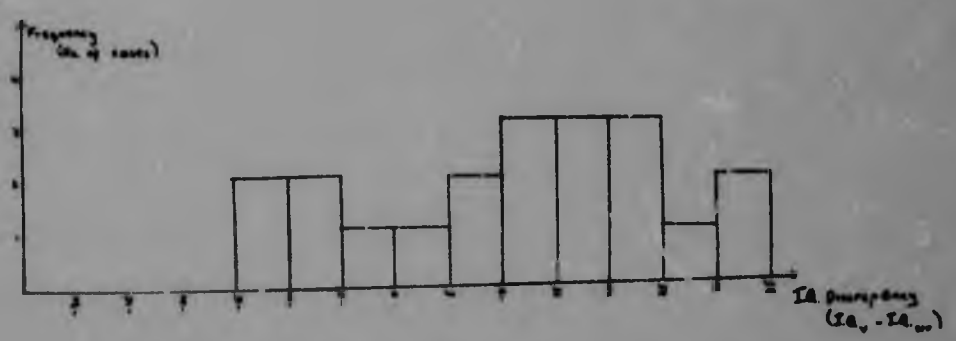


Fig. 5.3. Histogram showing distribution of I.Q. discrepancy ($I.Q._v - I.Q._{nv}$) for the $R_{(n+a)}$ Group (the Neurological Apraxic Group.)

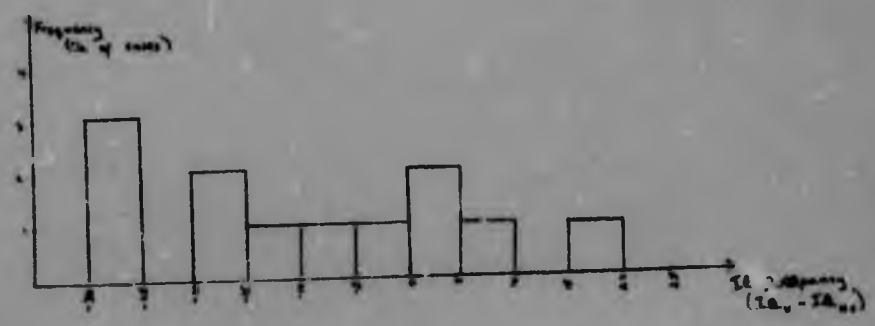


Fig. 5.4. Histogram showing distribution of I.Q. Discrepancy ($I.Q._v - I.Q._{nv}$) for the $R_{(n-a)}$ Group. (the Neurological non-Apraxic Group.)

The following points can be made:-

(a) In a case of the S group, the distribution is approximately normal and the mean discrepancy is +7.89 (see Table 5.1).

) In the case of the $R_{(-n)}$ group, the distribution is again approximately normal with a mean of almost zero.

(c) For both the $R_{(n+a)}$ and the $R_{(n-a)}$, the distribution is not normal, in the first case being somewhat negatively skewed and in the second case rather positively skewed. As already stated, the main discrepancies are 11.65 and -9.5, respectively.

It should be noted that if these two histograms were combined to give what would be the histogram for the R_n group, an almost rectangular distribution would be obtained.

Statistical Tests

So far no statistical tests have been applied to test the significance of the mean discrepancies or the difference between the means for two groups. The non-normality of the $R_{(n+a)}$ and the $R_{(n-a)}$ sub-groups presents a little difficulty. However, the following can be stated:-

(a) Obviously the mean discrepancy for the $R_{(-n)}$ group is not significant statistically.

(b) In the case of the S group, the application of a t test produces a t value of 2.78 (59 d.f.) which is significant at the 1 per cent level.

(c) Because of the non-normality of the $R_{(n-a)}$ grou, a χ^2 test has to be applied in order to test the significance of the discrepancy.

A 2 x 2 table is involved, namely:

	No.of discrepancies < 0	No. of discrepancies ≥ 0
Observed	5	15
Expected (on null hypothesis)	10	10

χ^2 = 5 which for 1 df is significant at the 3 per cent level (χ^2 3% = 4.89 approx.)

(d) The application of a χ^2 test to the data for the $R_{(n-a)}$ group does not give a significant result. However, this group does differ significantly from the others.

Thus:

(i) $R_{n-a)} \underline{v} R_{(n+a)}$

A χ^2 test applied to the 2 x 2 table

5	15
8	4

gives a χ^2 value of 5.398 which for 1 df is significant at the 3 per cent level.

(ii) $R_{(n-a)} \underline{v} 5$

This is obviously significant.

(iii) $R_{(n-a)} \underline{v} R_{(-n)}$

The application of a χ^2 test (or better, the exact procedure for 2 x 2 tables) again gives a result which is significant at about the 3 per cent level.

(e) The difference S $\underline{v}$ $R_{(-n)}$

Obviously significant by virtue of (b) above.

(f) The difference S $\underline{v}$ $R_{(n+a)}$

No significant difference is obtained in this case. In fact, as stated above, a feature of the investigation is the similarity between the S group and the $R_{(n+a)}$ group (the apraxics) in respect of I.Q. discrepancy.

(g) The difference S $\underline{v}$ $R_{(n-a)}$

Obviously significant.

Before leaving the matter of group differences in respect of I.Q. discrepancy, it is interesting to point out the general positioning of the three R groups relative to one another in the bivariate distribution of the R group for the two variables $I.Q._{v}$ and $I.Q._{nv}$. An attempt to indicate the general positions of the three groups in such a way is shown in Figure 5.5. The shaded portion of the diagram indicates the region from which the R group was selected. (It will be remembered that each member of the R group had to have a verbal or non-verbal I.Q. of no less than 90). Then, as a rough correspondence to the results obtained in this investigation, it might be said that the 3 R sub-groups occupy the positions shown. The actual bivariate distribution for the R group is shown in Figure 5.6.

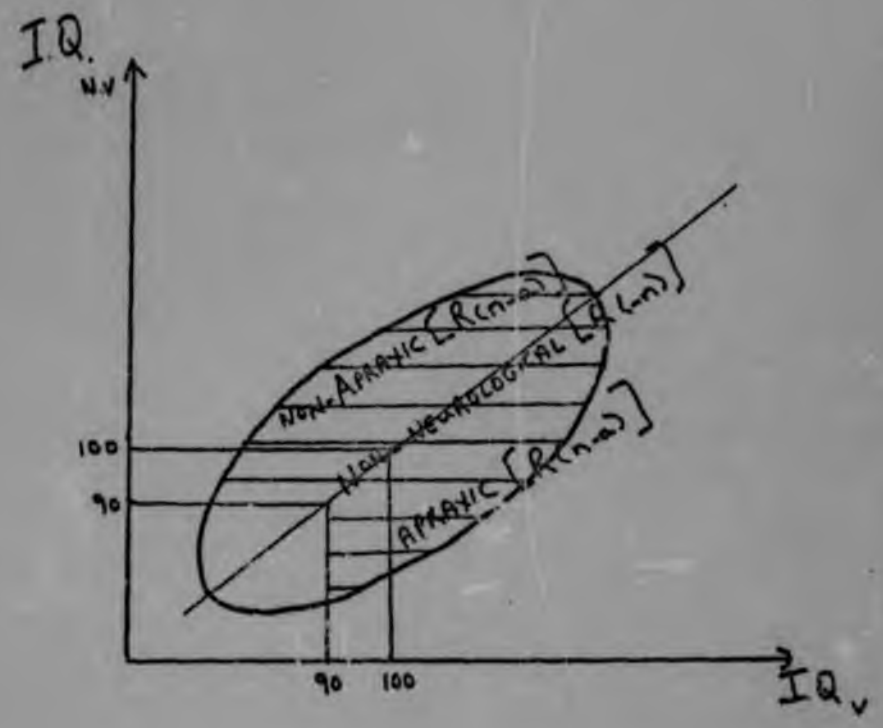


Fig. 5.5

General Position of the three R Groups in the Normal Bivariate Distribution of $I.Q._{v}$ and $I.Q._{nv}$. (The shaded area represents the portion of the distribution from which the total R Group is selected.)

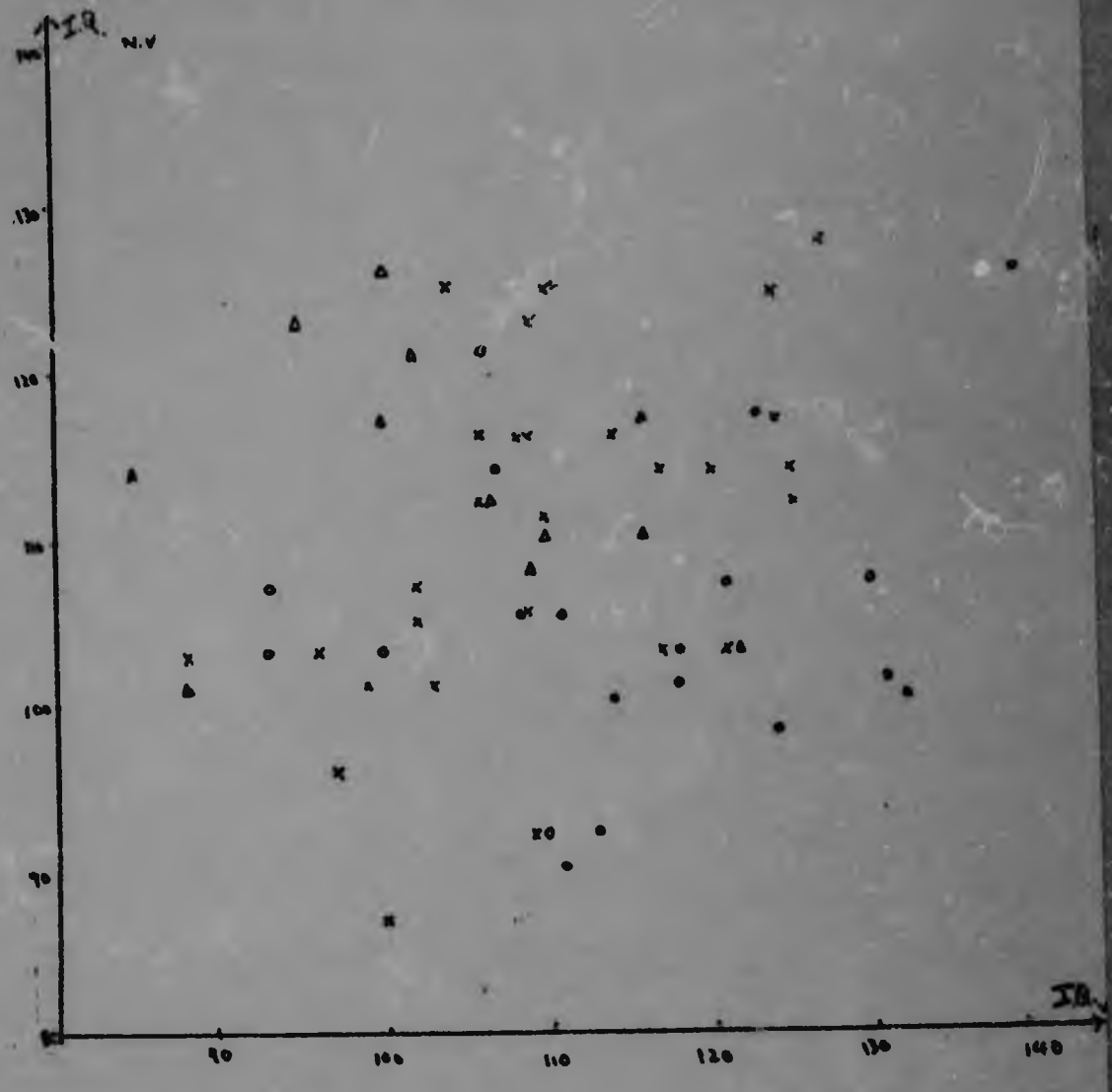


Fig. 5.6

Bivariate distribution of R Group for $I.Q._v$ and $I.Q._{nv}$ showing how these sub groups $R_{(-n)}$, $R_{(n+a)}$ and $R_{(n-a)}$ are distributed relative to one another.

The correspondence is, of course, far from exact. Otherwise the NSAIS could be used to select (or diagnose) the apraxic, the neurological non-apraxic and the non-neurological. It has to be remembered, however, that the correspondence also depends on the accuracy with which the school clinicians and psychologists assigned the pupils to the three groups.

Difference between the R-groups for other Test Data

It will be remembered from Chapter 3 that the members of the R group were subjected to a large battery of tests in addition to the three tests which they shared with the S group. As was stated, the tests are used to classify the children into those having difficulty and those not having difficulty for each of a number of areas. These areas are Auditory Perception, Visual Perception, Visuo-Motor Ability, Laterality and Body Image

Table 5.3 shows the numbers in each of the R groups who had difficulties in respect of these different areas.

TABLE 5.3

NUMBERS IN R GROUPS PRESENTING DIFFICULTY IN FIVE DIFFERENT AREAS

	$R_{(-n)}$ (N 28)	$R_{(n+a)}$ (N 20)	$R_{(n-a)}$ (N 12)
Poor Auditory Perception	15	15	10
Visual Perceptual Difficulties	11	18	8
Visuo-Motor Difficulties	17	20	10
Mixed Laterality	6	16	8
Poor Body Imago	23	12	11

In order to test the significance of the differences between the groups, χ^2 tests were applied to the data for each of the five areas being considered. The results are given in Table 5.4.

TABLE 5.4

RESULTS OF χ^2 TESTS APPLIED TO DATA IN TABLE 5.3

	χ^2 total (2 df) $R_{(n)} \vee R_{(n+a)} \vee R_{(n-a)}$	χ^2 (1 df) $R_{(n)} \vee R_{(-n)}$	χ^2 (1 df) $R_{(n+a)} \vee R_{(n-a)}$
Poor Auditory Perception	χ^2 = 4.29 NS	χ^2 = 4.05 Sig.at 5% level	χ^2 = 0.305 NS
Visual Perceptual Difficulties	χ^2 = 12.87 Sig.at 1% level	χ^2 = 11.13 Sig.at 1% level	χ^2 = 2.68 NS
Visuo-Motor Difficulties	χ^2 = 10.84 Sig.at 1% level	χ^2 = 9.61 Sig.at 1% level	NS χ^2 not applicable
Mixed Laterality	χ^2 = 17.67 Sig.at 1% level	χ^2 = 17.14 Sig.at 1% level	χ^2 = 0.71 NS
Poor Body Image	χ^2 = 5.07 NS	χ^2 = 0.88 NS	χ^2 = 3.72 NS

For 1 df, χ^2 at 5 per cent level = 3.841
and at 1 per cent level = 6.635
For 2 df, χ^2 at 5 per cent level = 5.991
and at 1 per cent level = 9.210.

It will be seen from Table 5.4 that significant group differences were obtained in the four areas: Poor Auditory Perception, Visual Perceptual Difficulties, Visuo-Motor Difficulties and Mixed Laterality. Also, the significant differences obtained lie only between the neurological and the non-neurological sub-groups, i.e., R_n v $R_{(-n)}$. The two neurological sub-groups $R_{(n+a)}$ and $R_{(n-a)}$ do not differ significantly in any of the five areas.

This raises an interesting question. The sub-division of the total neurological group R_n into the apraxics $(R_{(n+a)})$ and the non apraxics $(R_{(n-a)})$ was made on the tests of apraxia which are involved to a considerable extent in the tests for Visuo-Motor Difficulties and to some extent in the tests for Visual Perceptual Difficulties; and yet the differences between the two sub-groups are only slight for these two areas (actually the apraxics present slightly more cases of difficulty). Since we know that the two sub-groups differ significantly as is indicated by their mean I.Q. discrepancies - a matter already discussed - the only possible explanation of the non-significance of the differences between the groups, in respect of Visuo-Motor and Perceptual difficulties, is that the separating out of the apraxics was done largely on assessments not incorporated in the assessments for Visuo-Motor and Perceptual Difficulties - a somewhat strange finding. As is noted at the end of Chapter 4, the I.Q. discrepancies are known to the therapists in the assessment of apraxia and this may thus have been one of the most potent factors affecting the diagnosis. However, it

could not have been the only factor because at least 4 of the 20 apraxics had higher non-verbal than verbal I.Q.'s.

Birth Trauma, Late Speech Development and Family Incidence

It will be remembered that records were available for all members of the R group for these three items.

The frequencies of occurrence of these items for the three sub-groups are shown in Table 5.5.

TABLE 5.5

FREQUENCY OF OCCURRENCE OF BIRTH TRAUMA, LATE SPEECH DEVELOPMENT AND FAMILY INCIDENCE FOR THE THREE R SUB-GROUPS

	$R_{(-n)}$ (28 pupils)	$R_{(n+a)}$ (20 pupils)	$R_{(n-a)}$ (12 pupils)	χ^2 (2 df)
Birt.. Trauma	6	10	9	$\chi^2 = 13.66$ $P < .01$
Late Speech Development	12	5	8	$\chi^2 = 5.37$ N.S.
Family Incidence	10	2	2	$\chi^2 = 5.13$ N.S

It will be seen that it is only in respect of frequency of occurrence of Birth Trauma that a significant difference was obtained between the three R sub-groups and as with Visuo-Motor difficulty, Visual Perception and Mixed Laterality, this lay mainly between the neurological and non-neurological sub-groups.

Chapter 6

COMPLETE ANALYSIS OF THE N S A I S DATA : COMPARISON OF GROUP PROFILES AND DISCUSSION OF RESULTS

NSAIS Profiles of R and S Groups

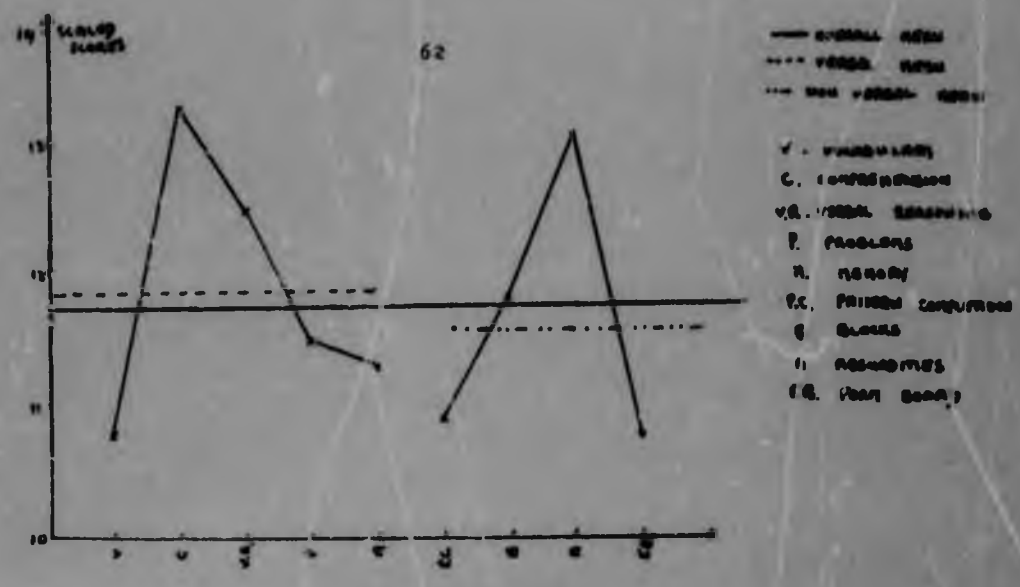
Table 6.1 gives the means and standard deviations of the R and S groups obtained on each of the 9 sub-tests of the NSAIS.

TABLE 6.1

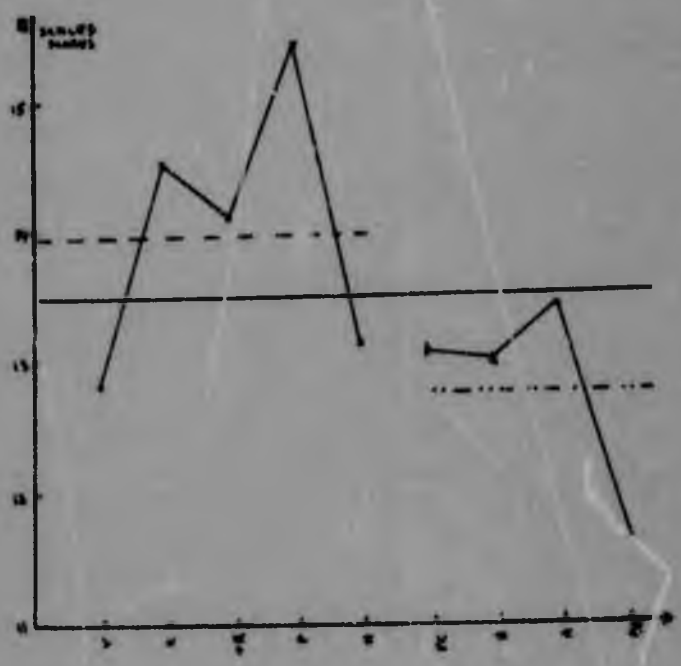
MEANS AND STANDARD DEVIATIONS OBTAINED BY R AND S GROUPS ON THE 9 SUB-TESTS OF THE NSAIS

Sub-Test	R Group (N60)		S Group (N 60)	
	Mean	Standard Deviation	Mean	Standard Deviation
Verbal Tests				
Vocabulary	10.8	1.7	12.8	2.5
Comprehension	13.2	2.7	14.5	2.6
Verbal Reasoning	12.5	3.1	14.1	2.2
Problems	11.5	2.5	15.4	1.9
Memory	11.3	2.8	13.2	2.7
Non-Verbal Tests				
Pattern Completion	10.9	2.4	13.1	2.5
Blocks	11.8	2.5	13.0	2.5
Absurdities	13.0	2.2	13.4	2.6
Form Board	10.7	2.5	11.6	2.6

Graphing these means, we obtain the profiles of the R and S groups as shown in Figure 6.1.



Profile of R Group



Profile of S Group

Fig. 6.1 NSAIS profiles for R and S groups

A comparison of the two profiles reveals obvious differences and resemblances :-

(a) As was shown in Chapter 5, there is a large positive I.Q. discrepancy in the case of the S group. In the case of the R group, the discrepancy is still positive but small.

(b) There is considerable resemblance in the 'rise and fall' of the profiles of the two groups. Only two sub-tests spoil the pattern of resemblance - Problems and to a smaller extent Pattern Completion.

NSAIS Profiles of the R Sub-Groups

Table 6.2 gives the means of the three R sub-groups obtained on each of the 9 sub-tests of the NSAIS.

TABLE 6.2

MEANS OBTAINED BY THE R SUB-GROUPS ON THE 9 SUB-TESTS OF THE NSAIS

Sub-Test	$R_{(-n)}$ (28)	$R_{(n+a)}$ (N20)	$R_{(n-a)}$ (N12)
Verbal Tests			
Vocabulary	10.5	11.5	9.3
Comprehension	13.2	14.3	10.9
Verbal Reasoning	12.1	13.6	10.8
Problems	11.[illegible]	12.2	10.3
Memory	11.8	11.2	9.8
Non-Verbal Tests			
Pattern Completion	1[illegible]	10.7	10.7
Blocks	12.1	10.8	11.8
Absurdities	13.4	12.0	12.8
Form Board	10.8	10.4	10.1

The corresponding profiles for the three R sub-groups are shown in Figure 6.2.

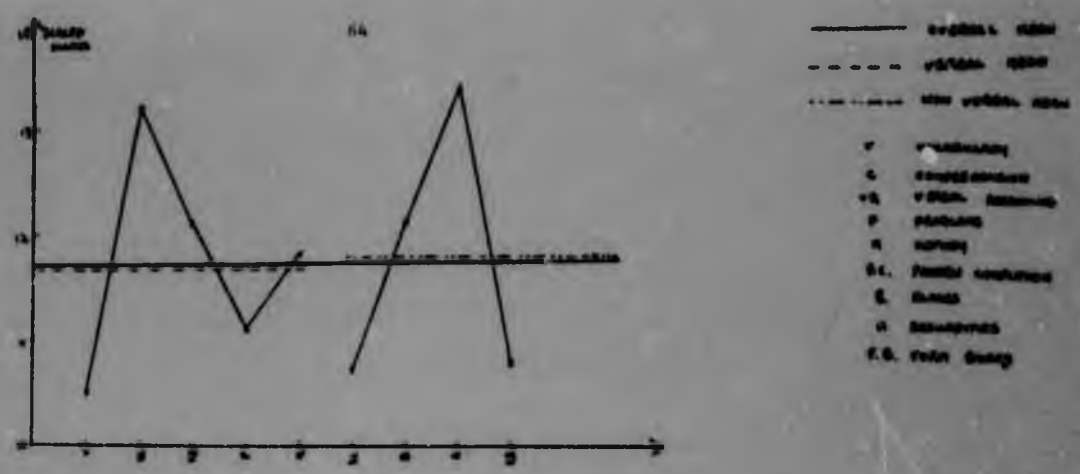


Fig. 6.2 Profile of $R_{(-n)}$ Group

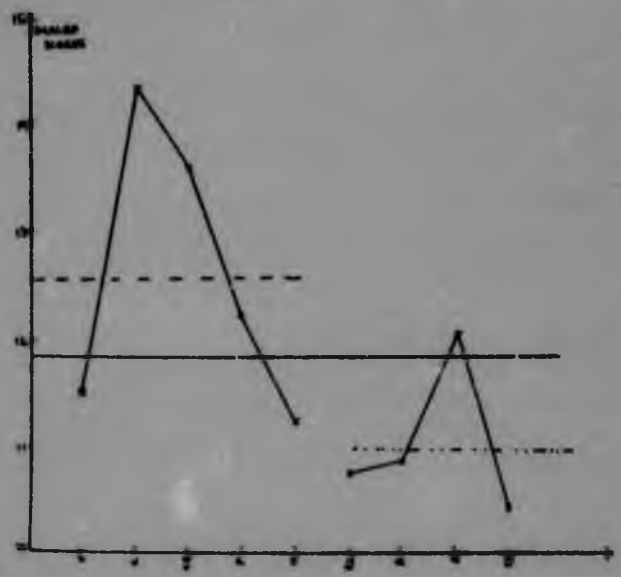


Fig. 6.3 Profile of $R_{(n-m)}$ Group

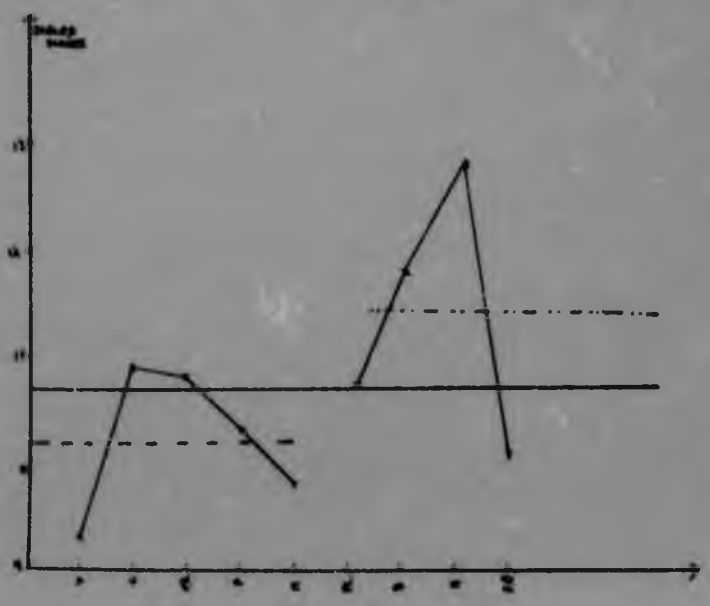


Fig. 6.3 Profile of $R_{(n-m)}$ Group

Once again it can be observed how the profiles bring out clearly the differences in I.Q. discrepancy. Also, the general pattern of the profiles, both for the verbal and non-verbal portions, is remarkably similar for all three sub-groups.

Complete Analysis of the NSAIS Data

(a) Test of Significance of Profile Variation

The fact that there is considerable resemblance between the profiles of the 4 groups (the S group and the three R sub-groups) would strongly suggest that the variation in mean score from sub-test to sub-test is highly significant statistically for each of the groups and cannot be attributed to random (chance) fluctuations. An analysis of variance of the data for each of the groups confirms this. Only the analysis of the data for the $R_{(n+a)}$ group (the apraxics) is reproduced here. This is presented in Table 6.3.

TABLE 6.3

ANALYSIS OF VARIANCE OF NSAIS DATA FOR $R_{(n+a)}$ GROUP

Source of Variance	df.	Sums of Squares	Variance
Between Sub-Tests	8	279.77	34.97
Between Pupils	19	285.53	15.03
Sub-Tests x Pupils	152	847.56	5.58
Total	179	1412.86	

The inter-sub-test variation is tested by forming the F ratio,

$$F = \frac{\text{Between sub-tests}}{\text{Sub-Tests x Pupils}} = \frac{34.97}{5.58} = 6.27,$$

which for 8 and 152 df is significant at well beyond the 1 per cent level ($F_{1\%} = 2.62$, 8 and 152 df.).

(b) Analysis of Variance of Sub-Test Data for all 4 Groups

The analysis of variance of the complete NSAIS data (9 sub-tests, 4 groups), is presented in Table 6.4.

TABLE 6.4

COMPLETE ANALYSIS OF VARIANCE OF NSAIS DATA
(9 SUB-TESTS, 4 GROUPS)

Source of Variation			d.f.	S.S.	Variance
A. Between Sub-Tests		Types	1	142.43	142.43
		Within Types	7	628.06	89.72
B. Groups			3	816.22	272.07
C Groups X Sub-Tests	C_1	Groups X Types	3	212.81	70.97
	C_2	Groups X Sub-Tests (Within Types)	21	251.44	11.97
D Residual		Between Pupils (Within Groups)	116	1678.60	14.47
		Within Pupils	928	4762.60	5.132
Total			1079	8492.16	

Before proceeding with tests of significance, it is necessary first to provide a few words of explanation about the form of the analysis.

The term Types represents the component of variance resulting from any difference between the two groups of sub-tests, the verbal and the non-verbal. In other words, it is a measure of I.Q. discrepancy over the four groups of pupils.

The residual term Sub-Tests within Types is the variance between sub-tests after the verbal v non-verbal difference has been taken out.

Similarly, the interaction term Groups X Sub-Tests has two components:-

(i) Groups X Types. If this component proves significant statistically, it indicates that the I.Q. discrepancy varies significantly from group to group. (From the analysis presented in Chapter 5, we know already that this is so.)

(ii) Groups X Sub-Tests within Types. This is the term which is used to test whether group profiles differ significantly after group differences in I.Q. discrepancy have been removed.

The Residual term also has two components:-

(i) The variance between pupils (within groups) which corresponds to pupil differences within groups, i.e. after group differences have been taken out.

(ii) The variance within pupils which is the error term we use in testing the significance of most of the above variances, in particular :-
Sub-Tests (either Types or Within Types)
Groups X Sub-Tests (either Groups X Types or Groups X Sub-Tests within Types.)

Tests of Significance :-

Obviously the variances Types, Sub-Tests within Types and Groups Types are highly significant. (These results we really knew already).

The important test supplied by this analysis is the test of Groups X Sub-Tests within Types against Residual within Pupils.

The F ratio = $\frac{11.97}{5.132}$ = 2.34, which for 21 and 928 d.f. is approaching significance at the 1 percent level. ($F_{1\%}$ = 2.37 approximately.)

It can therefore be concluded that the profiles of the 4 groups (the S group and the three R sub-groups) differ significantly even after group differences in I.Q. discrepancy have been removed.

It becomes necessary now to pin-point where this significant difference lies. An indication of this was provided at the beginning of this chapter when we examined the profiles of the 4 groups. It will be remembered:

(i) that the profiles of the 3 R sub-groups were remarkably similar if one ignored group differences in respect of I.Q. discrepancy;

(ii) that the profiles of the S group and the total R group were very similar but for the sub-tests Problems and to a lesser extent Pattern Completion (again ignoring differences in I.Q. discrepancy).

In the light of this we proceed to carry out two analyses:

(i) an analysis of variance of the data (9 sub-tests) for the three R sub-groups;

(ii) an analysis of variance of the data for the 4 groups of pupils but omitting the data for the Problems sub-test. (That is, this analysis will involve only 8 sub-tests.)

Having done this, we shall find that it is unnecessary to consider any possible group differences in respect of the sub-test Pattern Completion.

(c) Analysis of Variance of NSAIS Data (8 Sub-Tests - Problems Omitted, 4 Groups)

This analysis is presented in Table 6.5.

TABLE 6.5

ANALYSIS OF VARIANCE OF NSAIS DATA : 8 SUB-TESTS (PROBLEMS OMITTED) AND 4 GROUPS

Source of Variance		d.f.	s.s.	Variance
A. Between Sub-Tests	Types	1	86.40	86.40
	Within Types	6	586.98	97.83
B Groups		3	514.70	171.57
C Groups X Sub-Tests	Groups X Types	3	154.53	51.51
	Groups X Sub-Tests (Within types)	18	124.34	6.91
D Residual	Between pupils (Within groups)	116	1551.88	13.38
	Within pupils	812	4326.75	5.331
Total		959	7347.58	

It will be seen from Table 6.5 that the interaction term Grcups x Sub-Tests within Types is only slightly greater than the error term Residual within Pupils (6.91 v 5.33). It can therefore be concluded that the significant result previously obtained in respect of this interaction term is entirely due to group differences in respect of the Problems sub-test.

It only remains to be shown that the group differences in respect of Problems is due to a difference between the R and S groups. There are no differences between the three R sub-group profiles in respect of this sub-test.

(d) Analysis of Variance of NSAIS Data (9 Sub-Tests, 3 R Sub-Groups)

TABLE 6.6

ANALYSIS OF VARIANCE OF NSAIS DATA (9 SUB-TESTS, 3 R SUB-GROUPS)

Source of Variance		df	s.s.	Variance
A. Between Sub-Tests	Types	1	8.67	8.67
	Within Types	7	440.86	62.98
B. Groups		2	1.59	.795
C. Groups x Sub-Tests	Groups x Types	2	152.39	26.195
	Groups x Sub-Tests (Within Types)	14	60.26	4.304
D. Residual	Between Pupils (Within Groups	57	791.17	13.88
	Within Pupils	456	2416.71	5.298
	Total	539	3871.65	

It will be seen from Table 6.6 that the interaction term Groups X Sub-Tests within Types is again non-significant, which proves the point that the significant difference obtained between the profiles of the 4 groups (I.Q. discrepancy removed) is due almost entirely to a difference between the R and S groups in respect of the Problems sub-test and not due to any difference between the profiles of the R sub-groups.

(e) Correlations between Group Profiles

It is instructive to obtain a measure of the correlation between profiles. The correlations confirm the results shown above.

In order to understand the kind of correlation measure used here, it is necessary to realise -

(i) that, in comparing group profiles we are comparing group means for each sub-test after overall group differences have been removed;

and (ii) that the degree of correlation will depend on the degree of closeness between the group 'adjusted' means for each sub-test.

Following the underlying idea of the well-known correlation ratio, we might therefore take as our measure of correlation

$$\sqrt{\left(1 - \frac{\text{"variance within sub-tests"}}{\text{"total variance"}}\right)}, \text{ where}$$

the "variance within sub-tests" is the variance of the 'adjusted' group means for each sub-test averaged over the 9 sub-tests and the "total variance" is the variance of the adjusted group means altogether (i.e. when we ignore the fact that they come from different sub-tests).

We shall consider three cases :-

(i) Correlation between group profiles for the 9 sub-tests

The statistics necessary for the calculation of the correlation are contained in Table 6.4, namely:-

Source of Variance	d.f.	S.S.	Variance
Between Sub-Tests	8	770.49	
Groups X Sub-Tests	24	464.25	19.34
"Total"	32	1234.74	38.59

$$\text{Correlation} = \sqrt{(1 - 19.34/38.59)}$$

$$= 0.706$$

(ii) Correlation between group profiles for the 9 sub-tests after group differences in I.Q. discrepancy have been removed

The relevant statistics (see Table 6.4) are:-

Source of Variance	d.f.	S.S.	Variance
Between Sub-Tests (within Types)	7	628.06	
Groups X Sub-Tests (within Types)	21	251.44	11.98
Total	28	879.50	31.41

$$\text{Correlation} = \sqrt{(1 - 11.98/31.41)}$$

$$= 0.787.$$

(iii) Correlation between Group profiles, after Problems sub-test has been omitted and after group differences in I.Q. discrepancy have been removed

The necessary statistics are to be found in Table 6.5, namely :-

Source of Variance	d.f.	S.S.	Variance
Between Sub-Tests (within Types)	6	586.98	
Groups X Sub-Tests (within Types)	18	124.34	6.91
Total	24	711.32	29.64

$$\text{Correlation} = \sqrt{(1 - 6.91/29.64)}$$

$$= 0.876.$$

It will be seen that with each step, the removal of the differences in I.Q. discrepancy and then the removal of the differences in respect of Problems, the correlation between profiles steadily increases, reaching a final figure of 0.876 which is high, when one considers that sampling error considerably reduces the correlation between the profiles.

DISCUSSION OF RESULTS

If the differences between group profiles are due almost entirely to differences in I.Q. discrepancy and to the difference between R and S group profiles in respect of the Problems sub-test, then there remains the problem of explaining the considerable degree of resemblance between the profiles of the four groups after I.Q. discrepancy has been taken out and the Problems sub-test omitted from the profiles.

It would be a simple solution to conclude that the pattern of cognitive functioning, as measured by the NSAIS, is more or less the same for all groups. But this is most unlikely when one considers that one is dealing here with a superior group and three retarded groups. On the basis of the argument presented in Chapter 3, which was derived from correlation theory, one would expect the profiles of a superior and retarded group to be negatively rather than positively correlated; unless, as was also argued in Chapter 3, errors of standardisation are present which are large enough to mask the patterns of the 'true' profiles. The high positive correlation between our four group profiles would then be explained as a correlation between systematic errors which must of necessity be the same for all four profiles.

It is difficult to see any other explanation. Besides the errors of standardisation there could also be a tester bias factor, i.e. the testor's assessment of performance on any sub-test might, on the average, lie above or below the norm '10' for the sub-test. If such a factor were present it would of course be compounded with the 'standardisation' errors. In the present study it is impossible to separate out

errors of 'standardisation' from tester bias; this could only have been achieved if the children had been tested several times on the NSAIS, on each occasion by a different tester.

It is possible, however, with our given data to obtain a measure of the net effect of errors of standardisation and tester bias for each sub-test relative to the others taken together. This can be done by considering the profiles for the R and S groups after the Problems sub-test has been removed and the I.Q. discrepancy taken out. Each profile will have an overall mean and we can measure the deviation of each sub-test mean from this overall mean. If we take the average of the two deviations for each sub-test obtained from the two profiles, then we shall have a rough measure of our net effect. The results are presented in Table 6.7.

TABLE 6.7

ESTIMATES OF NET EFFECT OF ERRORS OF STANDARDISATION AND TESTER BIAS FOR THE NSAIS SUB-TESTS (EXCLUDING PROBLEMS)

Sub-Test	Estimate of Net Effect of Errors of Standardisation and Tester Bias
Verbal	
Vocabulary	- 1.00
Comprehension	+ 1.05
Verbal Reasoning	+ 0.50
Memory	- 0.55
Non-Verbal	
Pattern Completion	- 0.19
Blocks	+ 0.21
Absurdities	+ 1.02
Form Board	- 1.04

It is to be appreciated that although the estimates have been given to two places they are in fact crude. Thus, in the case of Pattern Completion and Blocks it might be said that the estimates are approximately zero. There must also be some doubt about the estimates obtained for Verbal Reasoning and Memory. But in the case of the other four sub-tests, it would be very reasonable to suppose that the net effect of errors of standardisation and tester bias is of the order of unity, being positive in the case of Comprehension and Absurdities and negative in the case of Vocabulary and Form Board.

It will be remembered from Chapter 3, that in the case of retarded readers (R.Q. = 80), 'real' profile variations on the WISC as calculated from assumed correlations between Reading and the WISC sub-tests ranged from 0 to not much more than 1. The same can probably be said of most other groups. If, therefore, errors of standardisation and tester bias can be of the order of unity, as would appear to be the case from the data of this study, they must seriously distort any profile obtained from a test such as the WISC or the NSAIS.

The analysis presented in this Chapter, therefore, confirms the view expressed tentatively in Chapter 3 that errors of standardisation (with which goes tester bias) can to some extent invalidate the use of the WISC or NSAIS for studying patterns of cognitive functioning. Indeed the use of these tests for this purpose becomes a very questionable procedure. It is probably a satisfactory method if one is interested only in I.Q. discrepancy but of doubtful validity in studying inter-test variations. An average over several

sub-tests will normally have a smaller error than that for one sub-test.

Of course, as was indicated in Chapter 3, the use of a control group overcomes this difficulty, in that errors of standardisation and tester bias will be the same for both the experimental and the control groups. The present study is one which falls into this category. In fact it was only because the S group could be used as a control for the R group that it was possible to detect and estimate the errors of standardisation and tester bias for the NSAIS sub-tests.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The present study falls into two parts. The first part consists of (a) a review of earlier studies in which the WISC has been used as a measure of the pattern of group cognitive functioning, and (b) a critical examination of the rationale of such studies.

The second part is an empirical investigation carried out in Johannesburg in which the NSAIS, a test similar in structure to the WISC, was applied to two groups of pupils both of normal I.Q., or above, but one with learning difficulties (the R group) and the other of normal or above normal ability (the S group). On the basis of additional data available for the retarded group, the latter was divided further into 3 sub-groups - (i) a non-neurological group $R_{(-n)}$ and (ii) two neurological groups, $R_{(n+a)}$ and $R_{(n-a)}$, the first being a group of children classified as apraxic and the second, a group that might be termed non-apraxic. A statistical analysis was made of the NSAIS data for the S group and the three R sub-groups which, among other things, confirmed the findings reached theoretically in the first part of the study.

(a) The Review of Earlier WISC Studies

The studies reviewed were confined to those where the WISC had been applied to:

(i) groups with reading difficulty;

(ii) groups showing symptoms of cerebral dysfunctioning;

(iii) groups with normal or superior intelligence.

Two aspects were considered:

(i) verbal v non-verbal I.Q. discrepancy;

(ii) the sub-tests of the WISC on which the groups obtained the lowest scores.

As regards the groups with reading difficulties, it was found that in nearly all cases, the mean verbal I.Q. is less than the mean non-verbal I.Q. Among the sub-tests on which the lowest scores were obtained, it was found that Arithmetic and Coding featured most frequently, followed by Information and Vocabulary.

In the WISC studies of groups showing symptoms of cerebral dysfunctioning, the investigators were concerned mainly with the magnitude and sign of the I.Q. discrepancy. In all but one case the mean non-verbal I.Q. was lower than the mean verbal I.Q.

The superior groups showed a tendency to high scores on the verbal sub-tests and lower scores on the non-verbal tests, and consequently showed higher verbal I.Q. scores than non-verbal scores - the reverse of the situation of the groups with reading difficulties.

(b) The Examination of the Underlying Rationale

The point was initially made that implicit in the earlier studies was the idea that the results obtained for any one group, e.g., a group with reading difficulties, would hold for all other groups with the same general

characteristics. It was emphasised that this assumption was justifiable if, in all cases, one were dealing with random samples from a total population, whereas, in practically all cases, one was dealing with an "intact" group, taken usually from a school or clinic, which could very well show features not representative of other groups. It was recognized, however, that studies of non-random or intact groups, say with reading difficulties, might show fairly general agreement among themselves as to their pattern of cognitive functioning. An examination of the results for the WISC studies confirmed this; the general results are quoted in (a) above.

The next step was to show that if one, say, were interested in the WISC pattern for groups with reading difficulties, a knowledge of the correlations between reading and the WISC sub-tests was sufficient to give this pattern. This followed from simple regression theory; the WISC pattern was simply a linear function of the correlations. There was, however, a qualification. The pattern derived from correlations would only be the same as that for randomly selected groups if the WISC test was perfectly standardised for the population considered and if there were no tester bias. If errors of standardisation (and tester bias) were present, they would distort the pattern obtained from randomly selected groups. The same of course would apply to non-random or intact groups. Without a knowledge of the magnitude of such errors it would be impossible to state how much profile variations for a group would be a reflection of the 'true' pattern of functioning for the group.

It was also shown how regression analysis could be used to derive patterns of cognitive functioning for groups selected in terms of two or more variables (the multivariate case). The method was illustrated by using data derived from a study, involving the WISC, carried out in Leeds, England.

The Johannesburg Investigation

The analysis fell into two parts:

(a) an examination of differences between R and S groups in respect of I.Q. discrepancy ($I.Q._{v} - I.Q._{nv}$) and of differences between the three R groups in respect of other variables, namely Visual Perception, Visuo-Motor Ability, Mixed Laterality, Auditory Perception, Birth Trauma, Familial Incidence and Late Speech Development;

(b) a comparison of the NSAIS profiles for the S group and the three R sub-groups.

(a) Group differences

(i) I.Q. Discrepancy:- Results indicated that the $R_{(n+a)}$ (the apraxic) group and the S group showed a similarity of functioning in that both groups showed a significantly higher verbal than non-verbal I.Q. This difference might be explained in terms of cultural and educational effects in the case of the S group and not in terms of neurological dysfunctioning as might be the case of the $R_{(n+a)}$ group.

In the case of the $R_{(n-a)}$ group the non-verbal I.Q. is higher. The $R_{(-n)}$ group showed no discrepancy between verbal

and non-verbal I.Q. scores.

(ii) Other Variables (Visual Perception, etc.):- It was found that significant group differences were obtained only in the areas of Poor Auditory Perception, Visual Perceptual Difficulties, Visuo-Motor Difficulties and Mixed Laterality and these differences lie only between the neurological and non-neurological groups. The $R_{(n+a)}$ and $R_{(n-a)}$ groups show little difference in respect of Visuo-Motor functioning and Visual Perceptual functioning (the two areas on the basis of which the diagnosis of apraxia is dependent). The inference drawn is that, to a large extent, the diagnosis of apraxia is made from tests and subjective impressions other than those incorporated in the assessments of visuo-motor and perceptual difficulties.

As regards the frequency of occurrence of Birth Trauma, Late Speech Development and Family Incidence, only Birth Trauma differentiated between the neurological and non-neurological sub-groups. These results are at variance with statements made in the literature regarding the importance and frequency of occurrence of all three aspects in retarded groups.

(b) Comparison of NSAIS Profiles

The final part of this study consists of a complete analysis of the NSAIS data with a comparison of group profiles.

Considerable resemblance occurs between the profiles of the 4 groups (the S group and the three R sub-groups). This suggests that the variation in sub-test mean scores is highly significant and cannot be attributed to random sampling. Statistical tests confirmed this.

A complete analysis of variance of the NSAIS data showed that the profiles of the four groups differ significantly even after group differences in I.Q. discrepancy have been removed. However, once the I.Q. discrepancy was removed it was found that the significant difference obtained between the four profiles is due almost entirely to a difference between the R and S groups in respect of the Problems sub-test and not due to any difference between the profiles of the R sub-groups. The correlations between the profiles confirm these results.

Correlations between profiles were obtained by deriving a statistic similar to that of a correlation ratio. It was shown that the correlation between profiles was increased from 0.706 to 0.787 when I.Q. discrepancy was eliminated and to the still higher figure of 0.876 when the Problems sub-test was omitted from the profiles. This of course accords with the results stated in the last paragraph.

The similarity between the profiles after I.Q. discrepancy and the Problems sub-section have been taken out can possibly be explained in terms of errors of standardisation and tester bias. These errors would be the same for all four profiles. (A subject for further study might be the separation out of tester bias from errors of standardisation.) The use of a control group in the present study enabled one to estimate the errors of standardisation and tester bias. It was possible to derive measures of the error of standardisation (and tester bias) for each of the NSAIS sub-tests with the exception of Problems. These estimates

of error ranged from 0 to 1 and are therefore of the same order as the 'real' profile variations derived from correlation theory. It follows that errors of standardisation (and tester bias) must produce considerable distortion of the 'true' pattern of cognitive functioning. One cannot avoid the conclusion that the use of tests such as the WISC and the NSAIS for the study of patterns of cognitive functioning is of limited value. This is perhaps the most important outcome of the study.

APPENDIX I

ANALYSIS OF WISC DATA PRESENTED IN LEEDS STUDY[1]

The primary purpose of the Leeds study was to test cognitive differences between two groups, each of 50 pupils:

(a) a Backward Group with reading quotients less than 80 and with a normal range of Non-verbal Intelligence (90-131);

(b) a Non-backward Group with average reading quotient of 106 (S.D. = 6.3) and matched with the Backward Group for Non-verbal Intelligence.

Among the tests applied were the four WISC sub-tests: Vocabulary, Block Designs, Object Assembly and Coding.

Group differences were all in favour of the Non-backward Group, the differences for Vocabulary and Coding being significant at the 1 per cent level, Block Designs at the 2 per cent level and Object Assembly non-significant (at least at any acceptable level).

In Chapter 3 of the present study it is argued that it is unnecessary to test for differences of this kind. Any knowledge of correlations and correlation theory shows that such group differences must exist.

In this Appendix, the data presented in the Leeds study are used to obtain estimates of the correlations between the four WISC sub-tests on the one hand and Reading and Non-verbal Intelligence on the other (as measured by the NFER tests).

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[1] Lovell, K., Shapton, D. and Warren, N.S. (1964). A Study of Some Cognitive and other Disabilities in Backward Readers of Average Intelligence as Assessed by a Non-verbal Test. Brit.J.Educ.Psychol., 34, 58-64.

This is of value in that, as stated in Chapter 3, there would appear to be no reported studies giving estimates of the correlations between the WISC sub-tests and Reading - a rather surprising situation. Also, the analysis employed here is of interest in itself. Furthermore, it brings out clearly the fact that a test which has been standardised on one population (in this case, the WISC on an American population) is not necessarily standardised for another population (in this case, a Leeds population). The steps involved in the analysis will now be presented.

1. Mean R.Q. for Leeds Primary School Population

It is stated in the study (p.58) that 139 pupils out of a total of 1,205 had an R.Q. of 80. Assuming a normal distribution for the population with S.D. = 15, one obtains as an estimate for the mean R.Q. a figure of about 97.

2. Correlation between Reading and Non-verbal Intelligence (as measured by the NFER tests) and mean $I.Q._{nv}$ for Leeds Population

The data presented on p.58 of the Leeds study enable one to estimate the tetrachoric correlation between Reading and Non-verbal Intelligence[1]. The method applied involved the taking of different values for $I.Q._{nv}$ and deriving the corresponding tetrachoric coefficients for the two sets of

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[1] Use was made of the Computing Diagrams for the Tetrachoric Correlations Coefficient by Chesire, L., Saffir, M., Thurstone, L.L., University of Chicago Bookstore, 1933.

data which appear on page 58. The coefficients obtained were then plotted against the corresponding values of $I.Q._{nv}$ and with two sets of data, two graphs were obtained which intersected at a point where $r_{tet} \doteq 0.37$ and the mean $I.Q._{nv} \doteq 99$. These values were then taken as the required estimates. (A correlation of 0.37 might appear low but it is well known that correlations between Reading and Non-verbal Intelligence seldom rise much above a value of 0.4.)

3. Variance and Correlations for Backward (and Non-backward) Groups

These statistics are required in the analysis which follows later. A diagram is useful. (See Fig. A.1.)

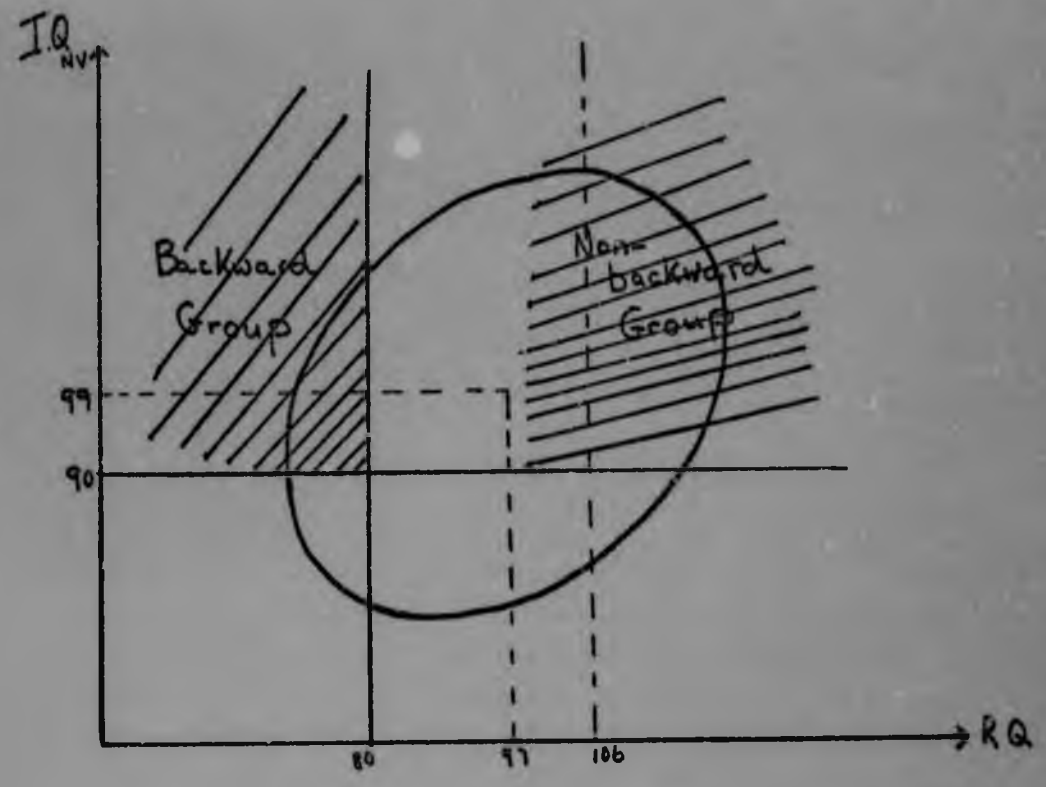

Fig. A.1.

Diagrammatic representation of bivariate distribution for R.Q. and $I.Q._{nv}$ showing areas occupied by Backward and Non-backward Groups.

Assuming a normal bivariate distribution for R.Q. and $I.Q._{nv}$, one can derive fairly easily estimates of the variances for R.Q. and $I.Q._{nv}$ in the case of the Backward Group. The values obtained are

$$\sigma^2_{RQ} \doteq 36 \quad \text{and} \quad \sigma^2_{IQ_{nv}} \doteq 70$$

If we convert to a standardised variates (variance unity), we obtain

$$\sigma^2_{RQ} \doteq 0.16 \quad \text{and} \quad \sigma^2_{IQ_{nv}} \doteq 0.31.$$

Also, by using the Selection Formulae of Karl Pearson we can derive the correlation between R.Q. and $I.Q._{nv}$ for the Backward Group.[1] It amounts to no more than 0.06.

In the case of the Non-backward Group, we are given that $\sigma_{RQ} = 6.3$ and that the group was matched with the Backward Group for non-verbal intelligence. It follows therefore that σ^2_{RQ} and $\sigma^2_{IQ_{nv}}$ have approximately the same values as for the Backward Group. We might also assume that the correlation between R.Q. and $I.Q._{nv}$ for the Non-Backward Group can be taken as 0.06.

4. Equations Required for Estimation of Correlations of WISC Subtest with Reading and Non-verbal Intelligence

Let x_1, x_2, x_3 be the standardised variates (mean = 0, S.D. = 1) for WISC sub-test, Reading and Non-verbal Intelligence respectively.

Then x_1 can be estimated from x_2 and x_3 by means of the regression equation

$$\hat{x}_1 = ax_2 + bx_3 \quad \text{_____ (1)}$$

where $$a + br_{23} = r_{12} \quad \text{_____ (2)}$$

and $$ar_{23} + b = r_{13} \quad \text{_____ (3)}$$

the r - values representing the correlations between the variables. From (2) and (3)

$$a^2 + 2abr_{23} + b^2 = ar_{12} + br_{13} \quad \text{_____(4)}$$

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1. Factorial Analysis of Human Ability by Godfrey H.Thomson, Third Edition, Chap.XI. (University of London Press, 1948)

Also R, the multiple correlation between x and x_2, x_3 is given by

$$R = \frac{\operatorname{cov}\left[(ax_2 + bx_3)\ x_1\right]}{\sqrt{(a^2 + b^2 + 2abr_{23})}}$$

$$= \frac{ar_{12} + br_{13}}{(a^2 + b^2 + 2abr_{23})}$$

$$\text{i.e. } R = \sqrt{(a^2 + b^2 + 2abr_{23})} \qquad \text{\_\_\_\_\_(5)}$$

by (4) above.

If now, as happens in the Leeds study, we select a sample (or samples) in terms of variates x_2 and x_3 so that

$$\text{var } x_2 = (\sigma_2)_s^2 \qquad \text{var } x_3 = (\sigma_3)_s^2$$

and $r_{x_2x_3} = (r_{23})_s$, the s - subscript indicating that we are dealing with a selected sample, then var(x_1) for the sample can be expressed in the following terms, namely:-

$$\text{var } (x_1) = (\text{variance due to regression on } x_2 \text{ and } x_3) + (\text{residual variance})$$

$$= \text{var } (\hat{x}) \text{ for sample} + (1 - R^2)$$

$$\text{i.e. var } (x_1) = a^2(\sigma_2)_s^2 + b^2(\sigma_3)_s^2 + 2ab(\sigma_2)_s(\sigma_3)_s(r_{23})_s + 1 - (a^2 + b^2 + 2abr_{23}) \qquad \text{\_\_\_\_\_(6)}$$

The quantities $(\sigma_2)_s^2$, $(\sigma_3)_s^2$ and $(r_{23})_s$ have already been estimated. (They are 0.16, 0.31 and 0.06 respectively). Also Table 3 of the Leeds Study (page 62) provides two estimates of the sample variance, var(x_1), one derived from

the Backward Group and one from the Non-backward Group. Since we can assume that the two groups have more or less the same $(\sigma_2)_s$, $(\sigma_3)_s$ and $(r_{23})_s$ and therefore the same var(x_1), we can take the average of the two estimates and substitute in equation (6) above. We then have an equation involving only two unknowns, a and b.

Two further equations, involving a and b and μ (the population mean for the WISC sub-test) can be obtained from equation (1), if we substitute in this equation the test means for each of the two groups. (These means are given in Tables 1 and 3 of the Study.)

With three equations, we can now solve for the three unknowns a, b and μ.

Also, knowing a and b, we can derive from equations (2) and (3) estimates of r_{12} and r_{13}. The unknown μ is then easily obtained from one of the two equations derived from (1).

An example should make the procedure clear. We shall show the full analysis for the WISC sub-test Coding.

5. Analysis of Data for WISC Coding Sub-test

Substituting means for Non-backward Group in equation (1) of section 4 above, we obtain

$$\frac{10.94 - \mu}{3} = a\,\frac{106 - 97}{15} + b\,\frac{103 - 99}{15} \quad \text{——(1)}$$

(assuming that the standard deviation for the Leeds population on the sub-test is still 3 - as for the American population).

And, for the Backward Group we obtain the equation

$$\frac{9.56 - \mu}{3} = a\,\frac{74-97}{15} + b\,\frac{103-99}{15} \quad \text{——(2)}$$

Subtracting (2) from (1), we obtain

$$\frac{1.38}{3} = a\,\frac{32}{15}$$

i.e. $$a = \frac{69}{32} = 0.2156 \qquad \text{_____(3)}$$

Variance of Backward Group on Coding sub-test

$$= 2.12^2$$

or, better, if we take average for the two groups, we obtain

$$\frac{2.12^2 + 2.68^2}{2} = 5.838 = 2.417^2$$

As shown above, this variance can be equated to

$$a^2 (\sigma_2)_s^2 + b^2 (\sigma_3)_s^2 + 2ab\,(\sigma_2)_s(\sigma_3)_s(r_{23})_s + 1 - (a^2 + b^2 + 2ab\,r_{23})$$

multiplied by 9 (We must remember again that S.D. for the WISC sub-test has been taken as 3.)

Substituting $a = 0.2156$, $(\sigma_2)_s^2 = 0.16$, $(\sigma_3)_s^2 = 0.31$, $(r_{23})_s = 0.06$ and $r_{23} = 0.37$, we obtain the

uation

$$\frac{2.417^2}{9} = (0.2156)^2(0.16) + b^2(0.31) + 2(0.2156)b\sqrt{0.16 \times 0.31}\,(0.06) + 1 - \left[(0.2156)^2 + b^2 + 2(0.2156)b\,(0.37)\right]$$

which reduces to

$$0.69b^2 + 0.1537b - 0.3132 = 0$$

whence $b = 0.57$ _____(4)

Substituting for a and b in (1) above, we obtain

$$\mu = 10.1 \qquad \text{_____(5)}$$

$$\text{also } r_{12} = a + br_{23}$$
$$= .2156 + 0.57\ (0.37)$$
$$= 0.43 \qquad \text{_____(6)}$$

$$\text{and } r_{13} = ar_{23} + b$$
$$= 0.2156\ (0.37) + 0.57$$
$$= 0.65 \qquad \text{_____(7)}$$

i.e. the correlations of WISC Coding with Reading and Non-verbal Intelligence (as measured by the NFER tests) are 0.43 and 0.65 respectively.

Also the mean on the Coding sub-test for the Leeds population is 10.1.

6. Analysis of Data for WISC Vocabulary Sub-test

When the same analysis is applied to the data for the WISC Vocabulary sub-test, the correlations of the sub-test with Reading and Non-Verbal Intelligence are found to be of the order of 0.6 and 0.8 respectively. The latter figure appears unduly high and would suggest that there is something wrong somewhere in the analysis of the data. It is most likely that the error lies in assuming a S.D. of 3 for the Leeds population in respect of this sub-test. The mean on this sub-test for the population is obviously low (the mean for the Non-backward Group is only 9.42) and when estimated by the above procedure is found to be of the order of 8.4. It would appear, therefore, that in applying our procedure we should have a S.D. for the sub-test, not of 3, but $(8.4 \times 3) \div 10 = 2.52$.

When this figure is used, the correlations obtained amount each to 0.62. (A correlation of 0.62 between Vocabulary and Non-Verbal Intelligence is much more acceptable than one of 0.8.)

7. Summary of Results of Analysis for the four WISC Sub-tests

The same procedure was followed for the two sub-tests Block Designs and Object Assembly. The results for all four sub-tests are summarised in Table A.1.

TABLE A.1

ESTIMATES OF MEAN, STANDARD DEVIATION AND CORRELATION WITH READING AND NON-VERBAL INTELLIGENCE FOR 4 WISC SUB-TESTS AS APPLIED TO LEEDS PRIMARY SCHOOL POPULATION

WISC Sub-test	Mean	Standard Deviation	Correlation with RQ	Correlation with IQ_{nv}
Vocabulary	3.4	2.5	0.62	0.62
Block Designs	10.7	3.2	0.39	0.64
Object Assembly	8.4	2.5	0.29	0.45
Coding	10.1	3.0	0.43	0.65

APPENDIX II

APRAXIA

A review of the literature pertaining to apraxia indicates that although this syndrome has been well described as a post traumatic condition in adults, little has been recorded of apraxia in children. In addition, there appears to be some discrepancy in terminology and a lack of statistical evidence concerning the type of tests used to diagnose apraxia and the results obtained from these tests.

Nature of Apraxia

Apraxia is a basic disorder in motor functioning in which the individual has the basic motor capability to perform a motor act but is unable to plan such an act at an ideational level or to transpose a visual impression into its appropriate motor counterpart. The apraxic individual suffers no intellectual lag and is able to function adequately on a verbal level.

Many simple movements are acquired by learning or practice and once established, are remembered and may be reproduced as required. Any purposive act may be conceived as occurring in several stages. First, the idea of an act must be aroused by an appropriate stimulus situation and then there is a mental representation of the act as a whole. This concept is translated into action by the excitation of the motor cortex and the corticospinal tracts which not only initiate particular movements of individual muscle groups but also modify or suppress the sub-cortical mechanisms that control the basic attitudes and postures

of the body. Thus kinaesthetic factors are always present, visual elements are involved and other senses also contribute to successful functioning. Russel Brain regards apraxia as a "disorganization of the sequence of events in the nervous system in time."(4)

In right-handed and most left-handed indiv. uals the neural mechanisms for the formulation of an idea of an act and its reproduction are believed to be centred in the posterior and inferior part of the left parietal lobe, near the angular gyrus and are connected with the motor areas of the right cerebral hemisphere.

Liepmann(42) in 1900 first described a case of unilateral apraxia and in 1905 he distinguished three varieties of apraxia :-

(a) Ideational apraxia. There is faulty conception of the movement as a whole and of the relationship of its spatial and temporal components to one another.

(b) Ideo-kinetic apraxia (sometimes termed ideo-motor). The difficulty lies in determining what the nature of a single movement should be. The patient can formulate the idea of an act but cannot execute it. There is an interruption between intact ideation and intact crude motor function.

(c) Limb-kinetic apraxia (motor apraxia). A lack of control exists over the selectivity of movement patterns. There may be apraxia of movements of head, mouth, tongue, etc., depending on the selectivity of the damage. There is a loss of kinaesthetic images of limb movements thus causing clumsiness and slowness of movements.

(d) Constructional apraxia. Mayer Gross describes the child with constructional apraxia: "There is undoubtedly a specific impairment of visuo-spatial cognition which can be characterized as an inability when given a real or imaginary visual pattern as a whole to analyze it piece by piece in order to construct it piece by piece." Brain has also described this type of apraxia and has suggested that it results from a disintegration of the visual and kinaesthetic elements in spatial perception. Difficulties in writing have frequently been associated with this type of apraxia (Critchley has noted this fact).(8)

(e) Dressing apraxia. (This syndrome may occur in isolation). The patient cannot relate the spatial forms of his garments to the form of his body.

Sometimes associated with an ideo-motor apraxia is a constellation of symptoms referred to as Gerstmann's Syndrome. This occurs with lesions of the dominant parietal lobe. It involves failure to distinguish right from left, loss of recognition of various parts of the body and is associated with an inability to write and to calculate and sometimes with reading difficulty.

Thus apraxic involvements may be manifested in general motor performance and in visuo-motor skills both gross and fine. It may exist with or without a symbolic disturbance. The ability to copy letters or other visual symbols is difficult because the symbol provides no clue to the movement patterns that should be used.

Myklebust and Johnson [22] define apraxia as an impairment of output and describe the apraxic individual as "inferior on the playground, in creative activities, in getting from one place to another and in completing a task, all because he cannot learn the motor patterns required." Co-ordination and spatial difficulties lead to associated difficulty in learning to write. A reading disability may or may not be associated with apraxia. Silver and Hagin,[32] studying apraxic children with an associated reading disability found an immaturity in the visuo-motor field, difficulty in spatial orientation and visual-figure background perception. Benton[8] states that poor reading may be part of a visuo-perceptive deficit -"a parietal dyslexia" which is associated with poor writing, drawing and construction. The lesion is in the angular and supramarginal gyri. Critchley[8] includes disorders of spatial thought (similar to adult parietal lobe dysfunction) as part of the symptomatology of dyslexia.

Jean Ayres[2] carried out a study to attempt to extract significant factors or symptoms of apraxia.

One hundred children of 6-7 years of age with learning difficulties were given a battery of tests; visual, tactile proprioceptive perception and some motor skills. The scores were correlated and subjected to factor analysis to determine the possible existence of associations among symptoms that would enable factors or syndromes to be extracted. Five such factors were extracted:

(a) apraxia

(b) perceptual dysfunction - form and position in space

(c) deficit of integration of two sides of the body

(d) perceptual dysfunction - visual figure - ground

(e) tactile defensiveness

Apraxia was loaded on

(a) motor planning

(b) finger identification

(c) tactile perception

(d) manual perception of form

(e) visual - figure - ground perception

(f) kinaesthesia

The discussion indicates that apraxia involves difficulty in directing hands or body in performing skilled or unfamiliar motor tasks. The major deficiency is tactile not kinaesthetic. Of the conditions which are usually considered aspects of body scheme disturbance (associated with apraxia) only diminished finger identification appears. The hypothesis is that the development of the central nervous system process of organizing, inhibiting and augmenting tactile impulses in association with meaningful experiences must precede the ability to perform skilled motor tasks.

The WISC has been used as part of the study of apraxic children. Walton, Ellis and Court[36], and later Gubbay et al.[13] found a discrepancy between verbal and performance I.Q. scores (higher verbal) the single most significant factor in diagnosing apraxia. A similar finding was made by Brener, et.al.[6] who also found poor Goodenough 'Draw a Man' scores amongst apraxic children.

The significantly higher verbal I.Q. score was also shown by children suffering from Gerstmann's syndrome and finger agnosia. (Warrington and Kinsbourne).[18]

APPENDIX III

TEST DATA FOR R AND S GROUPS

RESULTS OF TESTING ON NSAIS, VERNON GRADED READING TEST AND GOODENOUGH DRAW - A - MAN TEST

R GROUP

Pupil	Age		New South African Individual Scale											Vernon Reading Quotient	Goodenough (I.Q.)
					Verbal					Non-verbal					
	years	months	I.Q. Verbal	I.Q. Non-verbal	Vocabulary	Comprehension	Verbal Reasoning	Problems	Memory	Pattern Completion	Blocks	Absurdities	Form Board		
R(-n)															
1	6	10	106	116	10	14	7	10	15	8	13	15	14	73	77
2	7	8	109	123	8	13	9	7	11	14	15	16	9	83	91
3	7	9	109	116	12	10	13	9	14	12	12	15	11	73	103
4	7	4	124	117	11	14	13	15	16	10	12	16	13	95	89
5	7	9	117	114	8	13	15	15	13	12	10	12	15	70	90
6	8	4	106	112	11	14	10	10	11	9	14	15	10	89	93
7	8	9	110	125	12	11	12	13	11	16	14	14	11	86	94
8	8	8	100	87	7	14	10	11	10	6	7	11	9	87	61
9	8	9	109	116	9	11	12	16	10	11	11	14	14	89	97
10	8	2	102	105	10	13	6	14	10	12	10	16	6	91	91
11	8	8	125	112	12	15	15	14	14	9	14	14	11	92	110
12	8	5	121	103	12	13	13	15	14	16	11	12	6	69	101
13	9	10	114	116	13	15	15	11	8	7	18	15	10	93	74
14	9	5	117	107	11	15	14	12	12	10	10	14	9	74	80
15	9	6	96	103	10	9	12	9	9	9	10	11	13	93	92
16	9	11	103	101	11	14	11	5	13	6	8	14	14	86	83
17	10	5	125	114	11	16	11	14	18	10	16	12	11	81	96
18	10	7	104	125	11	12	12	10	10	13	16	14	12	56	120
19	10	6	120	114	13	16	15	10	12	14	12	15	8	95	67
20	11	6	124	125	11	16	14	14	14	15	14	14	12	68	94
21	11	7	102	107	11	11	9	11	9	9	13	11	12	68	69
22	11	3	127	128	12	18	18	18	15	16	13	15	13	71	89
23	11	10	110	111	10	14	14	10	11	10	14	14	9	76	100
24	11	5	88	103	8	5	12	7	11	8	11	13	11	79	77
25	12	8	97	96	9	11	12	11	7	9	9	12	9	69	89
26	12	11	109	105	12	14	11	11	10	12	11	11	10	74	61
27	12	6	92	102	10	16	12	9	11	8	12	9	8	88	92
28	12	5	99	101	8	10	12	11	10	10	10	10	12	79	93
R(n+a)															
1	6	9	100	103	7	12	10	10	13	9	10	11	13	74	115
2	6	10	111	105	13	15	10	12	10	11	12	14	7	82	125
3	7	10	118	101	12	17	16	13	7	10	8	13	11	89	89
4	8	4	114	100	11	15	17	10	9	12	9	14	6	78	100
5	8	1	121	107	10	14	16	16	11	12	10	14	9	69	93
6	8	9	132	100	11	20	17	11	16	10	9	12	10	91	89
7	8	4	110	92	16	13	13	14	9	9	11	7	10	92	87
8	8	9	93	103	9	10	7	10	11	10	12	14	7	79	106
9	8	5	107	114	12	10	12	15	8	14	12	10	13	85	125
10	8	3	139	126	12	17	18	17	16	11	12	17	16	97	88
11	9	5	109	105	12	15	11	10	10	12	10	9	13	71	96
12	9	8	113	92	10	11	12	13	8	7	10	12	8	75	113

R GROUP contd.-

Pupil	Age		New South African Individual Scale											Vernon Reading Quotient	Goodenough (I.Q.)
					Verbal					Non-verbal					
	Years	Months	I.Q. Verbal	I.Q. Non-verbal	Vocabulary	Comprehension	Verbal Reasoning	Problems	Memory	Pattern Completion	Blocks	Absurdities	Form Board		
R(n-a)															
15	9	4	118	103	13	13	12	12	15	10	10	11	12	89	91
14	9	10	106	121	12	14	15	8	7	12	14	12	15	97	84
15	9	2	124	98	13	15	18	12	11	8	11	9	12	85	106
16	10	1	123	117	10	14	15	14	15	15	12	13	11	79	107
17	10	2	131	101	15	18	15	14	16	10	9	12	10	89	76
18	12	8	93	107	11	13	9	10	4	11	11	12	12	96	75
19	12	4	111	90	13	12	12	9	14	9	8	11	8	91	73
20	12	7	130	107	13	17	16	13	14	13	15	12	5	52	69
R(n-a															
1	7	8	88	101	10	9	8	9	7	9	8	13	12	66	85
2	7	9	106	112	11	12	9	11	13	9	12	12	15	73	95
3	7	4	95	123	7	11	13	10	7	17	10	16	11	90	75
4	8	2	85	114	10	8	6	9	8	18	12	13	11	68	95
5	8	1	100	126	11	8	12	12	9	13	20	12	11	82	108
6	8	8	102	121	10	15	7	10	11	10	11	19	13	71	85
7	8	3	116	117	10	11	17	12	13	12	12	15	12	91	85
8	9	1	116	110	10	15	16	11	11	11	13	16	7	67	90
9	9	6	121	103	10	13	16	15	13	10	13	11	9	73	71
10	10	6	109	108	13	13	9	13	10	9	14	12	11	63	67
11	10	3	110	110	11	15	13	9	11	13	14	13	7	63	95
12	11	1	100	117	9	10	11	11	11	11	11	15	14	62	99

S GROUP

Pupil	Age		New South African Individual Scale											Vernon Reading Quotient	Goodenough (I.Q.)
					Verbal					Non-verbal					
	Years	Months	I.Q. Verbal	I.Q. Non-verbal	Vocabulary	Comprehension	Verbal Reasoning	Problems	Memory	Pattern Completion	Blocks	Absurdities	Form Board		
1	6	9	120	110	11	15	11	14	15	11	10	14	12	105	93
2	6	8	110	125	10	10	14	16	9	12	19	14	10	100	130
3	6	10	134	119	13	15	19	16	13	12	10	13	17	99	104
4	7	8	116	119	10	12	15	14	12	12	12	16	12	100	104
5	7	3	124	119	9	16	15	15	14	16	16	9	11	120	121
6	7	7	134	128	13	15	12	20	16	17	15	13	12	127	102
7	7	4	113	119	9	12	15	16	9	18	10	13	11	125	116
8	7	8	132	116	12	18	14	17	14	10	12	12	16	133	104
9	7	8	121	116	10	13	13	15	16	13	10	13	14	114	137
10	7	10	110	105	11	14	12	13	9	6	12	13	13	99	102
11	7	8	132	116	12	18	14	17	14	10	12	12	16	133	104
12	8	3	130	121	14	14	16	16	13	17	12	15	9	124	121
13	8	4	102	108	9	10	12	12	10	13	9	11	13	101	101
14	8	3	123	108	13	10	16	16	13	13	15	11	7	115	106
15	8	1	146	122	18	18	17	16	16	12	15	17	13	123	102
16	8	5	127	116	12	16	14	16	13	13	12	14	11	122	86
17	8	2	118	118	10	15	12	17	11	8	12	13	13	103	83
18	8	3	117	116	10	10	13	16	15	17	12	15	6	109	121
19	8	3	124	123	10	15	16	15	13	13	17	12	12	109	106
20	8	6	127	117	12	10	16	18	15	12	14	14	11	106	104
21	8	5	109	110	9	13	14	14	8	14	11	11	11	103	77
22	8	9	139	126	14	17	17	15	17	13	14	13	16	115	89
23	8	4	111	103	9	11	13	13	12	14	14	6	9	108	120
24	8	8	104	101	9	13	11	15	7	13	7	9	13	108	87
25	8	11	133	123	19	20	20	16	20	16	14	14	12	123	109
26	8	1	135	125	12	15	16	18	16	15	15	16	9	131	121
27	8	5	116	126	11	14	12	15	11	13	17	15	11	100	101
28	8	5	114	105	12	11	12	15	12	11	12	12	9	100	101
29	8	3	120	107	12	11	16	14	13	8	12	16	9	117	112
30	9	7	121	126	14	12	13	18	10	14	15	14	13	104	104
31	9	4	123	116	12	14	13	13	16	12	13	16	9	105	129
32	9	5	134	121	15	16	16	16	13	13	15	14	16	121	117
33	9	6	130	119	14	15	16	15	13	14	13	14	11	133	105
34	9	8	121	119	13	13	16	14	11	11	13	12	16	112	97
35	9	3	142	126	17	17	16	15	17	13	11	18	14	119	111
36	9	6	130	126	14	14	14	18	13	15	15	13	13	112	116
37	9	3	135	116	13	17	14	19	14	12	13	17	8	108	119
38	9	-	132	128	14	14	14	17	16	18	13	14	12	126	89
39	9	3	121	112	12	13	14	14	14	14	13	11	10	102	89
40	9	6	137	116	17	14	16	13	18	14	10	15	11	126	92
41	10	6	131	90	15	16	15	13	15	10	9	10	7	133	100
42	10	11	116	116	14	12	13	14	10	11	13	12	14	121	87
43	10	11	135	135	15	20	11	17	14	15	19	14	13	131	92
44	10	5	125	119	14	13	13	16	14	11	16	15	10	112	96
45	10	7	110	114	11	13	12	11	12	9	12	15	13	104	115
46	10	8	127	117	13	12	14	14	16	14	11	18	8	121	94
47	10	7	146	135	14	20	15	18	18	15	14	18	14	121	102
48	11	10	128	119	13	14	14	16	15	15	14	10	13	113	97
49	11	11	145	132	19	18	18	16	13	16	14	14	15	125	82
50	11	5	131	126	14	17	18	14	11	16	13	14	13	126	100
51	11	10	125	108	14	18	14	15	9	13	12	9	12	112	101
52	11	9	137	119	16	17	14	20	11	16	16	9	11	131	87
53	11	11	135	110	18	17	14	15	13	12	12	14	9	122	97
54	12	10	117	114	13	14	9	16	12	14	18	20	14	115	103
55	12	10	130	123	14	17	14	17	11	13	13	16	12	117	93
56	12	3	107	112	12	13	10	15	9	10	12	15	11	110	84
57	12	6	124	101	13	16	12	16	12	12	13	10	7	119	92
58	12	6	123	117	15	15	12	13	13	16	12	10	13	125	96
59	12	10	123	107	14	13	14	16	11	14	8	14	9	112	82
60	12	4	111	114	10	11	11	13	15	12	15	14	8	101	72

ADDITIONAL TEST DATA FOR R GROUP

As stated in Chapter 3, this took the form of classifying children into two groups, those having difficulty and those not having difficulty, for each of 5 areas:-

1) Auditory Perception
2) Visual Perception
3) Visuo-Motor Ability
4) Laterality
5) Body Image

In addition information was obtained for each child re Birth Trauma, Late Language Development and Family Incidence. The children were rated + (having difficulty) and - (having no difficulty) for each of the areas.

RATING OF CHILDREN IN EIGHT DIFFERENT AREAS

Pupil	Auditory Perception	Visual Perception	Visuo-Motor Ability	Mixed Laterality	Poor Body Image	Birth Trauma	Late Language Development	Familial Incidence
R(-n)								
1	+	+	+	+	+	+	+	+
2	-	+	+	+	+	+	-	+
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	+	+
13	+	+	+	+	+	+	+	+
14	+	+	+	+	+	+	+	+
15	+	+	+	+	+	+	+	+
16	+	+	+	+	+	+	+	+
17	+	+	+	+	+	+	+	+
18	+	+	+	+	+	+	+	+
19	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+
21	+	+	+	+	+	+	+	+
22	+	+	+	+	+	+	+	+
23	+	+	+	+	+	+	+	+
24	+	+	+	+	+	+	+	+
25	+	+	+	+	+	+	+	+
26	+	+	+	+	+	+	+	+
27	+	+	+	+	+	+	+	+
28	+	+	+	+	+	+	+	+
R(n-)								
1	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	+	+
13	+	+	+	+	+	+	+	+
14	+	+	+	+	+	+	+	+
15	+	+	+	+	+	+	+	+
16	+	+	+	+	+	+	+	+
17	+	+	+	+	+	+	+	+
18	+	+	+	+	+	+	+	+
19	+	+	+	+	+	+	+	+
20	+	+	+	+	+	+	+	+
R(n-a)								
1	+	+	+	+	+	+	+	+
2	-	-	+	-	+	+	+	-
3	+	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	+	+	+	+
7	+	+	+	+	+	+	+	+
8	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+
10	+	+	+	+	+	+	+	+
11	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	+	+

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